*Alle mie piccole*

# *Identity, Individuality and the Ontological Interpretation of Quantum Mechanics*

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I certify that this thesis, presented by me for examination for the PhD degree of the University of London, is solely my own work other than where I have clearly indicated that it is the work of others.

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# *Abstract*

This thesis examines the concepts of identity and individuality via scientifically-informed philosophical analysis. It has two parts.

The first part deals with metaphysical claims that turn out to be, in effect, very general empirical claims extracted from our (supposed, but rationally-accredited) knowledge of the world. I here compare two approaches:

a) the Leibniz-Quine view of identity as a derivative relation, and, relatedly, of individuality as dependent on the qualities of things; and

b) the view that identity is a non-analysable primitive, and, relatedly, that the individuality of things is not reducible to anything else.

The former position, based on the Principle of the Identity of the Indiscernibles as a criterion of individuation, might appear *prima facie* more plausible. However, I argue that it runs into difficulties both at the level of *a priori* analysis and in terms of 'fit' with the evidence described by our best science. It is, in fact, not even as compelling from the empiricist point of view as is commonly believed. I therefore argue that the position that identity and individuality are primitive may be preferred.

In the second part of the thesis - under the assumption that the proper role of metaphysics is to characterise the best solutions to issues that are left open by current science – I deal with the question regarding whether and how the ultimate constituents of reality can actually be conceived of as primitive individuals. I argue in favour of an ontology of *tropes*, develop the view in detail and defend it against various criticisms. The fundamental tropes that constitute the basic 'building blocks' of reality are identified with the state-independent properties of elementary particles. The way in which these constitute complex particulars is described, and certain peculiarities having to do with quantum statistics are accounted for.

I conclude by suggesting possible avenues for further research.

# *Table of contents*


1. *Introduction* 7
    1. Individuality 7
    2. Approaches to Identity 12
    3. Individuality as a Qualitative Notion: the Reductionist View and the Principle of the Identity of the Indiscernibles 16
    4. Summary and Outline of the Subsequent Chapters 19
2. *The Principle of the Identity of the Indiscernibles* 24
    1. How to Formulate the Principle of the Identity of the Indiscernibles 25
    2. Leibnizian Metaphysics 29
    3. The Identity of the Indiscernibles and the Bundle Theory 34
    4. Counterexamples 40
    5. Weak Discernibility, and a Further Version of the Principle of the Identity of the Indiscernibles 46
    6. Working Counterexamples? 51
    7. Ontology and Science: Experimental Metaphysics? 56

    Conclusions 66
3. *Quantum Mechanics and its Ontological Implications* 67
    1. Orthodox Quantum Mechanics and the Violation of the Principle of the Identity of the Indiscernibles 67
    2. Weak Discernibility to the Rescue? 75
    3. Bosons and the Appeal to Non-Individuality 92
    4. Bohmian Mechanics 100
    5. Where Do We Stand? A Recapitulation 105

Appendix: Identity and Indistinguishability in Other Interpretations of Quantum Mechanics *107*

4. *Primitive Identity and Substrata* *111*
   1. Suchness and Thisness *111*
   2. Primitiveness, Empiricism and the Principle of Acquaintance *114*
   3. Bare Particulars *122*
   4. Similarity and the Alleged Indispensability of Universals *144*
   5. Similarity and Nominalism *151*

   Conclusions *154*

5. *Which Nominalism? In Defence of Trope Ontology* *156*
   1. Resemblance Nominalism *156*
   2. Trope Ontology *173*
   3. Tropes, Other Properties, and Replies to Some Objections *176*
   4. Tropes: an Assessment *190*

   Conclusions *193*

6. *A Trope-Based Reconstruction of the Quantum World* *195*
   1. Fundamental Tropes *195*
   2. State-Dependent Properties and Quantum Statistics *208*

   Conclusions *227*

   Appendix: Statistics and State-Dependent Properties in Other Interpretations of the Quantum Domain *228*

*Conclusions and Outlook* *230*

*References* *234*

# Chapter 1

# Introduction

This chapter introduces the topic of the thesis and, in particular, the notions of identity and individuality. Following a consideration - and rejection - of other views regarding whether and how individuality can be analysed, two alternatives are identified: the conception according to which individuality is primitive and non-analysable, and the 'reductionist' view, which equates individuality with uniqueness of properties. The latter approach leads to the acceptance of what is known as the Principle of the Identity of the Indiscernibles. These two alternatives, it is also explained, correspond to two possibilities as regards the identity relation. With respect to such a relation, the Quinean suggestion that it can be substituted without loss with conjunctions of non-identity-involving formulas is opposed to the idea that it must be posited as a logical constant. An outline of the chapters to follow concludes this introduction.

## *1. Individuality*

The notions of identity and individuality are essential in philosophy. At least some philosophical problems surely have a metaphysical basis; and Lowe is unquestionably right that identity and individuality are

> "the two most important of all metaphysical notions [..., as they possess an undeniable] centrality [...and play a] pervasive role" [1998; 28].

The connection between these two concepts is the following: it seems plausible to claim that an individual is something that is such that statements regarding its identity always have a determinate truth-value. That is - looking at the other direction of the *bi-conditional* that constitutes the basic *definition* of individuality - that whatever is determinately identical to itself (i.e., possesses *self-identity*) and also determinately distinct from everything else (i.e., possesses *numerical distinctness*) is an *individual*.[1]

The important philosophical debate with which this thesis is concerned regards whether this is all we can say about individuality, or some degree of philosophical analysis is instead possible.

Various attempts have been made in the history of philosophy to show that the latter is in fact the case, and the intension of the concept of individuality is the same as that of some other, more 'down-to-earth' concept.

The idea that an entity is an individual if and only if it is *indivisible*, for instance, was defended by Saint Thomas Aquinas in his *Summa Theologica* ([Part I, Question 11, Article 2]). This view was later refined by Suarez, who argued that individuality is indivisibility into entities *of the same specific kind* as the original one [1572(1861); Disputatio V, Sec. 1, § 3]. Further specifications can be added, as illustrated, for example, by Gracia, who considers the possibility that individuality is indivisibility into entities of the same *quantity* as the initial one [1988; 29-32]. The view is in any case inadequate, however, as whether or not an entity possesses the identity conditions defined above for individuals is logically

[1] This immediately suggests a subdivision internal to a larger set of entities. Barcan Marcus [1993; 25], for instance, differentiates between 'objects' and 'things', the latter being objects provided with specific features - in particular, determinate self-identity – which are not essential to object-hood. It seems to me correct to consider 'object' as a synonym of 'particular', and consequently distinguish individual objects and non-individual objects as two distinct types of particulars.

independent of whether or not it has parts (of a certain type). At best, this view manages to identify a subset of the set of possible individuals.

Another suggestion is that something is an individual if and only if the word that denotes it in the language is *impredicable*. This view was put forward in Aristotle's *De Interpretatione*, and re-emerged in the Middle Ages via the commentary on Aristotle's work written by Boethius. It amounts to the claim that something is an individual if and only if the word(s) that we use to refer to it can *only* appear as the subject of a phrase. Many medieval philosophers maintained that this is a satisfactory definition, and that the fact that something necessarily corresponds to the subject of a grammatical sentence is necessary and sufficient for it to count as an individual. However, this is mistaken. One might respond that what counts as the subject of a sentence is a purely conventional matter, and so – while there indeed are individuals - nothing is absolutely impredicable. As argued by Ramsey [1925][2], being subject or predicate at the level of language is a relative notion, for we can always reformulate our expressions in such a way that what appears as a predicate in one expression appears as the subject in another, equivalent one, and vice versa. Of course, there still exists an ontological difference between a particular located in space and time that is attributed a quality that it shares with other things, and something that is exemplified by specific particulars and can be common to many things in different places and at different times. However, this ontological asymmetry cannot be brought to bear on a definition of individuality that is presented as *exclusively* based on features of language.

Another definition is proposed by Gracia, who emphasises the notion of *non-instantiability*. Gracia contends that:

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[2] Ramsey's argument will be examined in more detail in a later section (see chapter 4).

> "There is no great advantage in making a distinction between particularity and individuality [...because...] unlike singularity, which has plurality as its own opposite, particularity has no appropriate opposite of its own context, allowing us to use it as a synonym of 'individuality', and to oppose it to universality" [1988; 53].

His reasoning, then, goes as follows. From the identification of particularity and individuality, he derives that individuality is the opposite of non-particularity. Since whatever is not a particular is a universal, it follows that instantiability (the defining feature of universals) is what individuals lack. Hence Gracia's view that universals are singular (they are not plural in the sense of being aggregates) but not individual (as they can be instantiated); and that every singular thing that is not a universal, i.e., is not multiply instantiable, is an individual.

This view is in itself consistent, for once individuality is *equated with* particularity no contradiction arises. However, I see reasons not to equate the two concepts, and to claim that they refer to different types of things. In particular (introducing certain differentiations and definitions that will become relevant at a later stage), it is possible to claim that *self-identity* and *numerical distinctness from other entities* (that is, *countability*) do not necessarily go together; and accordingly to take particularity as defining the general category of non-instantiables; and then distinguish – within the class of particulars - between individuals and non-individuals, depending on whether or not they have both determinate self-identity and numerical distinctness.

This discrimination appears not only natural but also advisable once one considers the possibility of vague objects, often discussed in the philosophical literature. Of course, Gracia might just reject such a possibility, and consequently continue to deny the usefulness of the particular/individual distinction. Yet, besides being of independent philosophical interest, the concept of vagueness appears to have a clear - and far from 'abstract' – import, as it is intimately connected with issues regarding the interpretation of physical theory: in particular, with problems revolving around the metaphysical status of quantum entities.[3] Therefore, the differentiation between particularity and individuality appears indeed relevant, at least under the assumption that philosophical analysis cannot remain abstract from actual evidence, and from a consideration of our knowledge of the world. In the light of this, it is fair to claim that non-instantiability is necessary but not sufficient for individuation.[4]

We have thus seen that indivisibility, impredicability and non-instantiability are all insufficient for a 'reductionist' definition of individuality. A further suggestion, and one that cannot be dismissed as easily as those considered so far, is that the individuality of an entity supervenes on the entity's qualities: something, the idea is, is an individual - self-identical and numerically distinct from other entities - *because its properties are not the same as those of any other entity (and only if this is the case).* According to this line of argument, dating back at least to Leibniz, individuality is in fact a derivative concept, and talk of individuality could be in principle entirely replaced with claims

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[3] I will deal with this issue in detail in the present thesis (see chapters 3 and 6).

[4] But if self-identity and countability are distinct, one might at this point reply, then there should exist four ontological categories, corresponding to the four possible combinations, and not just two (individuals and non-individuals). Lowe [1998] suggests that this is in fact the case, as parts (or 'portions', or 'quantities') of homogeneous stuff (think about a jug of water) are 'quasi-individuals' with self-identity but not determinate numerical distinctness; and particular qualities are 'non-individuals' lacking both determinate self-identity and determinate numerical distinctness. I believe that Lowe is wrong on both counts: in the first case, he seems to conflate the epistemic arbitrariness of the identification of parts of homogeneous stuff (how many molecules count as a 'portion' or 'quantity' is not uniquely fixed) with lack of numerical distinctness in the ontological sense (it is not the case that there is no objective number of molecules in an amount of homogeneous stuff); in the second, he simply endorses a view of particularized properties different from mine.

regarding the properties of things. The alternative, to be discussed in much of what follows, is thus that between:

a) The view according to which the world is, at root, entirely constituted by *qualitative facts* (i.e., facts other than those concerning identity and number), and individuality is reducible to properties – a conception defended by Leibniz, Russell and Ayer among others; and

b) The idea that the individuality of things is something over and above their qualitative aspects and there exist - as believed, for example, by Scotus, Kant and Peirce - brute, primitive metaphysical facts of self-identity and numerical distinctness without any fact of qualitative difference corresponding to them.

In the terminology introduced by Adams [1979], the former approach takes the things' *suchnesses* as the only components of individuals, while the latter maintains that some form of primitive, purely quantitative, *thisness* also exists and is the source of individuality.

## *2. Approaches to Identity*

The above discussion made it clear that the question of individuality can only be answered by addressing another question. If an entity's individuality consists of certain identity conditions holding for that entity, then in order to clarify the notion of individuality we must analyse that of identity.

The canonical account of identity can be given in terms of first-order logic. In this context, it can be presented as a peculiar binary relation (expressed by the symbol '=') that satisfies the following two axioms:

*Reflexivity*: $\forall x(x=x)$

*Leibniz's Law*: $\forall x \forall y((x=y) \rightarrow \forall F(Fx \leftrightarrow Fy))$

(where '$x$' and '$y$' denote individual entities and F is an open formula in the language).

The reflexivity axiom states that every individual is identical to itself. Leibniz's Law amounts to the claim that if two individuals are identical, then any formula satisfied by one of them is also satisfied by the other.[5]

Reflexivity and Leibniz's Law together imply three other features of the identity relation: *symmetry*, *transitivity* and what is known as *Euclid's first axiom*, which states that any two things both identical to a third thing are identical to each other. Consider symmetry: if identity is not symmetric, then there must exist two entities for which it is not the case that $(a=b) \rightarrow (b=a)$. This entails that $(a=b)$ and $\neg(b=a)$ can be both true at the same time. But this in turn implies that $\neg(a=a)$; for the formula $\neg(x=a)$ is satisfied substituting $x$ with $b$ but, since $a$ is equal to $b$, by Leibniz's Law this must also be the case if $x$ is substituted with $a$. This, however, is made impossible by reflexivity and so the initial negation of symmetry is - once the two fundamental axioms are assumed – proven

[5] The supporters of so-called *relative identity* (see Geach [1967]) suggest that it is possible for two things $x$ and $y$ to be the same under one concept but not under another (for instance, to be the same book, but not the same copy of the book). This allegedly allows one to solve certain problems such as, for instance, the so-called paradox of constitution: if the clay $c$ is shaped on day 1 in the form of statue $s$, it looks like $c$ is identical to $s$; but what happens if, on day 2, $c$ is moulded in such a way that it constitutes a statue $t$ which is qualitatively different from $s$? Is $s$ identical to $t$, as Leibniz's Law would imply; or is it distinct, as the differences among statue $s$ and statue $t$ suggest? Perhaps one has the same piece of clay on day 2 as in day 1, but not the same statue. Relative identity thus entails that only restricted instances of Leibniz's Law apply, made relative to concepts. It is debated whether this view captures the true nature of identity; or, instead, Leibniz's Law in its unrestricted version represents the distinctive mark of identity and relative identity theorists derive too much from the *sortal dependency* of identity – namely, the fact that whenever it is possible to claim that $x$ is an individual, it must also be possible to answer the question 'What *kind* of individual is $x$?'. See Wiggins [2001; 53-54] for the proof that, if one adopts the unrestricted Leibniz's Law, then sortal dependency entails the impossibility of relative identity. As far as I am concerned, I believe that Leibniz's Law should not be restricted, and that the idea of relative identity stems exclusively from the fact that the same, unique physical object (obeying well-defined identity criteria) can be considered from different perspectives and in different functions. At any rate, whether identity is relative or absolute does not really matter for the issue we are concerned with, namely, whether it is *reducible* or not.

contradictory. As for transitivity, consider the case in which (allegedly) ($a=b$), ($b=c$) and $\neg(a=c)$. Again by Leibniz's Law, the first two equalities entail ($a=c$), and so the initial assumption is inconsistent. That Euclid's first axiom must also be accepted as a logical truth in the theory of identity is shown along similar lines, by assuming that ($a=b$), ($c=b$) and $\neg(a=c)$ can be all true at the same time and noticing that, via Leibniz's Law, this entails a contradiction.[6]

In short, identity is *the equivalence relation satisfying Leibniz's Law.*

Such a relation is often taken as a primitive. First-order logic *with identity*, for example, takes the identity sign as part of one's logical vocabulary, along with the usual individual constants, variables, quantifiers and predicate and relation symbols.

The alternative view exists, however, according to which it is possible to analyze the identity relation and conceive of it as a *non-logical* notion. This view is usually associated to the name of Quine.

Quine's idea (stemming from an elaboration of the work of Hilbert and Bernays [1934]) was essentially that, in a first-order language with a finite vocabulary, it is possible to eliminate the identity sign altogether, effectively reducing it, for each individual, to the conjunction of formulas that the latter satisfies in the language. As Quine puts it, in a first-order language

> "'=' will in effect be present, whether as an unanalyzed general term or in a complex paraphrase, at least provided that the vocabulary of unanalyzed general terms is finite. For, write 'if Fx then Fy' and vice-versa with each of the absolute general terms of the vocabulary in place of 'F'; also write '(z)(if Fxz then Fyz)' and '(z)(if Fzx then Fzy)' and vice-versa, with each of the dyadic relative terms in place of F; and so on [...].

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[6] For more on this, see Tarski [1941; Ch. 3] and Howson [2003; Ch. 9, esp. 119-120].

> The conjunction of all these formulae is coextensive with 'x=y' [...and] we can without conflict adopt that conjunction as our version of identity" [1960; 230].

But why should we believe that this is the case? We know that if two individual constants in a language denote the same entity, then they also satisfy the same formulas in that language (this is Leibniz's Law). However, it is possible that two *distinct* individuals – call them *a* and *b* - exist such that *a* and *b* satisfy all the same formulas in the language. Or so first-order logic with identity tells us. The possibility of unintended interpretations ignoring this has indeed been repeatedly identified as an unacceptable consequence of the Quinean perspective. It was first emphasised by Wallace [1964]. Williamson [2006] provides the example of a language with only two monadic atomic predicates F and G: in an interpretation on which 1000 members of the domain are both F and G, 1 is only F, 1000000 are only G, and 1 is neither F nor G, the 1000 $(F\wedge G)$s and the 1000000 Gs are – on a Quinean construal of identity - necessarily collapsed into two single objects. Scenarios such as this one supposedly expose the limited expressive powers of languages without identity as a primitive (limited with respect to what – allegedly – 'is actually the case').

It is in effect undeniable that at the abstract level of conceptual analysis the positing of identity as a primitive provides more expressive power than in a language without the identity relation as a primitive. Quineans, however, may well deny that this additional potential is ever put to use, on the basis of the idea that it is never required by the characteristics of the domain being talked about (of course, unless the domain is constructed *ad hoc*).[7]

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[7] They would thus argue that the reduction of the identity relation can always be carried out in a given context *without epistemic loss*, in the sense that, to the extent to which the

It therefore seems that sense can be made of Quine's proposal, and of the whole dispute about the status of the notion of identity, only by avoiding the consideration of artificial contexts and taking ontology more explicitly into account.

### *3. Individuality as a Qualitative Notion: the Reductionist View and the Principle of the Identity of the Indiscernibles*

Quine's claims can be summarized in the form of the following definition:

$(x=y)=_{def}\forall F(Fx\leftrightarrow Fy)$

That is,

$\forall x\forall y((x=y)\leftrightarrow\forall F(Fx\leftrightarrow Fy))$ (Quinean definition of identity)

Everybody agrees on the truth of

$\forall x\forall y((x=y)\rightarrow\forall F(Fx\leftrightarrow Fy))$

which is nothing but the abovementioned Leibniz's Law.

The distinctive feature of Quinean identity is, therefore, the right-to-left direction of the above bi-conditional, namely,

$\forall x\forall y(\forall F(Fx\leftrightarrow Fy)\rightarrow(x=y))$ (A)

However, I argued, the status of (A) cannot be evaluated *in abstracto*, and must necessarily be determined on the basis of the properties of the entities constituting the domain which (A) is applied to. What this entails is immediately seen once one makes a correspondence between formulas in the language and properties 'in the world' explicit. If there is a property P in the domain for every formula F in the language, then the truth of A in the language is due to the truth of

$\forall x\forall y(\forall P(Px\leftrightarrow Py)\rightarrow(x=y))$

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language mirrors its domain when identity is posited as a primitive, such a 'correspondence' is not affected by the proposed reduction.

in the world.

But this means that the justification of the Quinean view of identity must rest on the metaphysical assumption that no two numerically distinct things can have all the same properties.

The principle in question is, of course, Leibniz's well-known *Principle of the Identity of the Indiscernibles* (PII).[8] *It is therefore PII that must be carefully assessed in order to critically evaluate the Quinean position as regards identity.*

It is here that, after a tour through the logical and linguistic issues surrounding identity, we get back to the initial question regarding individuality. Since individuality consists of the holding of well-defined identity conditions (as regards both self-identity and numerical distinctness from other entities), and since PII plays a crucial part in supporting the Quinean definition of identity, PII now becomes a candidate for counting as a valid *criterion of individuation* from a perspective that denies the primitiveness of individuality. That is, it becomes what the position that I will call the *reductionist* position from now on presents as a 'rule' for finding out what counts as an individual, and which individuals exist in a given domain.

With respect to this, two possibilities arise.

On a *strong* reading of the Quinean-Leibnizian view, PII is necessarily true; that is, it is a *metaphysical truth* that no two individuals

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[8] Leibniz formulated PII in many occasions and on different ways. See, for an example, his [1704(1981)]. Here (and in what follows) second-order logic is used, but bear in mind that Quine does not do this and only uses first-order formulas (of a language with a finite vocabulary). As we will see in more detail later, the second-order formulation of PII is a *theorem* of second-order logic whenever self-identity is considered as a genuine property (see Ketland [2006; 313] and Howson [2003; 147-148]). However, as we will see, there are arguments to the effect that one should ignore this property - and related ones – when employing PII for purposes of individuation; and this is customarily done. Since no other relevant consequence seems to follow from the switch to second-order logic, there is no particular reason for objecting to the identification of Quine's claims about the reducibility of the identity relation with an endorsement of PII (see, for example, Saunders [2006]).

have all the same properties, and this *justifies* the reductionist approach to identity and individuality. On a *weak* reading of the reductionist perspective, instead, *as far as we know* there is good reason to believe that numerically distinct but indiscernible individuals do not exist.

It is important to emphasise a crucial difference. The strong reading is based on the idea that the truth of PII as a metaphysical claim can be established, and that this has *consequences* for our knowledge of, and claims about, things in the world. The weak reading, instead, reverses the order: in looking at what we know about the world with a view to formulating principles of general validity, it suggests a priority (at least as long as the present issues are concerned) of *epistemology over metaphysics*. Much more on this will have to be said later.

With the foregoing discussion, for the time being, I have made the need for a consideration of ontology explicit, while speaking rather vaguely of a 'world' of entities with properties. What about the specific domain, and consequently language, that need to be considered? Insofar as the identity and individuality of *material objects* is concerned (and not that, say, of numbers, or angels or any other 'otherworldly' thing), it seems that an assessment of the reductionist view must necessarily involve the entities and properties that are described by *physical theory*. Since the present work is indeed intended as a study of identity and individuality in the tangible world we live in, physics is therefore the discipline that (in parallel to PII as a metaphysical principle) will be considered in detail in what follows. As a matter of fact, one of the aims of this thesis is to formulate a plausible ontological interpretation of the physical world as it is described by our best current scientific theory about it.

### *4. Summary and Outline of the Subsequent Chapters*

The individuality of an entity has been identified with the metaphysical condition in virtue of which the entity possesses determinate self-identity and numerical distinctness from every other entity. This definition connects the strictly metaphysical issue regarding the nature of individuality to the logico-linguistic debate concerning the identity relation. A clear opposition has emerged between a reductionist perspective which denies that the identity relation is part of one's logical vocabulary, and is committed to PII; and the view that facts of identity and individuality are primitive and not further analysable, and PII is false.

The issue concerning the nature of individuality thus boils down to that regarding the status of PII. The essential question is: Does PII truly capture the nature of individuality? That is, is PII true? If so, is it necessarily or just contingently so? If it is merely contingently true, what is the real force of the Leibniz-Quine view of identity and individuality? That is, generalizing, to what extent are we allowed to make metaphysics dependent on epistemology? These are the key questions that will be dealt with in the first part of the thesis, devoted to a critical analysis of the reductionist view of identity and individuality and of the relationship between metaphysics and empirical science.[9]

The next chapter begins the analysis of the Quinean-Leibnizian reductionist position by ascertaining whether or not PII is necessarily true. If this turned out to be the case, then the reductionist understanding of identity and individuality would be compelling independently of the development of a specific position as regards the connection between empirical evidence and metaphysical claims, and of an assessment of what the available evidence tells us about identity and

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[9] Up to section 2 of chapter 4.

individuality. However, since – as we will see - this is not the case (i.e., PII cannot be convincingly argued to be a necessary truth), the Quine-Leibniz reductionist perspective can only be based on the claim that such a view is to be preferred in the light of our actual knowledge of the world. This requires one to take into account science, which is without doubt the best candidate for defining our non-logical vocabulary, with a view to establishing at least the contingent truth of PII. The latter, in the meantime, reduces to a very general empirical, rather than metaphysical, claim.

Chapter 3 moves on to the critical analysis of the claim that the reductionist view of identity and individuality, although not inescapable, is supported by the available evidence. To this purpose, a careful examination of the properties of those that count, according to our best current physical theory about the fundamental structure of matter - that is, *quantum mechanics*-, as the basic constituents of reality is offered. First, and in most of the chapter, the dominant interpretation of quantum theory is considered. It is shown that, under this interpretation, quantum many-particle systems constitute actual counterexamples to PII, regardless of recent attempts to 'refine' PII by letting it range over irreflexive relations. Against the suggestion that, in spite of this, we should stick to PII and re-describe reality in terms of an ontology that allows for the existence of non-individuals, I argue that any attempt to do so incurs inconsistency. This entails that the reductionist view is incompatible with the available evidence, once the latter is interpreted according to the canonical quantum theory. A (more brief) consideration of Bohmian mechanics follows, which leads to quite different conclusions. Bohmian mechanics, it is explained, preserves an essentially classical ontology, with individual particles that are always discernible from each other. It is argued, however, that - there not being grounds to prefer Bohmian mechanics over orthodox quantum mechanics as the true description of microphysical reality – even if one takes Bohmian mechanics seriously it does not follow that the reductionist perspective is justified. All that one obtains is a sort of underdetermination of metaphysics by physics which is clearly less than what is required for a defence of the reductionist position.

Therefore, I suggest that the view that – contrary to the Leibniz-Quine line of argument - individuality is primitive may legitimately be preferred on purely methodological grounds.

The second part of the thesis [10] is devoted to articulating and defending this latter claim, and shifts to the level of what may be called 'real' metaphysics. I conceive of the latter as the discipline that deals not with very general empirical claims derived from science, but rather with pure conjectures about the ultimate nature of reality (albeit formulated in agreement with science). This means that the second part of the thesis is of a rather different nature with respect to the first, and should be understood as a 'positive' attempt to define an entirely metaphysically motivated account (that can *then* be shown – I will argue - to mesh well with the relevant physics).

In chapter 4, I examine whether empiricism truly demands, or strongly pushes us towards, the endorsement of the reductionist view. By establishing what a key methodological principle - known as the Principle of Acquaintance - truly amounts to once aptly re-formulated for today's needs, I end up answering in the negative. A key ambiguity exists between the sensible idea of looking at the empirical evidence with a view to *justifying* the reductionist approach to identity and

[10] Chapters 4 to 6.

individuality; and many actual cases in which the latter approach is taken for granted and consequently interpreted as *imposing* a (re-) description of one's empirical domain of inquiry in reductionist terms.

In search for an ontological account consistent with the assumption that *primitive thisnesses* must be acknowledged as real metaphysical factors determining the individuality of things, I then argue in favour of two theses: first, even though it is not necessarily inconsistent or methodologically unacceptable to hypothesise 'bare particulars' over and above the things' qualities, the traditional notion of a *substratum* should nevertheless be avoided if possible because of some undesirable characteristics it is bound to possess; secondly, similarity facts can perfectly be accounted for without having recourse to realism about universals.

In chapter 5, I analyse the resulting nominalism, and suggest that *tropes* (irreducibly individual – that is, neither instantiated nor instantiable - properties) provide the basis for a consistent ontology in which identity and individuality are explicitly posited as primitives and that, at the same time, satisfies the demands that come from a sensible empiricism. First, trope ontology is shown to be preferable with respect to what is known as resemblance nominalism. Answers are then provided to criticisms traditionally raised against such an ontology.

In chapter 6, I show that trope theory allows one to conclude that quantum particles *can* consistently be regarded as individuals. The basic tropes constituting individual particles – and, ultimately, the whole of reality - are identified (of course, fallibly) with the state-independent properties of elementary particles as these are described by the Standard Model. These properties can be the same for many particles, but this does not prevent the latter from being numerically distinct, as their individuality is rooted in the numerical uniqueness of their component tropes. The alleged problem of explaining the peculiar features of quantum statistics from an individuality-based perspective is also solved. This is done by formulating a specific ontological hypothesis with respect to the nature of the state-dependent properties of many-particle quantum systems of indistinguishable particles: these, it is suggested, are invariably emergent relations (of course, to be understood as tropes).

I conclude by pointing out the relevance of the results of the present work in relation to other areas, and possible further developments.

# *Chapter 2*

# *The Principle of the Identity of the Indiscernibles*

This chapter analyses whether a justification exists for the claim that the Principle of the Identity of the Indiscernibles is necessarily true. It does this by addressing the time-honoured issue of whether counterexamples to it are possible. I conclude that counterexamples are conceivable to all versions of PII that do not presuppose identity, including those taking into account relations determining so-called 'weak discernibility'; and that all the existing arguments intended to neutralize these counterexamples are not compelling. Therefore, there is no reason to regard the principle as a necessary truth. This leads to a consideration of the empirical evidence and of the description of reality provided by our best accredited scientific theories aimed to establishing whether PII is at least true in the actual world. This appears to entail that the investigation into the nature of identity and individuality becomes a subject to be treated from the perspective of what is known as 'experimental metaphysics'. The status of the latter discipline, and the actual boundaries between science and metaphysics, are discussed.

## *1. How to Formulate the Principle of the Identity of the Indiscernibles*

The fact that there have been heated discussions about the status of PII in analytic philosophy throughout the 20th century suggests that it cannot be straightforwardly regarded as self-evidently true.

PII is, in fact, analytically true if predicates involving identity are included in the scope of the relevant universal quantifier.[11] For example, considering 'is distinct from' as denoting a genuine property, one obtains the following:

| | | |
|---|---|---|
| 1) | $x \neq y$ | (assumption) |
| 2) | $y = y$ | (reflexivity of identity) |
| 3) | $\exists P(Px \wedge \neg Py)$ | (from 1 and 2) |
| 4) | $(x \neq y) \rightarrow \exists P(Px \wedge \neg Py)$ | (from 1, 2 and 3) |
| 5) | $\forall x \forall y((x \neq y) \rightarrow \exists P(Px \wedge \neg Py))$ | (universal generalisation on 4) |

Conclusion 5) entails the truth of PII, as it is equivalent to

$\forall x \forall y(\neg \exists P(Px \wedge \neg Py) \rightarrow (x = y))$

and thus to

$\forall x \forall y(\forall P(Px \leftrightarrow Py)) \rightarrow (x = y))$.

However, it is obvious that this amounts to cheating in the context of the present discussion. Especially in view of the fact that the endorsement of PII, as we have seen, appears subordinated to Quine's conception of '=' as a non-logical sign[12], PII cannot be used for metaphysical purposes (i.e., as a criterion of individuation) if identity is presupposed at the level of properties. In order to make PII an

[11] For PII as an analytical truth, see Whitehead and Russell's *Principia Mathematica* [1925; 57], Church [1956; 302] and Brody [1980; 6-9].

[12] Remember that, putting it succinctly, the Quine-Hilbert-Bernays conception of identity makes the '=' sign a mere shortcut for a conjunction of other formulas in which it does not appear.

informative metaphysical principle (that is, to use it for ascribing individuality in any domain in which *individuals are not already defined*), every reference to (non-reducible) identities must therefore be eliminated.

Black [1952] makes this requirement explicit. He has one of the fictional characters of his dialogue assert that if

> "you want to have an interesting principle to defend, you must interpret "property" more narrowly – enough so, at any rate, for "identity" and "difference" not to count as properties" [1952; 155].[13]

This hints at the fact that identity-involving properties must be excluded altogether, and not just as long as they refer to the entities being talked about. Define an *impure* property as a relational property whose content depends on the identity of the 'other relatum', such as, for example, that denoted by the predicate 'close to the Moon'. Two things might be made discernible by one *impure* property defined with respect to a third entity and nothing else. This would allow one to avoid circularly referring to the identity of one entity when attempting to determine that of the other (as it happens in 1) - 5) above); and yet a question would arise as to the nature of the third entity. As an example, think of two identical twins A and B (ignoring, for the time being, their different locations), only differing over the fact that A knows a third person C and B does not. Obviously, this entails that it is impossible, according to PII, for A and B to be one and the same person, since there

[13] Similarly, Ayer remarks that "if no restriction is placed upon the type of predicate to be admitted, our rule very easily becomes trivial. Thus if A is allowed to have the property of being identical with itself, it is clear that there will be at least one predicate which will not be included in any set of predicates applying to something other than A, namely the predicate of being identical with A" [1954; 29]. Later authors (for example, Katz [1983], and Rodriguez-Pereyra [2006]) refined these early claims without modifying the basic point.

is a property which makes them discernible; but the problem remains of what determines the individuality of C, which should equally be established exclusively on the basis of the thing's qualities, via PII.

To distinguish impure properties that *necessarily* involve identity from impure properties that can be 'translated into' a pure property or a conjunction of pure properties (if such properties exist at all)[14], the notion of a *trivialising* property can be usefully introduced. A trivialising property is a property differing with respect to which (while not differing with respect to anything else) would amount either to differing *only* numerically; or with respect to some relational property involving the *non-further-analysable* identity of some other entity.

To sum up: in order to be metaphysically interesting, PII must be formulated in a way in which it does not let the universal quantifier over properties range over trivialising properties too. The precise question that needs to be addressed is, therefore, whether a non-trivial version of PII can be defended as a metaphysical truth.

Katz [1983] suggests that an affirmative answer is readily found under the assumption that things may have modal properties. If this is the case, he claims, we can reason as follow:

1) Since substances (i.e., "familiar concrete objects such as material bodies, plants, animals and persons" [Ib.; 39]) are contingent entities, then for any two substances it is possible for one to exist while the other does not;

2) Therefore, if the fact that – for every possible world *w* - a substance *x* exists at *w* entails that another substance *y* also exists at *w*, and vice versa, then necessarily $x=y$;

[14] That such properties could exist is suggested by Casullo [1984], who hypothesises that the universe is constituted by a limited number of privileged particulars uniquely individuated by their properties, and all other particulars are individuated by their relations with such privileged particulars.

3) Since the property of inhabiting a possible world is not a trivialising property, then equality of all non-trivialising properties necessarily entails identity, i.e., PII is necessarily true.

At a first glance, Katz's argument appears compelling. It, however, faces some difficulties. First, even granting Katz's key assumption regarding modal properties, there is the well-known (at least since Kant's rejection of the ontological proof for the existence of God) dispute regarding whether existence is a genuine property. One might have recourse to other modal properties: for instance, it could be the case that two objects *x* and *y* are indiscernible, but *x* is white contingently, while *y* cannot possibly be of any colour other than white. However, only existence seems to guarantee the degree of generality that Katz needs; for, at least for substances defined as in 1), contingent existence appears to be the only feature that all individuals share.[15] Besides this, it is not clear why it should not be possible that in all worlds in which *x* exists *y* also does, and vice versa, without *x* being identical to *y* (as claimed in 2)): it seems in fact conceivable that two numerically distinct substances are mutually dependent on each other for their existence. Moreover, it does in fact not seem to be the case that existence in a world individuates without trivialising PII (3)). For, consider the following. According to Katz, this is a possible scenario: two substances *x* and *y* have all the same properties in the actual world *w*, but they are made discernible by the fact that *x* exists in another possible world *w'* while *y* does not. The discerning predicate is thus 'exists in world *w*'', which denotes a property of *x* but not of *y*. The essential fact about *x*, however, can be expressed,

[15] On the other hand, it appears rather *ad hoc* to assume that for any two distinct individuals (sharing all their non-modal properties) there always is *some* modal property which they do not share.

in the language of trans-world identity that Katz must accept, via the predicate '*x* in *w*' is identical to *x* in *w*'. But the latter *is* clearly an impure predicate. In particular, Katz's suggestion renders identities in a world circularly dependent on identities across worlds that presuppose them, so turning out to rely upon doubly unacceptable trivialising predicates.

In the light of these problems, the version of PII proposed by Katz will be ignored in what follows, and modal properties excluded from the range of properties the principle must quantify over (if it is to be an informative metaphysical criterion of individuation).

### *2. Leibnizian Metaphysics*

Leibniz was, as we have seen, the first explicitly to formulate PII. He took it for granted that different individuals exist at different space-time locations and have different relations with other entities, but denied that their *monadic intrinsic* properties can all be equal. This is commonly defined as the *strong* version of PII. A classic statement of this view is in Leibniz's correspondence with Clarke:

> "There is no such thing as two individuals indiscernible from each other. An ingenious gentleman of my acquaintance, discoursing with me, in the presence of her Electoral Highness the Princess Sophia, in the garden of Herrenhausen; [*sic*] thought he could find two leaves perfectly alike. The Princess defied him to do it, and he ran all over the garden a long time to look for some; but it was to no purpose. Two drops of water, or milk, viewed with a microscope, will appear distinguishable from each other" (quoted in Wiggins [2001; 62]).

The reason for this, according to Leibniz, is that:

> "It is always necessary that beside the difference of time and place there be internal principles of distinction [...;] thus, although time and place serve in distinguishing things, [...t]he essence of identity and diversity consists [...] not in time and space" [Ib.].

To support this metaphysical view, Leibniz presented (often implicitly within a larger context) several arguments, based on a number of different assumptions. The most renowned of these arguments in favour of PII unites theology and metaphysics in a way that is analogous to Leibniz's reasoning in favour of a relational view of space-time. In his exchange with Clarke, Leibniz states:

> "When I deny that there are two drops of water perfectly alike, or any two other bodies indiscernible from each other, I do not say it is absolutely impossible to suppose them, but that it is a thing contrary to the divine wisdom, and which consequently does not exist" (see the 'Fifth Paper' in Alexander [1956; 55-97, Sec. 25]).

The reasoning underlying this conviction can be summarized as follows:

1) There is a reason why God creates what he creates (*Principle of Sufficient Reason*);
2) The actual world was created by God because it is the best possible world (this is often referred to as the *Principle of the Best*);
3) Two qualitatively identical worlds are such that neither is better than the other;
4) Therefore, there was no possible world qualitatively identical to the actual world among the alternatives God could choose from;

5) If a world contains indiscernibles there is another possible world which is qualitatively identical to it (by definition of indiscernibility and possibility of quality-preserving permutations of distinct individuals);

6) Therefore, the created world does not contain indiscernibles.

Looking at this argument one can, first of all, see that it is only valid if a qualification is made to premise 2), to the effect that being the best entails *uniqueness.* For otherwise premise 4) does not follow and can perfectly be replaced with the claim that, if there was a possible world qualitatively identical to ours, then that was actualized by God as well. This would then entail that, if there are indiscernibles in this world, another world qualitatively identical to it has indeed been created by God. And so the non-existence of indiscernibles would not be established. While it is not obvious what 'best' means in this context, or even what it must be taken to mean in general, if it is understood as 'richer with respect to qualities and their degrees' (with 'bad' properties intended only negatively as lack of certain qualities), then surely uniqueness is not established. One might suggest that Leibniz is claiming that the existence of two distinct but indiscernible entities would violate God's perfection, requiring the above maximum variety with the *greatest economy* in what is created. The best world would, according to this perspective, be the one with the widest range of qualities and the smallest amount of 'stuff'. However, it is not obvious that, given the degree of variety that obtains in a world with a certain number of indiscernibles, an equal amount can obtain in a world without indiscernibles; namely, it is impossible to exclude *a priori* that at least certain qualitative features of the world entirely depend on facts exclusively regarding the number of certain entities. On the other hand, if one understands God's aiming to have the most economical universe as requiring that only one world is created, then it is unclear why God could not simply have chosen to create only one of two equivalent worlds (with indiscernibles in it). To reply that this is because then God would not have had a reason on the basis of which to make the choice would only succeed in pointing out a conflict between the requirement of economy and the Principle of Sufficient Reason.

Another argument in favour of PII that can be traced in Leibniz's writings is based on his idea of a 'complete notion of individual'. In every true affirmative proposition, according to Leibniz, the notion of the predicate is contained either explicitly or implicitly in that of the object (if it is contained explicitly the proposition is analytic; if only implicitly, it is synthetic[16]). In close connection to this, Leibniz claims that every substance has a notion so complete – it includes everything that is needed to establish what is true of it at any point in time - that anyone who fully understood it could infer from it all the predicates, down to the smallest detail, which belonged, belongs and will ever belong to that substance. In section 9 of his *Discourse on Metaphysics*, Leibniz [1686(1992)] derives from this that no two substances are exactly alike in all their predicates, arguing that every individual always possesses a 'core' of predicates sufficient to distinguish it from every other individual, actual or possible. This argument, although it seems quite different from the previous one, is clearly equally based on questionable metaphysical assumptions. First, it rests on the specific Leibnizian view – clearly connected to his idea that all substances are self-contained 'monads' - that everything true of an individual, even if it is a contingent truth

[16] However, even though he distinguished truths of reason and truths of fact, Leibniz thought that all truths are analytic because reducible to statements of identity, and that the only differentiation is between different levels of epistemic access to them.

about the future, is present in the latter as a sort of 'eternal' intrinsic property. More importantly, the idea that only one substance corresponds to each complete notion is in fact derivative on the ideas about God and creation just discussed. Leibniz's contention is, in particular, that every substance is the actualisation of a concept that exists complete in the mind of God and, as such, it mirrors the entire structure of the world *in a unique (and a-temporal) way*. It is obvious, though, that the claim of uniqueness once again needs a justification; with this, one is led back to the question of why exactly God's features should make the creation of indiscernibles impossible: why, in this case, could one complete concept not be actualised twice?[17]

These considerations are by no means presented as conclusive, nor is the description of Leibniz's arguments intended to be exhaustive. The foregoing discussion was exclusively meant to show that Leibniz's reasons in favour of PII are certainly not sufficient for settling the dispute this thesis deals with. These reasons are far from compelling, I argued, independently of the specific nature of the assumptions they rest upon. But, of course, Leibniz's justification of PII is *crucially* based upon metaphysico-theological principles (some of these explicitly stated by Leibniz, others remaining more in the background) that are by no means straightforward and uncontroversial.

We therefore need to look elsewhere for a justification of PII as a necessary truth.

[17] For a discussion of Leibniz's complete notion of an individual, see Broad [1949].

### *3. The Identity of the Indiscernibles and the Bundle Theory*

A well-known, and much more relevant, argument for the necessary truth of PII is based upon a specific ontological conception of reality known as the *bundle theory*. It goes as follows:

a) Things are bundles of properties and nothing else;

b) The properties of things are instances of universals;

c) Universals are multiply instantiable, i.e., they are numerically identical across their instances, in the sense that it is literally the same entity (the universal) P that exists at each location in which the property P is exemplified;

d) Therefore, two things with the same properties are necessarily numerically the same: that is, PII is necessarily true.[18]

Given premises a), b) and c) together, the argument appears valid, and conclusion d) follows deductively. Yet, in spite of a widespread belief, this is by no means obviously the case.

Rodriguez-Pereyra [2004], for example, contends that the bundle theory *can* be understood as the claim that whenever a property is instantiated, two things exist: a universal *and* one of its instances. This, explains Rodriguez-Pereyra, allows one to claim that the bundle theory is compatible with the existence of numerically distinct indiscernibles: the unique identity of each one of two qualitatively identical bundles might be brought about by the instances that exist in them, that are ontologically distinct from the corresponding universals. This view, although it seems to amount to the endorsement of traditional realism *along with* the – essentially nominalist - idea that property-instances

[18] Although it is not necessary to endorse the realist view of universals expressed in b) and c), and the latter doctrine is logically independent of the thesis in a) (the bundled properties might not be universals), the expression 'bundle theory' is commonly intended as referring to the combination of these three assumptions.

possess their own numerical identity, is no doubt consistent. For nothing in the definition of a universal rules out the possibility that, by being instantiated, a universal determines the creation of a distinct entity endowed with primitive identity.

Loux's [1978] *substance ontology* can also be interpreted as a rejection of conclusion d) that does not imply a departure from the essential tenets of the bundle theory. This is achieved by modifying premise c). According to Loux, every individual is a bundle of instances of universals, but traditional bundle theories fail to appreciate that – in every substance - one of the bundled universals is a peculiar 'substance-kind' universal, determining what type of entity the individual is. On the basis of some passages in Aristotle's *Categories*, Loux claims that, contrary to what normally happens for universals,

> "in the case of substance-kinds, there is no alternative to construing instantiations of each universal as numerically diverse" [Ib.; 161].

So, for example, each specific instance of the universal 'manhood' – by being numerically distinct from all other instances of 'manhood' – makes a person the unique human being s/he is.

There seem to be some difficulties for this position. In particular, Loux must explain why substance-kinds are said to be universals and yet they are not numerically identical across instances, which is the distinctive feature of universals. Moreover, Loux is committed to realism about natural kinds. And even granting him this, he must provide a reason not to believe that natural kinds are reducible to sets of properties, that is, to 'traditional' universals. This would allow one to do away with substance-kind universals altogether, so leading to the dissolution of Loux's hypothesis concerning the identity of substances.

At any rate, Loux's substance ontology, whatever its weaknesses, is another example of the possibility of endorsing the (basic axioms of) the bundle theory without also automatically endorsing PII as a necessary consequence of it.

Loux's concept of a substance-kind universal is related to another view that is relevant in this sense: *moderate realism.*[19] According to moderate realists, *every* universal-instance possesses *two* ontological aspects – one repeatable and one non-repeatable - *at the same time.* With this, they claim to account for both individuality - by taking properties as particularized instances each one of which is numerically different from all other instances - and similarity - by assuming the ontological reality of universals. This appears to imply that PII is not true in a moderate realist ontology, as the unique identity of each instantiated property necessarily 'propagates', so to speak, to the bundle it belongs to.

This view also surely meets with problems, as can be shown by briefly examining the most fully worked out version of moderate realism, namely Mertz's (see his [1996] and [2003]). Mertz claims that his is a

> "realist ontology of unrepeatable unit attributes [...in which the existence is postulated of] individuated relation (including property) *n*-adic instances $R^n_i$, $R^n_j$, $R^n_k$,..., together with sharable *n*-adic intensions (universals) $R^n$, the latter being constituent qualitative aspects numerically the same across their like instances and separable only in abstraction" [2003; 128-129].

[19] Moderate realism was initially – in the Middle Ages - the thesis that universals exist only in the mind of God, as patterns by which he creates particular things. St. Thomas Aquinas and John of Salisbury were proponents of such a view.

Setting aside the fact that Mertz takes relations to be basic, and monadic properties to be limiting cases of the former, his claim must be emphasised that universal natures are *real qua intensions* that 'connect' all *their* instances as actual entities. [20] How can this be possible? Intensions do not exist 'out there'. Mertz himself says that every property-instance

> "is a simple entity with the two abstractable aspects of repeatable intension [...] and a particularized unifying agency" [Ib.; 142],

with which he seems to acknowledge that the distinction between particular property-instances and unifying intensions is purely conceptual. And hence to point towards nominalism. On the other hand, if Mertz explicitly 'reified' intensions, then moderate realism would collapse into traditional realism. It therefore seems that moderate realism represents an untenable middle ground between nominalism and full-blown realism.

At any rate, despite the reservations one may have with respect to Mertz's position and moderate realism about universals in general, the view just discussed seems to represent one further conceptual possibility showing that PII is not straightforwardly *implied* by the bundle theory.

The Leibnizian-Quinean supporter of the reductionist understanding of identity and individuality must therefore endorse the bundle theory in

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[20] In more detail, Mertz seems to suggest that the unrepeatability of each particularized property follows from its being instantiated in a specific bundle rather than another. This, however, appears circularly to connect the identity of the bundle being constituted to that of the instances of properties constituting it. One possible amendment might be that it is the *act of instantiation* that gives numerical identity to instances of universals. This would give specific identities to all property-instances without violating the spirit of the bundle theory. Besides the fact that this interpretation does not appear to be supported by what Mertz actually says, it looks as though it would entail that universals exist in a sense different from their instances, and ultimately lead to traditional Platonic realism. At any rate, there is no need to discuss the details of Mertz's proposal any further here.

its traditional formulation, explicitly excluding any variation and/or addition to it along the lines just considered (the shortcomings that I emphasised in the alternatives - ontological inflation in Rodriguez-Pereyra's proposal; *ad hoc*ness in Loux's; inconsistency in Mertz's - might indeed represent a good reason to do so). In the rest of this chapter, the 'canonical' bundle theory - and PII as a natural consequence of it - will indeed be taken for granted. But before assessing whether or not PII (so provisionally justified) is a compelling principle, more will be said on its exact formulation.

Leibniz, as we have seen, committed himself to the strong version of PII, excluding spatial location (and relational properties) from the scope of the universal quantifier over properties appearing in the principle. Once Leibniz's peculiar reasons for rejecting the possibility of equality of all monadic and intrinsic properties are dropped, however, *weak* PII presents itself as more plausible. That is, a version of the principle that also quantifies over locations and relational properties, so allowing (most notably) for otherwise qualitatively identical things made numerically distinct by the fact that they exist at different places.

O'Leary-Hawthorne [1995] interestingly suggests that the bundle theorist should instead embrace *strong PII without interpreting it as ruling out the possibility of indiscernibles.* O'Leary-Hawthorne argues that, exactly as one single universal can exist at many places, so can a bundle of universals. Hence, the repeatability of universals does not prevent, but rather gives rise to the possibility of, indiscernibility. In particular, if – as contended by many realists about universals -

universals are *immanent* (that is, they exist in space and time only)[21] and are capable of existence in many places at the same time, then:

> "The following possibility is a very genuine one: There is a bundle *F, G, H* five feet from itself and nothing else" [1995; 193].[22]

In a [1998] paper co-authored with Cover, O'Leary-Hawthorne elaborates on this and adds that ordinary people do not count by *strict* metaphysical identity, only based on bundled universal-instances; but by what he calls *loose* – or *folk* – identity, which takes location as an individuating factor when, strictly speaking, it is not. He suggests that the bundle theorist's claim that PII is necessarily true is only at odds with the latter [Ib.; 212-217], but what counts from the ontological point of view is the former.[23]

Presumably, the central assumption about location is made on the basis of the fact that the spatial location of a bundle is not a *constituent*

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[21] For more on this definition, that of *in rebus* universals – to be introduced shortly – and related ones, see chapter 4, section 4.

[22] This scenario is O'Leary-Hawthorne's reconstruction of the hypothetical universe that Black [1952] presents as a counterexample to PII and that will be discussed in the next section. Vallicella [1997] objects to O'Leary-Hawthorne that it is, in general, not straightforward that what is true of universals is true of bundles of universals (to take this for granted would be an instance of the 'fallacy of composition'). And that in fact, while universals get instantiated, bundles cannot, for they are particulars and particulars - by definition - do not get instantiated. Moreover, Vallicella adds, a bundle cannot be a universal, because being instantiated requires the ability to be "bundled together with other universals. But it makes no sense to suppose that [...a bundle...] is bundled together with other universals. [...] Since every bundle is complete, no bundle can be bundled together with other universals not in the bundle" [Ib.; 94]. This is substantially correct, and yet there is an easy way round Vallicella's objection: one can accept that it is universals that get instantiated, and add that if, say, a universal A can be instantiated at locations $x$ and $y$ at the same time, so can another universal B; and since it can consequently happen that both A and B get instantiated at both $x$ and $y$, the possibility of two indiscernible 'AB-individuals' (only differing in position) is *ipso facto* obtained.

[23] It seems clear that O'Leary-Hawthorne's strict identity is that defined via strong PII, while what he calls loose identity corresponds to weak PII. Of course, it is being assumed (contrary, for example, to Teller [1987] and Dieks [2001]) that space-time location is not a monadic intrinsic property (according to Teller and Dieks, supervenient on the other physical properties of things).

of that bundle. However, although it is not a component part of the entity composed by such-and-such instantiated universals, location appears essential for the determination of the bundle of those universals as *that* entity. It is indeed a common claim of realists about universals that the instances of a universal are made distinct by their different locations. Therefore, contrary to what O'Leary-Hawthorne suggests, spatial position cannot be ignored when it comes to evaluating the entity's individuality, and especially so in the *in rebus* form of realism embraced by O'Leary-Hawthorne. Not surprisingly, a distinction between 'proper' metaphysical counting and 'folk' counting has not been advocated by anyone else.[24]

In the light of the discussion in this section, it can thus be concluded that the reductionist who intends correctly to account for the dynamics of individuation has to endorse the 'traditional' bundle theory and *weak* PII. The question arises at this point of whether this form of PII is necessarily true.

### *4. Counterexamples*

The reasoning intended to support the Quine-Leibniz reductionist view of identity and individuality on the basis of (traditionally intended) bundle theory and weak PII can be (and has been) questioned via alleged counterexamples. The idea is that if a state of affairs in which PII is not true - that is, a state in which numerical distinctness is not accompanied

[24] One might object that, if space-time points were individuals primitively, location would be a trivialising property and the endorsement of PII illegitimate. Apart from the fact that this would not justify O'Leary-Hawthorne's differentiation (for he does not present his views on the basis of this consideration, and in fact suggests that space and time themselves can be reduced to universals), it seems fair to say that to admit of the primitive identity of space-time points is a far cry from giving up the bundle theory and PII altogether. In fact, it only entails that PII cannot be employed to individuate the (bare) space-time points that individuate bundles of universal-instances.

by discernibility with respect to any (non-trivialising) property including space-time location - can be consistently conceived, then PII cannot be considered as a valid criterion of individuation.

The *locus classicus* in this respect is Black [1952]. Black constructed a thought experiment involving a completely symmetric universe in which there are two numerically distinct spheres having all the same monadic properties and nothing else. Moreover, whatever can be predicated of one sphere which is not an intrinsic property is necessarily a property the sphere possesses *in relation to the 'other' sphere*; but if any such relation must be expressed – as required in order to avoid trivialization - completely in descriptive terms, then the spheres' relational properties are also equal [Ib.; 156]. In particular, spatial position, says Black [Ib.; 157-158], must be defined in relational terms because only the two spheres exist, and no absolute space-time has been posited. But *both* spheres have the relational property of being a certain distance away from a sphere with such-and-such properties.[25] In this hypothetical universe, therefore, PII appears to be violated in both its strong and weak form, as that *one* sphere is distinct from *the other* sphere seems to be a primitive fact not grounded in qualitative differences.

Ayer [1954] proposed a similar argument, based on the idea of an infinite series of equal sounds succeeding each other at equal intervals. It looks as though there exists no non-trivial individuating property in this scenario either. In particular, each sound possesses unique relational properties describing its distance in time from the other sounds (these determine that, for instance, sound *a* occurs later than sound *b* with respect to sound *c*, and so *a* and *b* are *prima facie* distinct sounds). However, these properties only individuate trivially, as they presuppose

[25] This does not mean that it is arbitrarily assumed that space-time relationalism is true *in general*.

the identity of at least one sound (in this case, *c*). It is clear that Ayer's world is the diachronic analogue of Black's, and equally suggests that in fact identities 'come first'.

Adams [1979] contemplates a slightly different possibility, based upon the tiniest qualitative difference (in a non-essential property) between numerically distinct individuals. He asks the reader to think about two nearly identical individuals, only rendered discernible by a minuscule qualitative difference. The latter might be, for example, a small chemical impurity in one of the spheres in Black's world. The reductionist will certainly accept that in such nearly symmetric scenarios one has two entities. But then, asks Adams, why should we exclude non-identity in cases of perfectly symmetric universes with indiscernibles? After all, it is conceivable that the difference disappears as time goes by. Should we think that this would make the two entities become one?

Adams' argument is useful in that it helps see the counterexamples to PII as limiting cases in a continuum of universes whose existence is not at any point deemed impossible by the reductionist. However, it is also clear that the supporter of PII might legitimately claim that a perfectly symmetric universe such as Black's exhibits a crucial feature that nearly symmetric ones such as Adams' do not have and that makes the former impossible: namely, indiscernibility.[26]

In the remainder of this section, Black's traditional counterexample, considered by some to be a clear demonstration of the failure of PII[27], will be analysed.

First of all, must one accept Black's scenario?

[26] See also Bergmann [1947], who presents a 'bundling problem' allegedly showing the inconsistency of Russell's 'particular-free' (that is, only based on universals - as corresponding to our sense data -) analysis of reality.
[27] See for example Denkel [1991], who claims that "there is good reason for saying that the well-known counterexample by Max Black has established the failure of Leibnizian principles of individuation conclusively" [Ib.; 214].

Odegard [1964] argues not. Understanding Black's argument as an attempted *reductio ad absurdum* of PII, Odegard claims that Black unwarrantedly assumes the two spheres to be distinct individuals. Despite the supposed absolute indiscernibility of the spheres, that is, Black refers to them as two. However, this implies that it should be possible to distinguish *this* sphere from *that* sphere independently of their properties; but such 'labelling' is, in fact, not allowed due to the very indiscernibility condition that must be assumed in order for the *reductio* to be attempted. The

> "successful use of different names [or, at any rate, demonstratives] in this case presupposes the possibility of qualitatively distinguishing the given particulars, i.e., the possibility of saying truly 'A is *the* particular which...' and B is *the* particular which...' And, *ex hypothesi*, there are no possible grounds for so distinguishing them" [Ib.; 205].

In a nutshell, the counterexample seems to work only because it is a *petitio principii*.

However, it is possible to reply to Odegard that Black does not present an alleged *reductio ad absurdum* of PII, but rather constructs *ex novo* a universe the conceivability of which shows that PII is not a compelling principle.

Tackling the issue from another perspective, Hacking [1975] (re-) interprets Black's world as one in which there is only one sphere in a non-Euclidean space. In a closed and curved universe, he argues, it is possible for a sphere to be at some distance from itself (in other words, non-zero distance becomes a reflexive relation, as a straight line departing from *x* could end up getting back to *x* itself). Therefore, it could be the case that exactly the same qualities as in Black's universe are instantiated, and yet only one sphere exists. Generalizing, it is always an option for the reductionist to reject suggested counterexamples to PII and systematically claim that the alleged description of a universe with indiscernibles is in actual fact a misdescription of a universe without them.

In other words, while Odegard questions the legitimacy of Black's hypothesis, Hacking suggests that it can at any rate be reinterpreted in agreement with reductionism. Hacking's argument might appear not entirely convincing, as counterexamples to suggested thought experiments should not be based upon substantive additional, or at any rate dissimilar, assumptions - in the present case, regarding the topology of space - with respect to those originally made.[28]

Even accepting Odegard's and Hacking's arguments, at any rate, if the only problem with Black's argument is that it does not *force* us to reject PII, but only identifies ontological constructions in which the principle is not true, then Black could indeed be considered successful in showing that PII is not *necessarily* true, but only such that it resists counterexamples *once it is assumed as a basic truth.* The question remains unanswered, however, of what should be regarded as more fundamental between PII and primitive identity.

At any rate, one does not need to bother with this philosophical *impasse* too much, or at least not yet. For the real issue regards whether Black's counterexample works at all. When presented with it, probably everybody has (like Odegard and Hacking) the feeling that something is tacitly 'smuggled in' in an illegitimate way. And indeed the mentioned critics of Black, although not completely successful in their objections,

[28] In Hacking's case, one might say that its space(-time) structure should be taken as part and parcel of the identity of a possible world, so that changing it means not to be talking about the same world anymore.

are correct in calling attention to the fact that something other than the existence of two spheres is essential for Black's counterexample to work. This something, in particular, has to do with the status of the *spatial relation* holding among the spheres.

Casullo [1982] provides a persuasive way to begin to see what this something is, and where the alleged counterexample fails. In order to establish the conceivability of some thought-experimental scenario (for which there does not exist a justification purely based on logic), Casullo claims, one can only apply a 'psychologistic criterion' based upon visualizability. To visualize something such as Black's universe as possible, he explains, means to picture in one's mind two spheres as distinct. However, this necessarily amounts to picturing the spheres as being located in different parts of the visual field, which is already enough to reject Black's argument. In Casullo's words:

> "In order to visualize two spheres, one must visualize them as occupying two different positions in the visual field. But if they occupy different positions in the visual field, then they differ in their positional qualities and, hence, do not have all qualities in common. Black's claim that we can imagine two spheres with all qualities in common is mistaken because of his failure to notice the difference in positional qualities" [Ib.; 600].[29]

What Casullo claims is, in effect, that the spheres are numerically distinct but also discernible, although in a way that we are unable to express via the predicates we (normally) consider.

Reflecting on the 'difference in positional qualities' that Casullo talks about, the doubt arises that there may be other predicates that should be

[29] Notice that Casullo is not illegitimately adding 'symmetry-breaking' observers to the universe envisaged by Black, but rather questioning its conceivability.

taken into account and that, consequently, perhaps *the weak and strong formulations of PII do not capture all possible qualitative facts about things.* Is it the case that some other formulation of PII is available, capable of accounting for Black's universe as a universe with two entities in it?

### *5. Weak Discernibility, and a Further Version of the Principle of the Identity of the Indiscernibles*

A positive answer to the question concluding the previous section can be given if one follows certain Quinean reflections on discernibility that have been (re-)discovered only very recently (thanks to Simon Saunders).

Quine [1976] explains that what he calls *strong* and *moderate discriminability* are not in fact the only possibilities, and one must also contemplate one further alternative, namely, *weak* discriminability.[30]

Strong discriminability, Quine explains, holds of an entity when it is the only object that satisfies a conjunction of open sentences in a given interpreted formal language. Moderate discriminability amounts, instead, to there being an open sentence in two variables that is satisfied by two objects in one order but not in the other. Taking every formula satisfied by one entity as denoting a monadic property of that entity, strong discriminability entails identifiability via strong PII. Regarding instead sentences in two variables as corresponding to relational properties, one can claim that if two entities are moderately discriminable then they differ in some relational – perhaps spatio-temporal - property, so requiring weak PII for their individuation. For example, in a very simple

[30] Quine uses the word 'discriminability' rather than 'discernibility'. Since Quine deals with formulas in a language rather than properties in a world, one might see the former as applying to individuals at the linguistic level, and the latter as referring to real entities.

world with two entities *a* and *b* and two properties P and Q only, and in which it is the case that P*a*, P*b*, Q*a* and ¬Q*b*, *a* and *b* are strongly discriminable. For, *a* uniquely satisfies the conjunction P*x*∧Q*x*, and *b* the conjunction P*x*∧¬Q*x*. A case of moderate discriminability is, instead, the holding of an asymmetric relation R between two entities. If *a*R*b* but ¬*b*R*a*, the open sentence *x*R*y* is satisfied by *a* and *b* in one order only.[31] In both cases, the antecedent of PII is false.

However, says Quine, it is also possible that two objects satisfy a sentence that has *x* and *y* as

> "sole free variables and yet [...is not equivalent to...] the conjunction of two sentences that have [...*x* and *y*...] respectively as sole free variables" [Ib.; 114].

This is what Quine calls weak discriminability. Quine explains that it occurs when the relevant sentence is *reflexively false of one of the objects*. In his general and abstract treatment, Quine does not enter into a detailed discussion of predicates. However, it seems fair to ask how it can be possible that a predicate that does not apply reflexively to an object does apply reflexively to another object. It is, instead, easy to see that Quine's notion of weak discriminability applies in the case of sentences expressing *irreflexive relations*, such as, for instance, '...goes in the opposite direction to...'. For relations of this type, Quine's condition for weak discernibility clearly applies, as the open sentences in two variables

[31] Of course, if the asymmetric relation is supervenient on intrinsic properties, the open formula in two variables is in effect derivative on two open formulas in one variable only that are already sufficient for strong discriminability. However, relations need not necessarily be supervenient, so moderate discriminability must be distinguished from strong discriminability. Also, the connection between moderate discriminability and weak PII requires one to change the discriminating asymmetric *relations* into *relational properties*. This is readily achieved by making the reference to the *relatum* 'internal' to the predicate so that, for instance, *x*R*y* is expressed as P*x*. This appears to be an unproblematic move here, but is connected to an important ontological distinction to be made explicit shortly.

that express them are not satisfied by two objects only in one order; and they are not the conjunction of two sentences that have one of the two variables as their sole free variable; and yet it seems obvious that there must be two distinct objects. Indeed, although in a way that is not entirely faithful to Quine's original work,[32] weak discernibility is generally regarded as based on the holding of irreflexive relations.

Since irreflexive relations are the sort of properties that (as we will see) turn out to be relevant for our discussion, for simplicity's sake (and without any explanatory loss) weak discernibility will indeed be understood in what follows as consisting of the fact that an irreflexive relation holds among two entities *x* and *y* in such a way that the sentence in two variables corresponding to it is satisfied by *x* and *y* together but not by either *x* and *x* or by *y* and *y*.

With this definition in mind, we can now look back at the alleged counterexamples to PII. As regards Black's spheres, we have seen that they are neither strongly nor moderately discernible, as they have all the same monadic and relational properties. However, they are weakly discernible, as there exists a discerning relation holding between them: as explained by Saunders ([2003] and [2006]), the latter is an irreflexive spatial relation, determining that each one of the spheres is at a certain distance from the other *but not from itself*.[33] It thus turns out that the notion of weak discernibility makes PII immune to the traditional counterexamples to the principle.

[32] In his paper, Quine himself clarifies that the holding of an irreflexive relation is not equivalent to the more general condition he defines.

[33] One might object that Hacking's criticism still holds: if the universe is curved and closed then relations of distance in space-time are (or, at least, can be) reflexive. Generalizing, irreflexivity may be said to be context-dependent. The point, however, is that *if* an irreflexive relation holds, then *some* form of PII applies; and that, in Black's case, if the spheres are two as presented, then an irreflexive relation does hold between them.

Quine's notion of weak discriminability allows us, more specifically, to formulate a version of PII that is weaker than both strong and weak PII as it individuates certain entities that the other forms of PII fail to individuate. What I will call *very weak* PII can be formulated as follows: $\forall x \forall y((\forall P(Px \leftrightarrow Py) \wedge \forall R \neg(R(x,y) \wedge \forall z \neg(R(z,z)))) \rightarrow (x=y))$.

Before moving on to a consideration of whether counterexamples can be devised against this version of PII, it is necessary to say something more about the ontological significance of weak discernibility. In particular, why is the holding of an irreflexive relation sufficient for discernibility, while the possession of a relational property expressing the same fact is not? After all, in Black's case we seem to point to exactly the same states of affairs when we attribute to a sphere the relational property of being, say, two miles away from a sphere with such-and-such properties; and when we claim that the relation of being two miles away from holds between one sphere and 'another' sphere. The key difference has to do with *ontological dependence*: the attribution of a relational property requires the presupposition of a specific entity exemplifying that property (or, in bundle-theoretic terms, that is constituted by that property – together with others) and of another relatum.[34] A relation, instead, does not 'belong to' any specific entity. As a consequence, it can be regarded as *ontologically prior to* its relata and, if irreflexive, as *determining* them as numerically distinct entities.

Indeed, it is exactly the idea that relations (can) *determine*, rather than *depend on*, the existence of their relata as numerically distinct entities that sidesteps the objection to PII that Black's spheres must be assumed as distinct in spite of their indiscernibility. More generally, it is this specific ontological presupposition as to the nature of relations that

[34] This is why, as pointed out in footnote 31, the relation can be reduced to a relational property if the individuals (the bundles acting as relata) are already there.

makes weak discernibility possible and distinct from other forms of discernibility.

The bundle theorist who wants to claim that entities can be merely weakly discernible is therefore committed to a specific ontological thesis about existential dependence. Similarly to what happens in the context of structuralism, s/he must deny that the fact that – at the level of semantics – we define *n*-place relations as particular sets of ordered *n*-tuples of individual entities has any ontological import (to the effect that individuals are more basic than relations). Instead, s/he holds that (at least in some cases) individual objects are wholly determined by relations, in the sense that the latter are prior to the former, and individuals are 'created' as those entities which occupy unique positions in relational structures.[35]

These claims are notoriously far from unproblematic.

Russell, for one, argued (against Moore) that particulars must exist over and above universals because there are certain relations entities cannot have to themselves [1911; 118] and presuppose relata. In the 1960s, Allaire ([1963] and [1965]) argued similarly for the existence of bare particulars, while others (Chappell [1964], Meiland [1966]) objected that relations can individuate and so there is no need to postulate anything over and above the qualitative aspects of things. In general, as also witnessed by the debate concerning mathematical structuralism (into the details of which we need not enter, but which has some interesting analogies with the issues being dealt with here)[36], that relations have the power to individuate surely is a controversial and disputable claim.

[35] MacBride [2006] talks of *predicatively* versus *impredicatively* constituted objects, where in the former case relations presuppose relata, while in the latter they do not.
[36] It is interesting to notice, in particular, that a recent debate concerning the viability of mathematical structuralism concerns exactly the notion of weak discernibility. Burgess [1999] and Keränen [2001] object to structuralism about mathematics that if objects are to

Granting the supporter of PII weak discernibility, however,[37] let us now consider the possibility of counterexamples to PII again in the light of the foregoing discussion.

## *6. Working Counterexamples?*

It is worth noticing that, while making the shortcomings of Black's argument explicit, a consideration of weak discernibility also provides the key to improving on that argument.

The way to do this is, obviously enough, by construing a universe like Black's in which, however, the assumption of spatial separation is substituted with one of mutual *interpenetration* with *complete overlap.* That is, a universe with two identical and *exactly coinciding* spheres. Since the two spheres in Black's universe only differ in virtue of the fact that the irreflexive relation of being at a (non-zero) distance from holds between them, in a universe in which otherwise qualitatively identical spheres occupy exactly the same location these are not even weakly discernible (as the distance relation becomes reflexive).

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be individuated on the basis of inter-structural relations, then objects occupying structurally indiscernible positions should be deemed identical; but entities that we take as distinct, such as any complex number and its conjugate, are structurally indiscernible. Ladyman [2005] invokes the notion of weak discernibility to maintain that this is not actually the case, as each complex number is related to its conjugate by an irreflexive relation. Ketland [2006] replies that identity is in fact presupposed; and that, at any rate, counterexamples can be found to the claim that all structures are such that distinct individuals are at least weakly discernible (see his 'dumb-bell' structure [Ib.; 309-310]). Ketland consequently claims that the existence of what he calls 'non-Quinian' structures shows that a reductionist analysis of identity is "mathematically unworkable" [Ib.; 312]. The example of mathematics is especially interesting from the present perspective because it looks as though in the case of mathematical objects counterexamples cannot be rejected as artificial, purely hypothetical, or based on postulates that need not be accepted. See also Bermudez's critique of Ketland [2007] and Ketland's reply [2007].

[37] Not only is it not my intention here to get into a discussion of structuralism; ontologically speaking, that relations are (at least in some cases) prior to their relata appears to be a perfectly consistent position that cannot be discarded *a priori.*

Clearly, in order for this updated counterexample to PII to work, it must be possible for more than one object to exist at any one location. But this does not seem to be a problematic assumption to make. Even though this might be disputed in the light of our everyday experience, it is surely true that impenetrability does not necessarily hold for all entities. Moreover, as we will see, not only is not impenetrability a metaphysical axiom in any sense; it is also explicitly violated by particles as they are described by our best theory about (the ultimate constituents of) the physical world, namely quantum mechanics.

While this might appear sufficient conclusively to reject the idea that PII is a necessary truth, a possible rejoinder remains available for the supporters of the principle. Della Rocca [2006] claims that the consideration of complete overlap is exactly what provides the opportunity to show

> "that the opponent of PII is committed to a kind of brute fact that all of us would or should find intolerable" [Ib.; 485].

And that, consequently, PII 'wins by elimination', as the alternative view – negating it in favour of primitive individuality – turns out to be unacceptable. What is the 'intolerable brute fact' that Della Rocca has in mind?

Della Rocca asks the reader to consider the possibility of 20 indiscernible spheres, existing exactly in the same place at the same time, and *with all the same proper parts*. This scenario violates a shared conceptual truth to the effect that it is not possible for distinct entities to occupy precisely the same location and have all the same parts. However, Della Rocca argues, if PII is discarded it would appear that nothing stands in the way of attributing individuality to each of the 20 putative spheres.

The reason for this claim is as follows. In order to avoid the patently counterintuitive possibility just described, the opponent of PII has to explain how s/he is supposed to reject completely overlapping indiscernibles only in the case in which they share all the same parts. Referring to simplicity, Della Rocca explains, does not do, for it is unclear why simplicity is not invoked in other cases; for instance, in the case of Black's universe, to claim that there exists only one sphere.[38] What Della Rocca calls the 'defeatist' answer – amounting to the claim that there simply is no explanation for why the suggested scenario appears intuitively unacceptable – is also unsatisfactory, as it adds to the primitiveness of identity and individuality another allegedly fundamental and non-further-explicable fact about things. Della Rocca goes on to suggest that the only thing that the adversary of PII can say is that:

> "Partial overlap is OK because it allows for an explanation of non-identity; complete overlap is not because, in that case, non-identity would be inexplicable" [Ib.; 489].

In other words, partially overlapping entities maintain (more or less) clear identity conditions that allow us to account for their numerical distinctness. In the case of completely overlapping entities, instead, their being numerically distinct appears entirely mysterious. So much so, that we exclude this possibility as inconsistent entirely *a priori*.

Unfortunately for the defender of primitive individuality, says Della Rocca, to follow this route amounts to acknowledging that claims of identity and distinctness actually *do* require an explanation, which is exactly what the opponent of PII wanted to deny. It looks as though if

[38] This is interestingly related to Hacking's reconstruction of Black's universe.

PII is not an option one must appeal to the principle that there can be no brute individuation in order to defend the position that there is brute individuation. This manifest circularity can only be avoided by accepting the possibility of numerically distinct indiscernibles sharing all their parts. Since we do not want to accept such a possibility, Della Rocca concludes, the foregoing considerations show that PII must be endorsed.

Della Rocca's argument is interesting, I believe, but there are ways to respond to it. The main point that can be made against it is that rejecting PII while subscribing to the mereological principle that things with exactly the same parts are the same thing (one might call this the *Principle of the Identity of the Equicomposed Entities* (PIEE)) is in fact a perfectly viable option. It provides a satisfactory explanation of why we want to exclude *a priori* possibilities such as that presented by Della Rocca, and does not necessarily represent a less appealing perspective with respect to the reductionist view.

Della Rocca claims that the supporter of PII has the advantage that s/he acknowledges that facts about identity require explanation, and then explains *all* such facts by having recourse to *only one* principle. Those who believe in primitive identity, he says, claim instead that facts about identity require no explanation, but then acknowledge that an explanation is in fact needed.

As I see it, however, the claim put forward by the opponents of PII is different: it is that facts about identity do not need explanation *except* in certain cases. And that these cases are correctly accounted for by having recourse to a mereological principle (PIEE) that should not be subsumed under PII and is in fact an autonomous basic metaphysical truth. As a result, it is necessary to subscribe to both a general assumption – identity and individuality are primitive – and a principle – PIEE – that defines constraints on the possibilities that such an assumption leads one to accept. This is a consistent point of view.

Secondly, the idea (suggested by Della Rocca's treatment of the 'defeatist answer') that to make two guiding assumptions instead of one represents a problem ignores the essential requirement that the explanations one provides by employing one's basic presuppositions must be *correct* in view of actual matters of fact. By ruling out all cases of indiscernibles, the opponent of the reductionist view can argue, PII is too restrictive and leads one to 'see identity' where there is in fact no identity at all. It is for this reason that, in spite of the greater economy and simplicity of the reductionist perspective, an alternative, 'differentiated' approach may nevertheless be necessary.

In addition to this, the supporter of PII might be criticised on the same grounds on which Della Rocca bases his attack. That is, by maintaining that s/he adopts an asymmetric approach that is avoided in other frameworks. The distinction (at the level of explanation of identity and distinctness) between partial and complete overlap, that Della Rocca rejects, is indeed analogous to that between almost complete and complete indiscernibility, that one who endorses PII as he does must accept (while it can be ignored by those who believe in primitive individuality).[39] In conclusion, Della Rocca's argument in favour of PII is not compelling[40].

More generally, I take it that counterexamples to every form of PII can be conceived, and no convincing reason to discard them has been provided so far. This means that *a priori* analysis does not lend support to PII and the reductionist view of identity and individuality.

[39] See Adams' argument against PII, based on almost indiscernible entities, mentioned in section 4.
[40] For a reply to Della Rocca along lines in part similar to those followed here, see Jeshion [2006].

*7. Ontology and Science: Experimental Metaphysics?*

Recalling a distinction drawn in the first chapter, we are now in a position to state the following: the conceivability of counterexamples to all forms of PII, and the lack of strong arguments for regarding the principle as a necessary truth in spite of them, entail that those who want to find a justification for the reductionist view of identity and individuality must aim to extract their intended metaphysical conclusions from what we know about things. In other words, *a priori* metaphysics makes room for metaphysics as derivative on epistemology and actual empirical evidence. For the supporter of PII, a consideration of the latter could serve to argue in favour of the thesis that the Quinean-Leibnizian view of identity is the one that is best supported by the world as we know it, as PII appears to be at least contingently true. For the primitive thisness theorist, on the contrary, the analysis of actual objects and their properties might provide evidence in support of the idea that PII cannot be considered as a criterion of individuation because there exist *actual counterexamples* to it and so the reductionist view is to be discarded altogether.

This change of perspective is a crucial one, and one that demands careful philosophical exploration. In particular, something must now be said about the status that logico-metaphysical concepts and issues acquire in a fallibilist perspective, essentially based upon actual evidence and revisable knowledge.

Aristotle produced a number of works which together were called the *Physics.* In an early edition, another set of writings was placed right after the *Physics.* Early Aristotelian scholars, therefore, called these τά μετά τά φυσικά βιβλια, "those (works) that come after the (works about) physics"; from this the word 'metaphysics' (in Greek, μεταφυσικά) derived. This term, however, is not only a word that mirrors the editorial organisation of Aristotle's works. It also points to the fact that the subject matter allegedly concerns things that underlie the empirical knowledge of the physical and are prior to it.[41]

In the modern era, as empirical knowledge gained greater and greater priority over purely *a priori* analysis, this conception was progressively abandoned. Metaphysics was first subordinated to science, and then ultimately disposed of in favour of the latter by many thinkers. For example, Bacon, while himself retaining the name 'metaphysics' to designate his science of the essential properties of bodies, harshly criticised the Scholastics and their emphasis on final causes. Locke, by limiting all our knowledge to two sources, sensation and reflection, excluded the possibility of speculation beyond the facts of experience and of consciousness. This line of thought was taken up by Hume, who declared that it is impossible to go beyond experience. It has remained a distinguishing feature of all strands of modern and contemporary empiricism, up to the well-known neopositivist condemnation of metaphysics as meaningless and the corresponding attempt to reduce philosophy to the logical analysis of the results of science.

Attempts to revive metaphysics by giving it a certain degree of autonomy, however, were made in the second half of the 20th century.

[41] In this case, the Greek word 'μετά', is not intended as the English 'after', but rather as 'beyond', taken in the sense of 'more fundamental'. The *Metaphysics* was divided into three parts: Ontology, Theology and Universal science. Theology was the study of God (or the gods). Universal science was the study of so-called first principles, that is, the elementary laws of logic. Ontology was the discipline that was later defined as 'the science of being *qua* being'. This means that while, - for instance - physics is the science of things as determined by physical properties, mathematics is the science of things as determined by their mathematical properties (that is, by their 'possessing quantity') and so on for every specific discipline and delimited domain of application, ontology is the study of the very conditions of existence and possible forms of everything that exists (or can exist.

An interesting view, in particular, of the metaphysical import of *physics* has been developed in the last 25 years or so, and is known under the label of *experimental metaphysics*. Such a view is obviously relevant in the present context.

This notion of experimental metaphysics was first introduced by Shimony [1981], and subsequently employed by other authors (for instance, Hellmann [1983], Jarrett [1989] and Redhead [1996; Chapter 3]). Shimony explicitly defined it in the context of a discussion of quantum mechanics, and in particular of Bell's inequalities and the experimental confirmation of their violation, which is thus useful briefly to look at.

In his [1964], Bell revisited the well-known EPR paradox, presented by Einstein and two co-workers (Podolsky and Rosen) [1935] as the basis for an argument against the idea that quantum mechanics is complete (i.e., there is nothing that it does not represent of the physical systems it is concerned with). The original argument was based on an assumption of *local action*, or *locality*, formulated in harmony with special relativity. In Einstein's words, the assumption was that:

> "It is characteristic of [...] physical things that they are conceived of as being arranged in a space-time continuum. Further, it appears to be essential for this arrangement of the things introduced in physics that, at a specific time, these things claim an existence independent of one another, insofar as these things "lie in different parts of space". [...F]or the relative independence of spatially distant things A and B, this idea is characteristic: an external influence on A has no *immediate* effect on B; this is known as the principle of "local action" [...]. The complete suspension of this basic principle would make impossible the idea of the existence of (quasi-)closed systems and, thereby, the establishment of empirically testable laws in the sense familiar to us" ([1948; 321–322], translation by Howard in his [1985; 187–188]).

EPR considered a source emitting one at a time pairs of electrons in the singlet state of spin. These electrons do not possess definite values of spin, but only correlated probabilities as regards measurement results. The electrons are directed towards distinct measuring apparatuses, and one of them is measured first. The outcome of this measurement is a determinate value of spin. What is striking is that, once this measurement takes place, the spin component of the second electron is also determined, *before* a measurement takes place on *it*, even though the two electrons are at that point space-like separated (that is, at a distance that – if Einstein's principle of 'local action' holds - rules out a direct causal connection between events according to relativity theory). In particular, one of the two outcomes available to (and equally probable for) the second electron invariably occurs, namely, the opposite of that obtained in the measurement on the first electron.

Einstein thought that this was enough to conclude that quantum mechanics is incomplete, as the abovementioned principle of local action forbids this kind of – apparently causal – connection, and so there must be something about the particles, not described by the theory, which determines the evidence in agreement with local action. Bell, however, [1964] examined the data and the conceptual constructions in play more closely and concluded that this is not the case. For, if it were, one should in principle be able to find 'hidden variables' (that is, additional physical factors the consideration of which makes the theory complete) enabling one to explain the evidence without having to admit of the existence of non-local causal connections. Relatively simple calculations (involving the violation of certain equations now known as 'Bell's inequalities') show, however, that any such hidden variable theory is bound to be non-local.

One possible reaction to all this is to claim that a 'peaceful coexistence' between relativity and quantum mechanics (that is, between locality and quantum correlations) should be sought. Some authors believe that it can indeed be found. Jarrett [1984] argues that the failure of the Bell inequalities can in fact be connected to the violation of either one of two different conditions: either a *locality* condition - different from Einstein's local action (and thus better defined as *parameter independence*) - which states that the outcome of the measurement at one end of the experimental setup is statistically independent of what is measured at the other (and of all the factors determining the exact nature of the other measuring device); or a *completeness* condition (or *outcome independence*), according to which the probability of the joint outcomes given the components measured and all the relevant parameters is just the product of the probabilities of each outcome separately. The evidence, Jarrett contends, implies only that at least one of these two conditions is violated; but only the former is entailed by special relativity.

On the basis of this, it has been argued that parameter independence is to be retained and outcome independence must be given up, as a rejection of the latter would not determine the possibility of superluminal signalling, which is what relativity rules out. This is the case because whenever outcome independence fails, an element of randomness is present which makes superluminal signalling impossible. As Jarrett puts it, if quantum systems only violate outcome independence, no contradiction with relativity arises as

> "it is a consequence of the failure of determinism that measurement outcomes are not (even in principle) under the control of experimenters" [1989; 77].

As could be expected, however, things are not so straighforward. First of all, it is unclear whether the fact that correlations cannot in practice be exploited for superluminal signalling is sufficient to claim that relativity is safe. For it might be maintained that relativity forbids any type of non-local connection, and not only the transmission of information between space-like separated regions. Moreover, it has been argued by Jones and Clifton that, even if quantum systems only violate outcome independence,

> "the possibility remains open that the experimenter might use some controllable feature of the experimental situation as a "trigger" which operates stochastically on the outcome at her own end of the experiment. The signaller could then influence, without completely controlling, the result in the individual case, and could thus signal superluminally by employing an array of identically prepared experiments" [1993; 301].

On the other hand, that relativity prohibits superluminal signalling has also been put into doubt (Friedman [1983; Secs. 4.6-4.7]). If true, this would obviously deflate the whole issue. In between these two extremes, a large number of positions have been explored. For instance, Fine [1989] denies that the detected correlations need an explanation at all; while Winsberg and Fine [2003] suggest that the joint state could in fact be wholly determined by the separate states of the two particles, although by a functional relation weaker than multiplication, and the correlations consequently be perfectly explicable in local terms. [42] The entire 'Jarrettian' approach considered so far has also been questioned: Maudlin, for instance, argues that if the aim is to study the nature of quantum non-locality, it is misleading to perform general analyses of the statistical

[42] See also Fogel [2007].

(in)dependence between the parts and the whole, and instead necessary to look at the specific ontologies postulated by the various interpretations of quantum mechanics directly [1994; 94-98].

At any rate, we do not need to get into further details of this discussion here. The important question to ask for present purposes is the following: assuming that the interaction existing between science and very general hypotheses such as locality is (more or less) of the sort described here with reference to the debate on EPR correlations and Bell's inequalities, what is experimental metaphysics?

According to Shimony [1981], a general pattern can be individuated in cases such as the one just described. It has the form E&H→P. E is an accepted theory used to describe the relevant experimental setup (for example, quantum mechanics as it is employed to perform actual tests of Bell's inequalities). H represents a general (allegedly) metaphysical hypothesis (in this case, locality). As regards P, it signifies a certain empirical prediction (in the above example, that the Bell inequalities hold). If P is disconfirmed and E is kept fixed, says Shimony, by *modus tollens* we should get to a rejection or modification of H, so bringing experiment to bear upon a metaphysical thesis. Shimony emphasises that this is exactly the dynamics to which the analysis of Bell's inequalities and their violations gave rise to. In particular, philosophical reflection on the available evidence led several philosophers of physics to put Einstein's assumption of locality as an untouchable metaphysical principle into doubt; and to then find (or, at least, look for) a peaceful coexistence between relativity and quantum mechanics via the identification of some internal distinction/specification within H. In Shimony's words, it seems that:

> "Bell has provided us with the means for treating certain metaphysical hypotheses with the same level of control that has been achieved for typical physical hypotheses" [1981; 572-573].

This claim is remarkable, as it asserts that we are in a position to learn metaphysical lessons on the basis of experimental data, mathematics, and suggestions taken from our best current theories.

As far as the issue this thesis deals with is concerned, our previous results could be interpreted in the light of this as pointing to the fact that the *only* way to establish the significance of PII as a criterion of individuation is via experimental metaphysics. In the present case, H would be PII, E would be the relevant physical theory (i.e., again quantum mechanics) *as a theory about individuals*, and P would be the prediction that numerically distinct individual physical systems are always found to be discernible.

The first question to ask is, though, *whether experimental metaphysics is metaphysics at all.* In the case of the EPR paradox and Bell's inequalities, it could be objected to Shimony that he is not justified in taking locality as a metaphysical hypothesis; and that, accordingly, it is not legitimate to conceive of the entire enterprise of examining the consequences of the violations of Bell's inequalities as a form of metaphysics. The reason for this claim is that what is at stake is the status of what ultimately appears to be only a very general statement extracted from our best and most well-established theories, and that lies *entirely* within the domain of science, not metaphysics: Einstein's presupposition to the effect that the world must be local[43] appears indeed to be exclusively a consequence of his endorsement of a specific theory –

[43] And the subsequent one that, in the light of the observed evidence, well-defined and mutually independent values for the observables of entangled physical systems must exist at all times, and so quantum mechanics must be incomplete.

relativity; or, at any rate, of a general worldview that was the by-product of (common sense and) well-established theories prior to, and including, relativity.

Similarly, especially in the light of what has been said in this chapter, PII might be regarded as a mere empirical generalization that turned out to be true so far. It is true that, if one takes PII to be rooted – as was suggested earlier – in the bundle theory, then *prima facie* it seems to be a principle of a clearly metaphysical nature. However, the problem is that the belief in the bundle theory appears *itself* entirely based on the contingent efficacy of descriptions of the world that we successfully employed in the past (or, at any rate, can employ at the level of ordinary objects).

Of course, one might call presuppositions such as locality, or PII, metaphysical anyway, on the basis of the fact that they are (among) the most general statements about reality we can make. But this would be a merely terminological choice, and would not detract from the fact that those 'principles' appear ultimately rooted *solely* in our knowledge of the empirical evidence, i.e., science.[44] If it is correct, however, that they are in effect *very general empirical claims that only hold, as long as they do, given our best scientific theories*, then (as for all empirical generalizations) one must be ready to revise them, or give them up altogether, when analysis and further evidence require one to do so - regardless of how entrenched the belief in their truth may be.

As regards identity and individuality, in particular, the inability of PII to qualify as a necessary truth (as far as the present state of philosophical analysis allows us to see, at least) coincides therefore with

[44] Einstein himself, in his 1948 paper, explicitly presents 'local action' as a principle that is necessary to us for practical purposes, and that never fully applies outside of field theory. That locality is not an obvious truth is, after all, clear to physicists since the early debates on the nature of gravity.

its becoming an *entirely empirical claim*. As such, it must be 'tested against' the evidence described by our best physical theories, which is what will be done in the next chapter.

Before moving on, however, something else needs to be said about metaphysics. In the preceding paragraphs, have put into doubt the status of certain general claims about reality as metaphysical principles, in the sense of general rules of *a priori* validity. Whether *any* general and necessary truth about the world can in fact be *a priori* is not of our concern here. It is interesting to ask, instead, whether the concepts and methods of metaphysics can still play *some* role in those domains in which the empirical element is essential.

It seems to me that another possible way of looking at metaphysics (perhaps an idea of what 'real metaphysics' is) is one that regards it as having to do with *hypotheses* rather than *truths*. It is the view according to which (a certain type of) philosophical analysis aims to account for the same reality as that described by science but, at the same time, substantially departs from the level of the 'verifiable' (or, as Popper would rather say, the 'falsifiable') and moves into the domain of the conjectural. That is, it is the conception according to which metaphysics constitutes an attempt to provide general categories and concepts that transcend the empirical and yet (albeit via hypothetical constructions) allow for an interpretation of what science tells us.[45] The second part of the thesis will indeed be devoted to looking at identity, individuality and our best physics from this perspective (clearly, quite different from that assumed in this chapter, the previous one and the next).

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[45] Of course, metaphysical conjectures can be subsequently confirmed by scientific inquiry. The important point is that in metaphysics hypotheses are put forward that go beyond what science currently says.

*Conclusions*

Even in its very weak version, taking genuine relations into account, PII is not exempt from counterexamples. The study of PII must therefore move from the level of the logical and metaphysical to that of the outright empirical. This means that a close examination of what physical theory has to tell us is essential in establishing the viability of a reductionist understanding of identity and individuality. Correspondingly, the question regarding why one should stick to PII as a fundamental principle becomes all the more pressing. At the same time, the possibility emerges of 'proper' metaphysics as the formulation of hypotheses as to the nature of reality that are not mere generalizations of the already known, but venture instead beyond current science as full-blown conjectures.

# *Chapter 3*

# *Quantum Mechanics and its Ontological Implications*

In this chapter the real value of the reductionist view of identity and individuality will be examined by assessing the validity of PII in the specific domain of quantum mechanics (which is natural to look at, as it is the most well-established and successful scientific account of the basic structure of material reality). Quantum particles are shown to constitute actual counterexamples to PII if described according to the orthodox interpretation of the theory. In particular, it is denied that at least some of them can be regarded as weakly discernible. Doubts are, moreover, cast upon the idea that it is possible to re-describe quantum entities as non-individuals, thus obtaining a 'peaceful coexistence' between PII and standard quantum mechanics. On the other hand, it is shown that Bohmian mechanics fits well with the reductionist perspective, as it is essentially based on a classical ontology. However, it is argued, this at best avoids refutation of the PII, leading to some sort of underdetermination of metaphysics. It does not constitute an argument in favour of the reductionist view of identity and individuality.

## *1. Orthodox Quantum Mechanics and the Violation of the Identity of the Indiscernibles*

In classical mechanics (CM), a presupposition of impenetrability is generally made. In the third *regula philosophandi* of book III of the

*Principia* [1687(1999)], Newton included impenetrability in a list of fundamental properties of matter (together with hardness, capacity of motion, inertia etc.) determining that each body always has a unique location in space. As a matter of fact, impenetrability is not an axiom of CM (as, for instance, Newton's first axiom - stating that every body preserves its state of rest or uniform motion in a straight line unless it is compelled to change that state by a force impressed on it). It is not a dispensable assumption either, though, as it plays a fundamental role. Usually, it is simply taken for granted, in the sense that it is postulated that only force functions that satisfy certain continuity assumptions are allowed, as these lead to equations that have unique solutions - and so also guarantee impenetrability (i.e., uniqueness of location in space). However, by substituting other force functions into Newton's fundamental equation, non-unique solutions follow. As a consequence, cases of non-uniqueness must be more or less arbitrarily excluded. Given this, it is only once - at the initial stage of the development of the theory - the requirement of uniqueness of solutions is accepted as basic that impenetrability becomes a necessity in CM. With this proviso in mind, in what follows classical entities will be said to always differ at least with respect to space-time location. As a consequence, weak PII will be taken as necessarily true in CM.

Impenetrability is not, however, a (quasi-)axiom in the theory that we now take as the correct description of the fundamental constituents of reality, namely, so-called 'standard', or 'orthodox', quantum mechanics (QM).[46] As a matter of fact, as we will see in more detail below, particles

[46] As anticipated the most well-established version of QM, namely the 'standard' interpretation based upon the formalisation given by Von Neumann and on the idea of 'collapse' of the wavefunction, is assumed here as in most of the relevant literature. As we will see at the end of the chapter, Bohmian mechanics provides a rather different picture of reality, and so licenses quite different conclusions as far as the issues dealt with in this

are described by quantum theory as being able to occupy the same location.

Having said this, it is now possible to move on to an evaluation of PII in the quantum domain. This requires, first of all, a detailed explanation of what exactly must be evaluated, namely, of what counts as a property in QM.

Properties are represented in the quantum formalism as *Hermitian*[47] operators in Hilbert space. The eigenvectors [48] of these operators represent the possible values of the observable quantity represented by the operator. The important point is that, in general, the state of the system (which is also represented by a vector) is not an eigenvector of any property (or 'observable'). This coincides with the fact that, normally, no value can be attributed to the system for a given observable with certainty, and it is instead only possible to assign a *probability* to each eigenvalue.

To see this, consider the following. The inner product $\langle\Psi|P^A_i|\Psi\rangle$ - with $P^A_i$ being the projection operator onto a ray[49] containing $v_i$ as an eigenvector for observable $A$[50], and $\Psi$ the state of the system – is what represents the 'relation' in Hilbert space between $\Psi$ and $v_i$. To ascertain whether $\Psi$ will be measured to possess value $v_i$ for observable $A$, we first project $\Psi$ onto $v_i$ via $P^A_i$, and then calculate the inner product[51] between

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thesis are concerned. Other theories and interpretations also exist, which will be briefly considered in the Appendix.

[47] An operator $A$ on a state space is Hermitian iff:

1. $A$ is *linear*, that is, for all vectors u and v and any number c,
   a. $A(u+v)=Au+Av$
   b. $A(cv)=c(Av)$
2. $\langle u|Av\rangle=\langle Au|v\rangle$ (see the definition of inner product below)

[48] The eigenvectors of an operator $A$ are vectors $v_1$, $v_2$, ... such that for each i $Av_i=a_iv_i$. The $a_i$s are the eigenvalues of the operator $A$. If $A$ is Hermitian, these are real numbers.

[49] That is, a one-dimensional subspace of the total Hilbert space.

[50] For simplicity's sake, I will refer to observables and to operators describing observables interchangeably from now on.

[51] Defined, for any two vectors a and b (with the same origin), as $\langle a|b\rangle$=length of a times length of b times cos(angle between a and b).

the initial vector and the projection. If $\Psi$ and $v_i$ coincide, which naturally expresses the fact that the state has the value for $A$ represented by the eigenvector $v_i$ (it simply *is* the state in which the observable has that value), then the inner product is equal to 1 - for the vectors under consideration are all 'normalized' (i.e.; they have unitary length), and cos(0°)=1. If $\Psi$ and $v_i$ are orthogonal, on the other hand, the inner product is equal to 0 (as cos(90°)=0), which is taken to mean that the state does *not* have the value in question. Given this, and since the inner product can *only* take values from 0 to 1, the theory lends itself naturally to an interpretation in terms of *probability assignments* regarding states and their observables.

It can thus be said that quantum properties have an irreducibly probabilistic nature: the theory only answers questions about the properties possessed by physical systems by providing probabilities. In particular, these probabilities refer to how likely, given the system, specific results are *upon measurement*, which is the only means to make actual values for quantum observables emerge. The probabilities are computed from the above inner product according to the statistical algorithm

$$\text{Prob}\,(o_i)_O^{|\Psi>} = <\Psi|P^O_i|\Psi>$$

known as *Born Rule*. This gives the probability that a measurement of the observable corresponding to the operator $O$ on a system in state $\Psi$ yields result $o_i$.

Similarly,

$$\text{Prob}\,(\Delta)_O^{|\Psi>} = <\Psi|P^O_\Delta|\Psi>$$

gives the probability that a measurement of the observable *O* on a system in state Ψ yields a result in the interval Δ.[52]

On the basis of these premises, it can be shown that, whenever they are part of the same physical system, particles that share all their state-independent properties such as mass or charge (called *identical* particles by physicists)[53] can also share all their monadic and relational state-dependent properties, *including spatial location* (in this case, they are said to be *indistinguishable*). Let us see this in more detail.

French and Redhead [1988] consider two-particle systems of identical particles and an observable *O* with eigenvalues *x* and *y*, and analyse both *monadic* properties of the form $\mathrm{Prob}(x)_{Oi}^{|\Psi>}$ – that is, those expressed by the probability that in the state Ψ observable *O* 'actualises' upon measurement with value *x* for particle *i*; and *relational* properties of the form $\mathrm{Prob}\,((x)_{O_1}|(y)_{O_2})^{|\Psi>}$ – that is, corresponding to the conditional probabilities of one value being actualised for *O* in one particle, *conditional on* the actualisation of the other value for the same observable in the other particle.[54] Deriving values for these probabilities from the quantum formalism, they conclude that, both for fermions and for bosons, two indistinguishable particles

> "do in fact have the same monadic properties and the same relational properties one to another" [Ib.; 241].

To see why, consider the following.

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[52] In this case, of course, the projector operator projects onto a subspace, not (necessarily) a ray.

[53] Of course, this use of the word 'identical' is different from the philosophical one, as it does not imply numerical sameness.

[54] Evidently, the fact that here it is the probabilities on particle 1 that are conditional on those on particle 2 is absolutely arbitrary, and the description can be reversed. The specific choice of values is also irrelevant.

We can introduce a *permutation operator* $Perm_{1,2}$ having the following properties. First of all, $Perm_{1,2}|a>_1|b>_2=|b>_1|a>_2$ for any $|a>_1|b>_2$ (that is, $|ab>$) representing the system constituted by a and b in the Hilbert space which is the tensor product of the two separate Hilbert spaces for a and b. From this, it follows that $(Perm_{1,2})^2=I$ (with $I$ being the identity operator), and so $Perm_{1,2}=Perm_{1,2}^{-1}$.[55] Moreover, the operator has the same characteristics as those representing 'proper' observables, and this entails that it is its own adjoint[56], and so $Perm_{1,2}^{\dagger}=Perm_{1,2}$. Hence, the permutation operator is unitary, and $Perm_{1,2}^{\dagger}=Perm_{1,2}^{-1}$. Therefore, one has, in particular, that $Perm_{1,2}^{\dagger}Perm_{1,2}=I=Perm_{1,2}Perm_{1,2}^{\dagger}$.

The permutation operator acts as a unitary transformation of any operator $O$. Suppose $O$ is considered with respect to two systems, namely, that $O_{12}=O_1\otimes O_2$. One has that $Perm_{1,2}^{\dagger}O_1\otimes I_2Perm_{1,2}=I_1\otimes O_2$ and that $Perm_{1,2}^{\dagger}I_1\otimes O_2Perm_{1,2}=O_1\otimes I_2$. Therefore, $Perm_{1,2}^{\dagger}O_{12}Perm_{1,2}=O_{21}$.

Additionally, for any (anti-)symmetric state the *Indistinguishability Postulate* (also known as *Permutation Invariance*) holds, according to which for any $n$-particle state and observable $O$ on the $n$-fold tensor product state space, $<Perm\,\Psi|O|Perm\,\Psi>=<\Psi|O|\Psi>$ (with *Perm* being the operator associated with an arbitrary exchange of particles).

Given this and the statistical algorithm above, for any observable $O$ and value $x$ for that observable one obtains

$$\mathrm{Prob}\,(x)_{O_1}^{|\Psi>}=<\Psi|P^{O_1}{}_x|\Psi>=<\Psi|Perm_{1,2}^{\dagger}\,P^{O_2}{}_x\,Perm_{1,2}|\Psi>=$$

$$=<Perm_{1,2}\,\Psi|P^{O_2}{}_x\,|Perm_{1,2}\Psi>=<\Psi|P^{O_2}{}_x|\Psi>=\mathrm{Prob}\,(x)_{O_2}^{|\Psi>}$$

Since all known particles (that is, both fermions and bosons) give rise to states that are (anti-)symmetric (they obey what is known as the

[55] For exchanging two particles with each other twice leads back to the original situation, so effectively giving the same result as an application of the identity operator; but it is also obvious that an operator times its inverse is equal to the identity operator.

[56] Roughly speaking, the adjoint of an operator stands to the operator as the complex conjugate of a complex number stands to the complex number.

*Symmetrization Postulate*) and the choice of observable and value has been left absolutely unspecified, the above result allows us to conclude generally that identical particles in the same physical system have all the same monadic properties.

As for relational properties, one can prove that $\text{Prob}((x)_{O_1}|(y)_{O_2})^{|\Psi>}$ = $\text{Prob}((x)_{O_2}|(y)_{O_1})^{|\Psi>}$ as follows.

By a fundamental property of probabilities[57], the above equality is the same as

$$\text{Prob}((x)_{O_1}\&(y)_{O_2})^{|\Psi>}/\text{Prob}(y)_{O_2}^{|\Psi>}=\text{Prob}((x)_{O_2}\&(y)_{O_1})^{|\Psi>}/\text{Prob}(y)_{O_1}^{|\Psi>}$$

The denominators have just been shown to be equal. But the numerators are also equal. Since,

$$\text{Prob}((x)_{O_1}\&(y)_{O_2})^{|\Psi>}=<\Psi|P^{O_1}{}_x P^{O_2}{}_y|\Psi>=$$

$$=<\Psi|Perm_{1,2}{}^{\dagger}\, P^{O_2}{}_x (Perm_{1,2})^2 P^{O_1}{}_y\, Perm_{1,2}|\Psi>=$$

$$<Perm_{1,2}\Psi|\, P^{O_2}{}_x P^{O_1}{}_y|Perm_{1,2}\Psi>=$$

$$=<\Psi|\, P^{O_2}{}_x P^{O_1}{}_y\,|\Psi>=\text{Prob}((x)_{O2}\&(y)_{O1})^{|\Psi>}$$

From this, it follows that all state-dependent properties are the same for indistinguishable particles in the same system, and

> "so the weakest form of PII which we can formulate[,] which involves both monadic and relational properties, is violated" [Ib.].

French and Redhead also show that systems of three indistinguishable paraparticles (still undetected[58] particles that are neither fermions nor bosons and are hypothesised to exist as obeying different types of symmetry and statistics) are such that two particles

[57] According to which Prob(A|B)=Prob(A&B)/Prob(B).

[58] But see Camino, Zhou, and Goldman [2005]. The detection of paraparticles would of course make them much more relevant for present purposes (and not only). In what follows, however, they will be ignored.

differ from the third in some property but have all the same monadic properties and all the same relational properties as each other.

French and Redhead's results have been later improved upon by Butterfield [1993] and Huggett [2003]. Butterfield extended the proofs regarding relational properties to properties of two particles involving their relation to a third entity. Huggett gave a general proof of violations of PII for any number of particles and any number of observables. As for paraparticles, Huggett's results show that for systems of $n$ identical paraparticles only a number $m<n$ (determined by the type of particle) of them is such that they are indiscernible (Huggett also proved that the $m$ indiscernible paraparticles are (anti-)symmetrized).

It thus seems that indiscernibility is an actual feature of quantum entities, clearly mirrored in the formalism.

The possibility has been contemplated, it should be noted, of identifying a quantum particle by referring to its history. Cortes [1976] pointed out that even knowing the entire history of a particle would not be sufficient for individuating it when it is part of a system of indistinguishable entities, because we would still be unable to 'pick out' a particle by making reference to its history. Barnette [1978] objected that this is a merely epistemic fact that does not necessarily determine metaphysical facts about individuality, and so the possibility that histories individuate remains open. However, it can in turn be responded (see the discussion in the previous chapters) that to 'extract metaphysics' from what we know is the best we can do. Hence, our inability to use histories in practice for individuation might be deemed sufficient to exclude histories from the range of properties that can count as making things discernible. [59] Regardless of epistemic limitations on their accessibility as full-blown properties, at any rate, it can be doubted that histories can solve the problem with the individuation of particles for a simple reason: 'history' can only mean evolution *of the same individual* in time, and it consequently looks as though talk of particle histories, and the histories themselves, in fact *presuppose* identity. In other words, while, for instance, Van Fraassen [1991] states that the only problem with individuating histories is that they are 'empirically superfluous' - in the sense that they do not add anything to the physical description of the systems in question -, the real problem, it seems to me, is that to think of properties corresponding to histories existing as 'free-floating' until bundled with other properties makes no sense.

### *2. Weak Discernibility to the Rescue?*

French and Redhead and the other authors mentioned above appear successfully to show that weak PII is violated in QM. However - obviously enough in the light of the discussion in the previous chapter - supplementary evidence must be taken into account as regards the possibility of tracing some degree of weak discernibility in quantum systems of indistinguishable particles. Do the latter exhibit, in addition to the more 'canonical' monadic and relational properties considered above, any individuating irreflexive relation?

The *Exclusion Principle* (EP) has sometimes been referred to (for example, by Weyl [1949]) as a vindication of PII for *fermions*. Because EP bans two indistinguishable fermions from having all the same

[59] In a sense, histories would be excluded in this case on the same grounds as primitive identities. That is, that they would be postulated as epistemically inaccessible individuating factors.

quantum numbers[60], it seems to entail their discernibility. However, as first pointed out by Margenau [1944], EP represents a constraint only on *future* experimental outcomes, and fermions in the same physical system indeed have the same values for *all* their observables (provided, of course, that properties are identified with pre-measurement probabilities in the way described in the previous section).[61]

Still, it is a fact that identical fermions in the same system have all the same properties but we also know with certainty that, starting from a condition of *entanglement*[62], they will give rise to opposite results when measured. Does this not point towards an actual fact of the matter – concerning a *relation* among the particles – that is sufficient for individuation even before the measurement?

Saunders has recently ([2003], [2006]) tried to resurrect the claim that PII is vindicated for fermions exactly along these lines, by having recourse to weak discernibility. Fermions in the singlet state of spin[63], Saunders claims, are weakly discernible because they are in an irreflexive relation expressed by

[60] Where each quantum number specifies the value of a quantity that is conserved by the particle in the dynamics of the quantum system it belongs to, and the set of all the quantum numbers of a particle exhaustively specifies its properties. For a single electron in an atom, for instance, one has a principal, an azimuthal (also called angular, or orbital), a magnetic and a spin quantum number. Taken together, these numbers fully specify the qualities of that electron.

[61] This is the working presupposition in French and Redhead's reconstruction of the violation of PII in QM. Massimi [2001] maintains that indistinguishable fermions in entangled systems cannot be attributed monadic properties, and suggests taking their properties as relational. At any rate, she agrees that weak PII is violated by fermions.

[62] The term 'entanglement' denotes the fact that the quantum states of two or more systems do not convey all the available information. A complete description of an entangled system must necessarily describe the entangled sub-systems with reference to each other, because there are irreducible correlations between their properties. The essential point about fermions is that EP determines that identical fermions in the same system *only* exist in entangled states. Here, the existence of component sub-systems is taken for granted, but this is exactly what I will put into doubt in what follows.

[63] I.e., an entangled state with a correlation among spin values and total spin 0.

> "the symmetric but irreflexive predicate '... has opposite ↑-spin component of spin to...'" [2006; 59].[64]

Upon scrutiny, it looks as though not only is the spin correlation pointed to by Saunders a genuine property: it is exemplary of the type of property in the quantum domain that we can be realist about. The eigenstate-eigenvalue link (EEL), accepted as a correct postulate within the standard interpretation of the theory, connects quantum descriptions to real properties of physical systems. It states that a system can be said to actually possess a given property if and only if the theory tells us that it will exhibit it upon measurement with probability 1. In the other cases, by contrast, since the described property can fail to be actualised, *one can always deny that the corresponding quantum predicate describes something real now*.[65] For quantum systems such as those under analysis (i.e., for systems of entangled fermions), EEL does not allow us to attribute definite spin properties to the separate components. Entangled fermions are not in *pure* states (a pure state is a state which is represented by a vector in Hilbert space; if it is also an eigenvector for observable $O$ with eigenvalue o, then the system in that state will be measured as having value o for $O$ with probability 1) but only in *mixed* states (only defining probabilities – smaller than 1 - for a number of possible outcomes).[66] However, the composite system, represented in the Hilbert space which is the tensor product of the Hilbert spaces representing the component particles, is in a pure state.

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[64] Bosons, instead, *might be* individuated by irreflexive relations coinciding with spin correlations, but are not such that some form of discernibility always exists. I will say more on bosons in the next section.

[65] This will be of paramount importance in the rest of the discussion.

[66] It must be stressed that the theory (*via* the so-called *Axiom of reduction*) *always* allows one uniquely to identify separate mixed states for the component particles.

Because of the above, the composite system constituted by two entangled fermions can always be said to *actually* possess spin 0. This latter fact, though, appears directly to lead one to regard the correlation between the entangled fermions as equally real. For, the total spin state of a system of two entangled fermions 1 and 2 is represented by the following expression:

$1/\sqrt{2}(|\uparrow>_1|\downarrow>_2 - |\downarrow>_1|\uparrow>_2)$

And the above conveys the information that, in spite of the fact that they have equal monadic and relational spin properties (in particular, they are both in the mixed state $1/2|\uparrow>+1/2|\downarrow>$), fermions 1 and 2 will *necessarily* have opposite spin values upon measurement. That is, there is the same probability that fermion 1 will have spin up and fermion 2 spin down and that fermion 2 will have spin up and fermion 1 spin down, namely, 1/2. This is easily shown by recalling the statistical algorithm and noticing that[67]

$<\Psi|P^{O}_{i}|\Psi>=|c_i|^2$

and so

$\text{Prob}(o_i)^{|\Psi>}_{O}=|c_i|^2$

With reference to the above singlet state, it follows that (with $S$ denoting the observable corresponding to the chosen component of spin),

$\text{Prob}(\uparrow_1|\downarrow_2)^{|\Psi>}_{S}=\text{Prob}(\downarrow_1|\uparrow_2)^{|\Psi>}_{S}=1/2$

But this, Saunders maintains, points to the holding of an *irreflexive relation*: the conveyed information is about an actual property; it has to

[67] Since any projection operator is Hermitean and idempotent, and so (given a projection operator $P$ onto the one-dimensional subspace spanned by the eigenvector v)
$<v|P|v>=<v|PP|v>$ (idempotence)
$=<Pv|Pv>$ (Hermiticity)
$=<cv|cv>$ (effect of the projection operator)
$=c^*<v|cv>$ (properties of the inner product)
$=c^*c<v|v>$ (properties of the inner product)
$=c^*c$ (normalization)
$=|c|^2$ (properties of complex numbers).

do with what is (will be) true *of the two particles together*; it is not equivalent to two properties possessed by each particle separately; and it holds regardless of the order in which we consider the particles.

But if this is correct, one obtains that there is a relation R holding between any two entangled fermions *a* and *b* and such that R*ab*, R*ba*, ¬R*aa* and ¬R*bb*. As a consequence, $\forall R \neg(R(x,y) \wedge \forall z \neg(R(z,z)))$ - the additional conjunct characteristic of very weak PII - is false when *x* and *y* are replaced with *a* and *b*, and so very weak PII tells *a* and *b* apart as distinct individuals. Whence, it looks as though fermions can be individuated by PII even when they are indistinguishable in the sense intended by physicists, and are neither strongly nor moderately discernible.

This result is interesting. Nonetheless, I believe that it can be questioned. There are three reasons for this.

The *first* has already been hinted at in the previous chapter. The basic claim Saunders makes regarding fermions is that they are *exclusively* individuated by relations, and that if spin correlations did not make them weakly discernible, then fermions would be absolutely indiscernible (and consequently identical). Therefore, Saunders is in effect subscribing to the view that relations can be independent of their relata, and actually be prior to them in the sense that they determine their numerical distinctness. This is obviously not inconsistent, and actually squares nicely with the structuralist ideas that Saunders explicitly underwrites. On the other hand, such a view, as explained earlier, is certainly questionable. Looking at the physics side of the matter, the following may be relevant in connection to this: there are results showing that the correlations between the subsystems of individual isolated composite quantum systems cannot be taken to be real and objective local properties of that system, with 'real and objective' taken to mean of a property P of system S that 'P is such that it cannot change in immediate response to what is done to a system not interacting with S'.[68] Seevinck [2006], in particular, takes certain relatively simple proofs to be sufficient for saying that the correlation between entangled particles is not ontologically 'robust', the latter qualification being taken to encompass impossibility, without interaction, of i) creation, ii) elimination via mixing, iii) flow into some environment upon mixing. It is certainly an interesting question whether or not a strong structuralist-like understanding of relations of the sort Saunders suggests requires ontological robustness so defined. I will not delve into this further here, however, as I take another fact to count decisively against Saunders' attempt.

This leads me to introduce the *second* reason for doubting Saunders' argument. It is more specific, and regards the nature of the relations that Saunders has recourse to. In order to formulate it, it is useful to look first at the criticism raised against Saunders by Hawley [2006].

Hawley attacks Saunders on two counts. On the one hand, she argues, PII *permits*, rather than *compels*, one to take fermions as distinct objects, and it is instead Leibniz's Law that *requires* one to posit distinct objects in certain cases. On the other hand, adds Hawley, the relations Saunders points to do not allow for the different treatment of fermions and bosons. In my opinion, Hawley misses the essential point, or at least does not give it the required attention.

[68] Cabello [1999], Jordan [1999] and Seevinck [2006] argue, in different but related ways, that if one assumes that the correlations among entangled quantum particles are objective and real local properties of the composite systems these particles give rise to, then Bell-like inequalities for pairs of correlated pairs of particles can readily be formulated and shown to be violated.

As regards the first criticism, it is true that PII tells us that indiscernible entities are identical, not that discernible entities are distinct objects; and that it is only Leibniz's Law that allows one to infer numerical distinctness from discernibility. We have already seen, however, that Saunders follows Quine in *defining* identity as indiscernibility. This entails that he endorses a bi-conditional claim that absorbs *both* PII and Leibniz's Law. It follows that his general perspective on identity and individuality does in fact constitute a sufficient criterion for attributing numerical distinctness in the case at hand.

As for the point about relations and the different treatment of fermions and bosons, first of all Hawley says that

> "Saunders argues that an entangled-fermion system has proper parts, while an entangled-boson system does not. For him, an entangled-boson system is just irreducibly symmetric. Then why not say that an entangled fermion system is just irreducibly anti-symmetric? Neither symmetry nor antisymmetry has a better or worse claim to ontological basicness. We know that if entangled fermions did exist, the being-of-opposite-spin relation between them would not supervene upon their other properties. The same goes for the being-of-the-same-spin relation between putative bosons [....] The difference between antisymmetry and symmetry doesn't give us positive grounds for recognizing fermions but not bosons" [Ib., 301-302].

But this is, at best, unclear. Saunders exploits the fact that only particles that give rise to anti-symmetric systems, *since they obey EP*, have opposite spin necessarily. That is, his claim is that only in the case of fermions does one necessarily have irreflexive relations. It is for the latter relations, though, that he puts forward a claim of 'ontological basicness'. Of course, then, it is the ontological status of the alleged irreflexive relations that one must discuss, not that of (anti)symmetry.

With respect to this, Hawley argues that the notion of weak discernibility is unappealing because

> "[f]irst, it incites us to divide an object with, say, four units of mass into a three unit part and a one-unit part. Second, it conflicts with the modest, empiricist stance which makes PII attractive in the first place. PII tells us to restrict our ontology to the minimum required by Leibniz's Law, to choose a single object over two indiscernibles any time. The present principle tells us to make work for Leibniz's Law, to choose mereological complexity over simplicity whenever we can" [ Ib.; 302].

But this methodological criticism appears weak. First, there is no need to make such unequal divisions as those suggested by Hawley. According to the generalist, an object's parts can, to the contrary, be equal as regards their intrinsic properties, including mass, provided that they enter into irreflexive relations. If they do not, the very existence of distinct parts can be put into doubt. As for empiricism and simplicity, it seems plausible to claim that the empiricist stance is, in fact, to require facts regarding the things' number to be determined by qualitative facts; and irreflexive relations appear to be the type of qualitative facts that demand complexity over simplicity. In this sense, the endorsement of the concept of weak discernibility does not lead one to abandon the tradition of 'modest' empiricism: it just invites to elaborate upon it on the basis of Quine's reflections on relations. Indeed, even independently of whether or not one is an empiricist, it is difficult to deny that an irreflexive relation points to numerically distinct relata. Why should an empiricist ignore this?

Hawley touches on the real issue only in passing, when she says that

> "[w]e can treat each [both the relation holding between identical fermions and that connecting identical bosons in the same system] as either an irreducible property of the system or else as a non-supervenient relation amongst the parts" [Ib.].

The key point is, in effect, *whether one has a relation at all in the fermionic case*. But this requires much more philosophical analysis than offered by Hawley. This is what I will try to provide in what follows.

Saunders' reasoning in favour of the weak discernibility of fermions is essentially based on an *analogy* between entangled systems of identical particles and Black's universe (that can be accepted – as I said in the previous chapter - as a valid counterexample to strong and weak PII, but fails to refute very weak PII). As Saunders puts it, Black's thought experimental scenario fails to count as a counterexample to very weak PII because the fact that two individuals stand in a mutual spatial relation (that of being at a non-zero distance from) by no means entails

> "that they each have a *particular* position in space" [2006; 59, italics mine].

Consequently, a condition for weak discernibility (non-zero distance) may hold, and *in fact holds*, in spite of the fact that conditions necessary for stronger forms of discernibility (in this case, distinct space-time locations defined in non-relational terms) do not. This amounts to saying that the possibility and relevance of weak discernibility is based upon the *non-supervenience* of an (allegedly) discerning *relation*.[69] Having taken

[69] In effect, if the discerning relations were supervenient on properties of the relata, the latter would be sufficient to determine discernibility too. But this means that monadic and/or relational properties of the relata would be different, and so one would in fact have strong or moderate discernibility.

this sensible position with respect to Black's universe, Saunders argues that since two entangled fermions possess (dispositions to reveal) opposite spin components upon measurement without each having, because of this, a *particular* value for its spin component, the same reasoning holds for quantum systems too. If the overall situation exhibits a non-supervenient spatial relation that is enough to individuate two spheres in Black's universe, that is, then it must also be accepted that the total state determines a non-supervenient spin correlation that is sufficient for individuation in the quantum case.

However, while the claim of non-supervenience cannot be disputed in either case, the analogy is not compelling, because it is only partial. A crucial ambiguity lies in the meaning that is to be attributed to the word 'particular'. In the case of spatial relations, it seems that Saunders can only be correct if by 'particular' he means 'absolute', or 'specific'; not if he means 'actual'. For, obviously two things can be at some distance from each other independently of what position each one of them occupies, and also independently of whether or not such a position is individuated in an absolute space-time. But, surely – at least in the classical domain - each thing must occupy *a* location *at the moment of the holding of the relation* (by which I am *not* suggesting that absolute space must be presupposed). In Black's case, the essential fact is exactly that we can be sure that, if there exists a (non-zero) distance relation R at time $t_1$, then necessarily there also exist two distinct objects at $t_1$, namely, those connected by R.

In the quantum case, however, this is not so. Since quantum properties only convey information about future experimental outcomes, despite the fact that we know with certainty at time $t_1$ that there is a certain correlation within a physical system, on the basis of such a correlation we can only say that *at a later time* $t_2$, that is, after measurement, there will be two distinct physical systems. But this leaves it *completely open* whether

a) What is a single system (without component particles) at $t_1$ will split into two at $t_2$, or

b) Two sub-systems already existing at $t_1$ will come into possession of such-and-such properties at $t_2$.[70]

Although these two alternatives are empirically *entirely equivalent*, as they both account for the evidence, they are radically different from the ontological point of view, because the correlation holding at $t_1$ points to the existence of particles at that time only in the former case. In other words, the conclusion that the *correlation* in question is a *relation* and, as such, it holds among numerically distinct individuals, is far from obvious *in the quantum case*.

The possibility suggested by a) above, namely that the correlation is a monadic property of the entire system, is clearly connected to that of describing entangled quantum systems along the lines of what is known as *ontological holism*.

That quantum systems exhibit holistic features is commonly acknowledged, and has been already explained when pointing out the characteristic features of entanglement. Entangled systems, as shown, for instance, by a consideration of EPR-like correlations, are such that the whole is more than the sum of the parts: that is, there is more information in the total system than in its (supposed) parts considered together. Of course, some form of *property holism* (some properties of the whole are not supervenient on properties of component parts, but

[70] In this respect, the fact – described earlier - that EEL does not authorise one to regard the states of the (supposed) entangled fermions as describing actual properties of distinct systems is essential.

sub-systems exist in spite of the non-separability of the corresponding *states*) might appear more plausible on an ontologically 'conservative' understanding of the theory. However, a stronger form of holism such as *system* non-separability, determining that the system simply *has no component parts*, might also be true. In the context of ontological holism, spin correlations can only be taken as expressing what *will*, upon measurement, become of the entire system, *which has no physical parts now*. In particular, given a physical system, we *will* surely detect particles with certain qualities, but this only legitimises the claim that there *will* exist individuals.

Unlike in Black's case, the ontological holist would say, there do not exist distinct particles and distinct properties in an entangled system. It is clear that, were this the case, it would just be an incorrect move to 'project backwards' after measurement and deduce from the fact that there exist two distinct individuals then that this state of affairs already obtained before the measurement.

It might add further clarity to formulate this second criticism against Saunders in the terms introduced by Cleland [1984]. Spatio-temporal relations are plausibly described as what Cleland defines as *weakly non-supervenient* relations. [71] A weakly non-supervenient relation, says Cleland, is a relation that cannot be reduced to properties of relata, and yet requires certain distinct instances of properties to exist. This is what establishes weak discernibility in Black's case: since classical *spatial relations are dependent on other properties* (and, in particular, non-zero distance can exist only[72] if *distinct instances* of size and shape exist and occupy *different locations*), then – necessarily - the holding of a non-

[71] Indeed, in her paper Cleland takes spatio-temporal relations as *paradigmatic* weakly non-supervenient relations.
[72] Independently of whether space-time is relational or substantival.

zero distance relation is sufficient for the individuation of two entities (as possessing those properties). However, Cleland convincingly differentiates the weakly non-supervenient relations just described from *strongly non-supervenient relations.* While the former are not reducible to properties of individuals, but are such that some intrinsic properties of distinct relata must necessarily be acknowledged if the relation holds, the latter are *not reducible and are such that no intrinsic property whatsoever need be posited once they exist.* But in a perspective in which relations are not necessarily ontologically dependent on related objects (provided, of course, that nothing else leads one to postulate the existence of distinct relata) this opens the way for a *re-description of the alleged relation as a monadic property of the whole.*

As it turns out, spin correlations in entangled systems are *strongly* non-supervenient in Cleland's sense. That this is the case was first explicitly argued by French [1989] and is also suggested, for example, by Esfeld [2004]. These authors forcefully show that nothing whatsoever in the related 'particles' is entailed by the spin correlation. Given this, the essential point can be made again that since they do not entail anything about relata, *spin correlations in entangled systems can always be re-described as monadic properties of the whole system.* Consequently, underdetermination arises concerning their ontological status, and they turn out not to be sufficient for individuation.[73]

The essential question thus concerns the status of ontological holism. Perhaps I only pointed to a possibility that can be discarded as irrelevant?

Saunders might maintain that he is only taking QM at face value, so effectively assuming, *à la* Quine, that what is being described is a domain

[73] It can be claimed that the peculiarity of strongly non-supervenient properties coincides with the 'gap' between times $t_1$ and $t_2$ on which the previous formulation of this argument was centred: the holding of an irreflexive *cor*relation does not necessarily entail anything about distinct related entities existing at the time of the correlation.

of individuals and what appears to be a relation is indeed a relation. However, Quine's aim was to provide a recipe for 'reconstructing' the identities of already given individuals in an identity-free language. But the reductionist about identity and individuality cannot do the same, and must *entirely* reduce individuals to qualities. Doing otherwise would require the *certainty* that PII is a valid criterion of individuation, and can thus be employed for confirming one's *provisional* assumption as to the existence of distinct individuals. As we have seen, however, there are (still) no grounds to look at PII in this way. In this context, in particular, assuming numerical distinctness and *then* applying PII as a 'test' for individuality is not allowed because the only form of discernibility that it is possible to reconstruct (i.e., weak discernibility) crucially *depends* on the initial assumption.[74] Were Saunders to insist on the 'face value' assumption, it would be legitimate to ask why one should take QM at face value only as long as it agrees with PII, and not when it attributes unique individuating 'labels' to particles. Or, which amounts to almost the same, why is it that reflexive relations should not be considered enough for individuation (such relations can be reconstructed by following a procedure for bosonic systems analogous to that described above for allegedly irreflexive relations between entangled fermions). To respond that this is not allowed because it violates PII would, of course, only manage to beg the question regarding the validity of the principle once again.

It seems that the only alternative is for Saunders to provide arguments against ontological holism from the perspective of the

[74] It may be noticed that this is interestingly reminiscent of the earlier discussion of trivialising predicates. It looks as though the assumption of numerical distinctness would be admissible only if the 'test' represented by PII turned out to fail. In that case the assumption would be self-refuting (or, alternatively, PII should be abandoned). This is exactly what happens with bosons.

physical theory and its interpretation. French and Krause appear to have this in mind when they explain that Saunders

> "is working with a relational conception of the quantum state here and this specific irreflexive relation is simply a manifestation of the anti-symmetric state itself: since they are in such a state, the electrons must have opposite spin. Furthermore, to insist that we can only talk about two entities in such a state if they can be said to possess separable states — which they obviously cannot— is equivalent to insisting that only such states, corresponding to monadic properties, allow us to distinguish and hence individuate the entities. But now the question begging has been turned, since it is precisely this latter insistence that Saunders wants to move away from" [2006; 170].

However, while this is correct, contrary to French and Krause I doubt that it represents a response Saunders can have recourse to. Surely, to have a relational conception of the quantum state may allow one to 'take the irreflexivity seriously', that is, as a genuine physical property 'essential' to the entangled state; and to do away with the naive assumption that distinct individuals must be in separable states. But it requires one further step to claim that the irreflexivity lies in a genuine relation and not in a monadic property of the whole, and therefore one has distinct weakly discernible objects. It is this additional step that is missing in Saunders' argument.

Perhaps one could emphasise that entangled states can always be decomposed into well-defined *separate* (mixed) states, and suggest that this is naturally accounted for along the lines of property holism. That is, of distinct systems which, although the whole they give rise to is not reducible to them, exist as well-defined separate entities. The problem with this is that, at least if one follows EEL, separate states by no means correspond to distinct systems; and the whole point of the present discussion concerns exactly what criteria should be applied for determining what distinct individual systems exist in the domain described by the theory. While property holism, as I said above, is surely the weakest (in the sense of least 'revolutionary' with respect to commonsense) consequence that can be derived from the evidence regarding entangled states, ontological holism could be argued for on other grounds. In particular, it could be, and has been, contended that it is necessary to endorse it in view of the results, discussed in chapter 2, related to EPR-like correlations and the violations of Bell's inequalities. Recently, Lange [2002] has done exactly this.[75] He suggests that in an entangled state

> "the whole particle pair isn't anything more than the sum of its parts [... and...] the wave-function collapse occurs over both wings because there aren't separate physical objects on the left and right until after the measurement has taken place, so locality is satisfied" [Ib.; 294].

Here, note, I do not need a conclusion to the effect that ontological holism is correct, or more plausible than property holism; but only that it is a *possible* interpretation of entangled systems, and there are arguments in its favour. And this has been uncontroversially shown to be the case. Therefore, without entering again into the details of the debate regarding quantum non-locality and EPR, it now seems legitimate to say that there

[75] The suggestion that quantum entangled systems may exemplify ontological holism is also present in Howard [1989]. There, Howard says that "maybe we can opt for radical ontological holism and still do some physics" [Ib.; 252] and, even more strongly, that "the universe is 'really' one, but once we put a specific question to it, it falls apart quite naturally into apparent parts" [Ib.; 253].

are no convincing arguments Saunders can have recourse to in order to break the ontological underdetermination pointed out in this section.[76]

Before concluding, two smaller remarks: first, the claim I have made is *not* that Saunders points at discerning facts that obtain only after measurement (this would miss the key fact that Saunders is not interested in strong or moderate discernibility, which is what the measured properties of the separate individuals would give) but that he has insufficient evidence for concluding in favour of weak discernibility (before measurement). Secondly, the foregoing objection does not contravene EEL: the property expressing the correlation among entangled fermions is surely real, independently of whether a measurement is actually performed on the particles, and this is not denied at any point. It is not certain, though, (to repeat once more) whether it actually is a relation holding between subsystems; or just a monadic property of the entire system as a whole (albeit one that will necessarily evolve so as to give rise to two anti-correlated particles). The supporter of the weak discernibility of fermions needs to exclude this latter possibility; however, it would seem that s/he can do so only on purely *a priori* grounds.[77]

So much for the second question that can be raised about Saunders' analysis. The third, and final, one will be formulated in a separate section, as it is more 'indirect' and has to do not with the treatment of fermions as individuals (because allegedly weakly discernible), but with that of

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[76] This seems even more correct once one considers that Saunders himself, as we will see in the next section, takes (or, at least, can be interpreted as taking) ontological holism as a natural perspective for understanding systems of indistinguishable bosons.

[77] On the other hand, as I pointed out already, the denial of the existence of actual properties of separate entities in entangled systems is also based on EEL, and it is therefore fair to stress that different conclusions could be drawn if EEL were not regarded as a basic postulate. However, EEL is commonly assumed in the interpretation of quantum mechanics, and Saunders seems not to rely on any specific assumption to the effect that it is *not* a valid postulate. Nor can he be regarded as having *shown* that EEL should be dispensed with.

bosons as non-individuals (because absolutely indiscernible). Importantly, the arguments that follow also apply to those who – unlike Saunders – do not intend to have recourse to very weak PII, and yet try to stick to PII as a valid criterion of individuation *by entirely sacrificing the assumption that the latter is a theory about individuals.*

### *3. Bosons and the Appeal to Non-Individuality*

After arguing that fermions are genuine individuals, Saunders goes on to consider bosons. Indistinguishable bosons, as mentioned earlier, cannot be individuated via weak discernibility, because they *can* be irreflexively correlated in the same way as fermions but, since EP does not hold for them, such discernibility is not warranted in all cases.[78] In the light of this, Saunders concludes that:

> "The only cases in which the status of quantum particles as objects is seriously in question are therefore elementary bosons [...; with respect to these, w]e went wrong in thinking the excitation numbers of the mode, because differing by integers, represented a count of things; the real things are the modes" [2006; 60].

As I will argue in what follows, this claim too is problematic when put forward from the reductionist perspective.

Saunders' use of the concept of 'mode' indicates that he has in mind the quantum-field-theoretic description of reality (basic field-points, whose excitations are taken to correspond to what we commonly take as particles, are indeed called 'modes'). That particles are not individuals is

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[78] Sticking to the spin example, two identical bosons can be found in states that attribute either spin up or spin down to both of them. In such situations, no correlation holds among the two bosons that makes them at least weakly discernible, and so very weak PII is violated.

plausible from the viewpoint of quantum field theory, where it can no doubt be motivated independently of philosophical considerations.[79] Not so, however, in the context of Saunders' treatment of standard QM, in which the choice of taking certain entities as non-individuals is *exclusively made on the basis of the assumption that PII is a valid criterion of individuation*.[80]

The natural interpretation of Saunders' claims (suggested by the very title of his paper) is that everything that exists is either an 'object' or a 'non-object', that the distinction depends on the things' identity conditions, and that PII is a criterion of object-hood because it allows us correctly to identify these conditions.

If this is what Saunders has in mind, however, a problem arises. Suppose that he claims that, since they are not made discernible by PII, the natural interpretation of bosons is the field-theoretic one according to which they are only epiphenomenal manifestation of the bosonic field as a whole. If so, we have a situation in which, according to Saunders, fermions are individuated by PII *provided* that ontological holism is excluded; and bosons are instead interpreted according to ontological holism *because* they violate PII. It seems clear that Saunders is forced to apply a sort of 'double standard', and that circularity arises as regards PII and the ontological interpretation of the relevant physical systems. This appears to represent one further confirmation of the fact that the generalist is faced with an ontological underdetermination in the quantum domain that s/he cannot break by only having recourse to the tools at his/her disposal. Either s/he first independently settles the

[79] In particular, although it is possible to interpret quantum field theory as a theory about individual particles, the usual interpretation is that particles are mere 'epiphenomena' with respect to the underlying fields.

[80] One should not forget the peculiarities of quantum statistics, of course. These, however, are not taken to represent a threat to the claim that particles are individuals by Saunders. Quantum statistics will be discussed in chapter 6.

question regarding the plausibility of ontological holism, or s/he must acknowledge that spin correlations cannot be employed for individuation and, consequently, fermions and bosons cannot be treated differently (and must both be regarded as non-objects from his/her perspective).

Another interpretative option is to assume that by 'object' Saunders means 'individual', as opposed to other entities that lack (part of) the identity conditions required for individuality and yet count as 'objects' in the sense attributed to the word by the perhaps more established vocabulary. That is, in the sense of being self-identical entities which are at best only cardinally countable when grouped together. On this construal, one can interpret Saunders as suggesting not that bosons are not objects at all, but rather that they are non-individual objects. This would allow him to avoid a holistic understanding of bosonic systems, as bosons would not 'dissolve' into unitary fields, but rather constitute 'aggregates' of countable non-individual entities.

In this case, though, a definition of non-individuality compatible with the reductionist perspective on identity and individuality must be provided. For, consider the following. Cortes [1976] starts from the Leibnizian idea that no two substances differ *solo numero*, and uses it to *define*, *à la* Quine, individuality as the relational property of discernibility from all other entities. From this, he derives that, according to Leibniz's view, non-individual objects (intended as indiscernibles) do not exist. He then goes on to argue that non-individuals (again, understood in a Leibnizian fashion) do exist, as demonstrated by the evidence of QM regarding bosons (in particular, photons), and consequently PII is false. Hence, Cortes effectively provides a straightforward *reductio ad absurdum* of the Leibniz-Quine position. But of course the situation changes if one claims that PII is in fact a valid criterion of individuation because it is only violated by *non-individuals, and the latter can be defined as such on grounds other than (in)discernibility.*

In chapter 1, when discussing (and defending) the non-synonymy of the terms 'individual' and 'particular', I suggested that a difference between individuals and non-individuals within the broader class of particulars could be meaningfully established with respect to identity conditions. And work in this direction has already been done in the literature (although in the context of the, related but distinct, discussion of vagueness). It is thus to this work that we can briefly look now.

Lowe [1994] argues - against Evans' [1978] well-known rejection of the possibility of 'vague' particulars - that for quantum particles it is the case that, although each particle is self-identical, it can be indeterminate whether one is identical to the other. Evans considered the property P of 'being indeterminately identical to *x*' to deduce that it cannot be indeterminate whether *a*=*b*. For, assuming that *a*=*b* is in fact indeterminate, *b* has P with respect to *a* but *a* does not, for every entity is determinately identical to itself (or so Evans holds). As a consequence, due to Leibniz's Law, *a* and *b* are determinately non-identical, because there is at least one formula that does not apply to both. Lowe replies that, by assuming that it is indeterminate whether *a*=*b*, one *ipso facto* assumes that both *a* and *b* have P, because the identity of the entity that P is made relative to remains indeterminate. Since both entities are indeterminately identical to *some* entity, P does not make them determinately distinct.

But how is it possible for particles *a* and *b* to be determinately self-identical separately but, at the same time, such that there is no objective fact of the matter as to whether or not *a*=*b*? French and Krause [1995] try to make sense of this possibility by tracing the source of ontic indeterminacy to the relations holding between entangled particles. They argue that quantum particles of the same kind differ from their classical counterparts only because of these relations, and so the root of their ontological peculiarity must be that there are non-supervenient relations making facts about *a* and *b* true without also determining which specific fact is true of which specific particle [Ib.; 22]. French and Krause claim that – once an ontology of relations is admitted – even assuming that particles are individuals

> "we cannot *tell* whether electron *a* is identical to *b*, or not [...and...] we cannot *in principle* tell this; [therefore] assuming that quantum mechanics is correct, we cannot tear away the veil of non-supervenience and get at what is 'really' going on. It is not an epistemic problem but an ontic one" [Ib.].

However (even granting that an in principle epistemic impossibility is equivalent to an ontic fact[81]), we have seen in the previous section that if one interprets the non-supervenient properties of entangled systems as relations, these suffice to make particles discernible and consequently, given PII, determinately distinct.[82]

French and Krause consider a second option, and put forward the idea that the peculiarities of quantum particles are due to the fact that concept of identity simply does not apply to them. In particular, that for

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[81] This might in fact be disputed, but appears to agree with the view - which we have deemed compelling at least as regards the issues being dealt with here - of metaphysics as something that coincides with the most general empirical truths, and that is consequently to be 'tested against' the evidence.

[82] One may claim that, even independently of relations, French and Krause explicitly say that in this scenario particles are vague *individuals*, and so this option is irrelevant in the present context. However, their claim that one may have vague individuals in quantum mechanics is based on the assumption that self-identity is sufficient for individuality (and, consequently, indeterminacy in numerical distinctness does not affect individuality). Here, instead, determinate numerical distinctness has been deemed necessary for individuality.

these entities it is not true that each one of them is identical to itself. Logics in which the expression $x=y$ is not a well-formed formula have indeed been developed in support of such scenarios. The most fully worked out examples are the formalisms based on the notion of a 'quasi-set', introduced, for instance, in Krause [1992] and in Da Costa and Krause [1997]. The basic idea is to posit as basic *Urelemente* so called *m*-atoms that are completely indiscernible and can be counted only cardinally. For such elements, French and Krause explain,

> "identity, as it is usually understood, lacks sense; in other words, these entities are linked only by a weaker relation (≡) [indistinguishability], which mirrors an equivalence relation, but the language does not allow us to talk about either the identity or the diversity of the m-atoms" [1995; 23].[83]

If this is correct, PII must then be understood as follows: *PII applies to all particulars*; if it establishes facts of identity and distinctness in agreement with the available evidence as regards countability, then it can be concluded that it picks out individuals; if, on the contrary, it turns out to be false, as in the case of bosons, then it is being applied to particulars that are not also individuals.[84]

[83] Moving along similar lines, Dalla Chiara and Toraldo di Francia [1993], point out that quantum particles cannot be uniquely labelled and propose to regard them as 'intensional-like entities', where the intensions - much in the spirit of Quine's conception of identity - are represented by conjunctions of intrinsic properties. On this construal, the extensions of the relevant natural kinds are collections of indistinguishable elements, called 'quasets'.

[84] It is important to point out the significance of the use of the verb 'to apply' here. Some authors (for instance, French [2006]) *assume* that the distinction between individuals and non-individuals is meaningful, and that PII only applies to the former. They feel consequently free to say that the issue of whether PII holds for non-individuals is simply obviated (and this is a possible explanation of the violations of PII by quantum particles). Although one may think that more needs to be said by way of justification of the assumptions being made, this position is in itself consistent. From a Quinean-Leibnizian perspective, however, PII is to be regarded as a principle of general applicability. Therefore, whenever it *applies, but is violated*, an explanation *must* be provided. The individual/non-individual distinction could perhaps be employed in order to formulate such an explanation along the lines being suggested here. This, however, demands an answer to the question of whether the distinction can be drawn at all, i.e., a coherent definition of non-individuality

However, I do not see how this can be of any help for the supporter of the reductionist account of identity and individuality. For recall that s/he *defines* identity on the basis of the conjunction of the formulas satisfied in the (first-order and finite) language. Namely, s/he assumes that identity and uniqueness of description are *the same thing* and one has a true *bi-conditional* of the form $\forall x \forall y(\forall F(Fx \rightarrow Fy) \leftrightarrow x=y)$. This entails that, from the Quinean-Leibnizian perspective, a thing's identity conditions are fixed as soon as it is determined which properties the thing possesses. But this *is indeed the case for all quantum particles.* Generalizing, it looks as though once, along Quinean lines, one reduces identity to uniqueness of description, one effectively gets rid of the very possibility of non-individual objects.

One might try to resist this conclusion by claiming that non-individuals have *indeterminate* self-identity. Translating again in Quinean terms, this would mean that it can be indeterminate whether an entity satisfies the same predicative formulas as itself. It might be argued that this is possible, because properties can be 'indeterminately exemplified' by things. In the cases in which this happens, the argument might continue, one has entities that satisfy conjunctions of predicative formulas indeterminately, and so possess indeterminate self-identity. However, even allowing for the possibility that properties (and conjunctions thereof) can be vaguely (i.e., not determinately) possessed by particulars, on a closer look this suggestion turns out to be untenable as well, because based on a fallacy. The indeterminacy of property-exemplification only causes the conjunctions of properties to be indeterminately exemplified; it does not entail that it is indeterminate whether a given individual has the same properties as itself. Suppose that

be formulated, by the reductionist. That this is not the case is what I will be arguing in what follows.

an individual *a*'s identity is fully defined on the basis of its colour C (say, because its other properties – and the relations it enters into - are not sufficient for discernibility). Now, it may be possible for C not to be determinately exemplified by *a*, so that it is indeterminate, say, whether *a* is red, and similarly for any other colour. But does the fact that *a* is not determinately of any colour imply that it is indeterminate whether *a* is of the same colour as itself (which is what would provide the grounds for attributing indeterminate identity to *a*)? As a matter of fact, it seems to me, there exists no such implication, and identity is a relation that holds between an entity and itself determinately, *regardless* of anything that can be the case about that entity's properties. Analogous remarks can be made of course as regards the numerical distinctness between things: if two things are numerically distinct as soon as they have distinct properties, then there is no space for indeterminate, or at any rate non-definable, numerical distinctness within a reductionist framework.[85]

It thus seems that the earlier, and more immediately plausible, interpretation of Saunders' claims about bosons as non-objects is the correct one, supported not only by what Saunders actually writes, but by the impracticability of the very distinction between individuals and non-individuals in the context of the reductionist view of identity and individuality.

What has just been said also entails a more general argument against the reductionist perspective. It now becomes clear that those reductionists who do not employ the notion of weak discernibility cannot account for many-particle system of indistinguishable quantum

[85] It is worth pointing out that a) the reasoning applies even if no property whatsoever is attributed to an entity (for in that case the identity of that entity is defined by an empty conjunction of qualitative formulas); and b) even if it is accepted that quantum mechanics does not attribute properties determinately (which, I suggested, is at any rate insufficient to argue for lack of identity), state-independent properties are nonetheless possessed by particles determinately.

particles either. Because even though they avoid making problematic assumptions with respect to the properties of entangled systems, for them too it is the case that the principle they employ for determining what distinct objects exist cannot be made consistent with the available evidence.

It can thus be concluded that, even accepting Saunders' argument in favour of weak discernibility for fermions, problems arise as regards the possibility of consistently extending the ontological account he proposes to bosons. And this can be generalised so as to equally apply to the position according to which *all* quantum systems of many indistinguishable particles are not composed of distinct objects/individuals.

### *4. Bohmian Mechanics*

Throughout the present chapter, the canonical interpretation of QM has been assumed. The reason for this is that, as explained at the beginning of the chapter, the orthodox interpretation of the theory, based on the idea of collapse of the wavefunction and on the mathematical formalism first defined by Von Neumann, surely is the established one. It is, therefore, the obvious candidate for being the object of a realist[86] look at science aimed to assessing whether an

[86] I take realism about scientific theories to be presupposed here because it seems to me that one needs to regard a given theory as a true (or approximately true) description of the world if one is to derive metaphysical conclusions from it - at least provided that metaphysics is considered, as seems plausible, as the study of fundamental features *of reality*. Of course, one may not be a metaphysical realist and yet be interested in studying metaphysics; or be interested in studying the metaphysical consequences of theories one does not regard as true or approximately true; or take some other theory/interpretation as a true (or approximately true) description of the world. In all these cases, the question regarding the metaphysical consequences of alternative theories becomes relevant; and even more so if, as I suggested is the case with PII, the metaphysical claims one intends to study are in effect nothing but

empirical justification can be found for PII and the reductionist perspective based on it. Not surprisingly, it is for such a standard view of QM that the results regarding identity and individuality that have been described and discussed at length above have been proved and shown to arise with the greatest clarity. Nevertheless, as is well-known, alternative interpretations and altogether different theories have been developed, which rose to the status of serious and legitimate candidates for the explanation of the micro-world. And of course it is a possibility that these alternatives have rather different consequences from those of the orthodox theory. It is thus necessary to look (if briefly) at these other theories and interpretations too from the perspective of the present study.

Things appear to change radically with respect to the preceding discussion if one considers Bohmian mechanics, which is a paradigmatic example of a theory presented as distinct from, but empirically equivalent to, standard quantum mechanics. Bohmian mechanics is based on an essentially classical ontology, with traditional particles whose behaviour is determined by 'guiding fields'. Some authors (for instance, Bohm himself [1952], also together with Hiley [1993], Albert [1992] and Valentini [1996]) are realist about the latter and stress the ontological dualism between particles and fields. This leads them to conceive of the theory as a second-order theory, with classical particles moving under the influence of various forces. However, a minimal interpretation of Bohmian mechanics has also been developed (see, for instance, Dürr, Goldstein and Zanghì [1992]) which dispenses with fields and makes do with particles and the guidance equation only. In such an interpretation, Bohmian mechanics becomes a first-order theory with particle velocities as the fundamental quantities.

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very general empirical statements extracted from science. This question will be dealt with in this section and in the Appendix.

In general, Bohmian mechanics can be described in terms of five postulates:

i) The state-description of an *n*-particle system is given by specifying the total state and the actual position of each of the *n* particles;

ii) The quantum state evolves according to the Schrödinger equation $i\hbar\frac{d|\Psi\rangle}{dt}=\hat{H}|\Psi\rangle$ where *H* is the Hamiltonian H= $-\sum_{k=1}^{N}\frac{\hbar^2}{2m_k}\partial^2/\partial q_K^2+V(q)$ with *V(q)* denoting the classical potential and $m_k$ the mass of the *k*-th particle;

iii) The velocity of an *N*-particle system is defined as $v^{\Psi}(Q)=\frac{dQ}{dt}$ where $v^{\Psi}(Q)=(v_1^{\Psi},v_2^{\Psi},...,v_N^{\Psi})$ is a velocity field on the configuration space that evolves as a function of Q according to $v_k^{\Psi}=\frac{dQ_k}{dt}=(\frac{\hbar}{m_k})\mathrm{Im}[\frac{\Psi^*\partial_k\Psi}{\Psi^*\Psi}](Q_1,...,Q_N)$;

iv) The 'quantum equilibrium' configuration probability distribution for an ensemble of systems each having quantum state Ψ is given by $\rho=|\Psi|^2$;

v) The quantum state gives rise to a quantum potential U= $-\sum_k(\frac{\hbar}{2m_k})(\frac{\partial_k^2R}{R})$ determining a related force field which causally affects the particles.

This last postulate is what the different formulations of Bohmian mechanics disagree over. It is the source of the suggestion of a dualist ontology of fields and particles, as the quantum potential, according to some, is necessary correctly to account for the evidence (most notably, to explain particle trajectories) and must be regarded as determined by real fields because of the requirements of a proper causal explanation. Others, as mentioned, consider the influence of quantum potentials and of the related fields as being purely nomological.

What is relevant here is that, even without entering into the details of the formulation of the theory, it is possible to claim that Bohmian mechanics has the peculiar feature of defining an ontology with more or less classical discernible individual particles.[87] This is due to the fact that Bohmian mechanics postulates that position is always unique for each particle. As a consequence of this, the essential feature that makes weak PII true in the classical domain is retained, and particles can be said to be always discernible in Bohmian mechanics. This comes as no surprise, as one of the basic assumptions of Bohmian accounts of the quantum world is that the available evidence can be perfectly explained in the classical terms of impenetrable particles moving in space along continuous trajectories and interacting with each other.

What does this entail for our discussion?

Surely, were Bohmian mechanics to be taken as the true description of microscopic reality, PII would be vindicated, at least in its weak form (essentially, as a claim of impenetrability). However, Bohmian mechanics is not regarded as the (approximately) true theory by the majority of the members of the scientific community; and an evaluation of its pros and cons may provide a hint as to why this is the case. On the one hand, besides postulating an ontology in continuity with the classical one, Bohmian mechanics allegedly solves the measurement problem without postulating wavefunction collapses or recurring to the concept of decoherence. On the other hand, though, it is a manifestly non-local and contextual theory; it makes specific assumptions about the particles'

[87] The guiding fields might be real, but for them questions of individuality do not arise. Hence, they can be ignored in the present context.

distribution and (in some cases) the existence of real guiding waves which causally affect particles but are not, in turn, affected by the latter; and the list could perhaps continue. The debate regarding Bohmian mechanics is in effect open in the scientific community. At any rate, it is certainly not obvious that Bohmian mechanics has any more right to claim the role of (approximately) true description of the microscopic world than orthodox quantum mechanics. Its classical, or almost classical, ontology is, to be sure, an element that many see as an intuitively compelling reason to explore it, and perhaps to regard it as preferable. But this alone cannot be taken to be a sufficient motivation for choosing Bohmian mechanics over the alternatives. It surely is not, at any rate, in the present case: we are discussing exactly on what grounds one's ontology (in particular, one's notions of identity and individuality) should be defined; and this obviously has a bearing, among other things, on the comparative evaluation of the ontological consequences of our theories. Does orthodox quantum theory truly *entail* anything highly non-classical and counterintuitive?[88]

It seems to me that the right assessment of the situation is that there is, at most, a sort of underdetermination of the 'right' theory by the evidence and the other factors normally taken into account when choosing among alternative theories. And that, consequently, even if one were to ignore the fact that the orthodox interpretation is the dominant one (say, on the basis that this could merely be a historical contingency), no univocal conclusion could be reached anyway. Therefore, while the standard interpretation of quantum mechanics, I argued, suggests that PII and the reductionist view of identity and individuality are incompatible with the evidence, once Bohmian mechanics is also taken onto account

[88] In the second part of the thesis, I will suggest that it does not.

one can at best claim that the existing alternatives for describing the quantum domain point in different directions. In view of the fact that (at least as far as I could see) there is no convincing non-empirically-based argument for PII and reductionism, though, this is still sufficient for reaching a conclusion with respect to the issue on which the first part of the thesis focused. For it means that, even once our best knowledge of the world is taken into account, *no positive reason emerges for endorsing the reductionist view of identity and individuality.*

### *5. Where Do We Stand? A Recapitulation*

We set out initially to study the nature of individuality. Having defined individuality as the condition in virtue of which an entity possesses determinate identity conditions (in particular, it is determinately self-identical, and determinately distinct from all other entities), we then focused on the notion of identity. With respect to the latter, an alternative to the view that identity is a primitive relation was identified by making reference to the work of Quine. According to Quine, the identity of an entity can be defined as the conjunction of non-identity involving formulas that the entity satisfies in the language (provided that the latter has a finite vocabulary and is first-order). This entails acceptance of PII as a principle that can be employed as a criterion on the basis of which to attribute individuality to things.

PII, we have seen, has not been convincingly shown to be necessarily true except in a metaphysically non-informative form. It is thus necessary for the reductionist to try to justify the Quinean view and PII on the basis of the empirical evidence. With respect to this, physics, and in particular quantum mechanics, is the best candidate for defining the non-logical vocabulary on the basis of which to (attempt to) provide a reductionist account of things' identities. As we have seen in this chapter, however, quantum particles falsify PII in the orthodox theory of quantum systems. This claim is controversial for fermions, for which weak discernibility (distinctness brought about by irreflexive relations) might be an option, but is straightforward for bosons. As regards fermions, to make recourse to weak discernibility requires, first of all, a commitment to the thesis that relations can be ontologically prior to their relata. Whatever one's reaction is regarding this, Saunders' claim that fermions are weakly discernible can at any rate be rejected as not conclusive, on the basis of the fact that it cannot be claimed with certainty that the properties allegedly individuating them truly are relations. As regards (at least) bosons, if - for some reason - one insists on endorsing PII, an explanation must be given of why it is violated by such particles and yet is still to be regarded as a valid criterion of individuation. Such an explanation, it seems, must be based on a distinction between either objects and non-objects or non-individual and individual objects (particulars). Each of the two differentiations, however, must be drawn with respect to identity conditions, and the latter must in turn be explained in Quinean terms because of the very reductionist thesis with respect to identity that characterises the position. This entails, though, that in fact the distinction cannot be made at all within the reductionist framework. One could react by presenting Bohmian mechanics as an alternative. Bohmian mechanics, indeed, vindicates weak PII, as it attributes unique positions to the particles. It, however, is at best an equally valid alternative to orthodox quantum mechanics. From this, it follows that my previous claim of *refutation* of the reductionist perspective is only weakened: what we now have is a form of *underdetermination* by the evidence of a principle which, however, *does not have any other justification.*

For all these reasons, the reductionist view of identity and individuality can legitimately be deemed unconvincing. Even though it has by no means been conclusively refuted, and so the alternative to it - based on primitive identity - need not be considered necessarily correct, it is nevertheless interesting now to look at the latter in some detail. The issues to be dealt with in doing so belong, I believe, to the sort of 'proper' metaphysics – more decidedly concerned with the domain of the conjectural - the peculiarity and relevance of which I argued for at the end of the previous chapter. First and foremost, a new issue now emerges that concerns what ontological reconstruction (if any) can be offered (in terms of primitive identities) of reality in general and of the domain that has been taken into account in this chapter in particular. An assessment in this sense requires the application of specifically ontological categories, products of purely philosophical speculation, for the development of a consistent and plausible general scheme, to be then applied for the interpretation of the (part of) reality described by microphysics.

It is to this kind of enterprise that I will turn in the following chapters.

### *Appendix: Identity and Indistinguishability in Other Interpretations of Quantum Mechanics*

The relevance for the present discussion of the fact that there is more than one theory and interpretation of the quantum domain has already been stressed; and the possibility of deriving different conclusions from each one of these different theories and interpretations has also been illustrated via a consideration of the two emblematic, and opposite, alternatives constituted by orthodox quantum mechanics and Bohmian mechanics. It is interesting, nevertheless, to look at other possible theoretical descriptions of reality (albeit briefly in an Appendix) from the perspective of the present study.

There is more than one modal interpretation of the quantum formalism, but for present purposes it suffices to consider Van Fraassen's ([1972] and [1991]). This does away with the projection postulate and distinguishes between the actual, determinate state (*value state*) of the system and the description of its possible future evolution (*dynamical state*). The dynamical state (unless it corresponds to a pure state) only constrains the possible value states, and is not an objective description of the system. An objective interpretation of probability is thus restricted to value states only, and the EEL is consequently not accepted, as the system might actually possess a specific value for an observable even without it being the case that the quantum state is an eigenstate of the observable corresponding to that value. All this re-introduces the possibility of individuation via PII at least for certain particles, namely those to which distinct value states can in fact be attributed.

Both Bohmian mechanics and modal interpretations reject the idea of collapse. Other alternatives keep collapses in the picture, but modify other elements.[89]

[89] Another interpretation that, similarly to modal variants and Bohmian mechanics, drops the idea of collapse of the wavefunction is Everett's [1957] relative-state interpretation, which inspired other important developments such as the many-worlds interpretation (DeWitt [1971]), the many-minds interpretation (Albert and Loewer [1988]), the many histories interpretation (Gell-Mann and Hartle [1990]) and the relational approach (Rovelli [1996]). These views, however, appear to have significant differences from standard QM only with respect to what a measurement (broadly intended) is and determines in the universe, not as regards the properties attributed to physical systems before measurement. The latter thing is, however, what is relevant in the present context, so we do not need to get into the details of these interpretations here.

One possibility in this sense is that represented by spontaneous collapse theories, such as those presented by Ghirardi, Rimini and Weber [1986] and Ghirardi, Pearle and Rimini [1990]. These have been developed with a view to solving the measurement problem and the paradoxes connected to it, such as the well-known Schrödinger's cat paradox. It is hypothesized that collapses of the wavefunction are not induced by measurements but are spontaneous in nature. To express this, two new constants are introduced in the formalism, which define the localization accuracy and the mean localization frequency respectively. While the original model, based on discontinuous 'jumps', as acknowledged by Ghirardi himself,

> "does not allow to deal with systems of identical constituents because it does not respect the symmetry or antisymmetry requirements for such particles" [2002],

this does not happen for its subsequent evolution, known as the 'continuous spontaneous localization model'. Concerning the latter, it seems fair to say, the only difference being in the dynamics of the collapse, no significant divergence exists with respect to standard QM as regards property attributions, identity and individuality.[90]

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[90] It must be pointed out that there is no agreement over the interpretation of this theory. The original formulation was shown (by Albert and Loewer [1990]) to fall prey to the 'tails problem', consisting of the fact that the collapse of the wavefunction does not determine a complete localisation. Albert and Loewer [1996] suggested an interpretation rule known as the 'fuzzy link', only requiring the presence of most of the wavefunction in the relevant region of configuration space. But this, in turn, gave rise to the 'counting anomaly' (Lewis [1997]), consisting of the fact that for systems of *n* objects (with a large enough *n*), each one of them is located in a region and yet the compound is not. The 'mass density' link (see Ghirardi, Grassi and Benatti [1995]) has been then presented as a valid alternative (Monton [2004]). According to it, *n* objects are located in the region if there are *n* regions for which a mass density distribution in ordinary three-dimensional space meets certain requirements. However, Lewis [2005] argues that the mass density link gives rise to the 'location anomaly': one can be sure that *n* objects are located in a region but also that, at the same time, not all of them will be found there upon observation (and not for practical limitations). Even though somehow tangent to our present concerns, these remarks show that it is not obvious that the spontaneous collapse theory satisfactorily solves the measurement problem.

One last interpretation that is worth mentioning (in spite of its manifest lack of popularity) is the ensemble, or statistical, interpretation. Einstein notoriously believed that quantum mechanics could describe only ensembles of similarly prepared systems, and this idea has been developed by Ballentine [1970]. According to the ensemble interpretation, the wavefunction is an abstract mathematical object that is not directly connected to real individual systems, and only gives us information about the latter indirectly, by describing ideal ensembles of systems with the same features. Because of this, nothing can be said about specific physical systems given the quantum formalism. It follows that nothing can be said about metaphysical issues such as those regarding indiscernibility, identity and individuality either.

# *Chapter 4*

# *Primitive Identity and Substrata*

In the first part of the thesis, the Quinean view of identity and individuality was shown to be unconvincing. This chapter begins by offering a tentative diagnosis of why it, nevertheless, looks so attractive to some. It is claimed that this is the result of a misunderstanding of certain (legitimate) empiricist demands. This heralds the beginning of the second part of the thesis, based – as explained earlier - on 'proper' metaphysics as a conceptual enterprise aimed to provide hypothetical accounts of the structure of reality. In this part, the view of identity and individuality as primitives is defended, articulated and ultimately applied for an interpretation of the relevant physics. In the present chapter, I analyse the possibility of claiming that the individuating work is performed by bare particulars. While - it is argued - most traditional criticisms raised against such a view miss their intended target, difficulties exist for an ontology of bare particulars related to the fact that the latter must be intended as necessarily attached to (some) properties if certain important ontological commitments are to be avoided. This leads one to explore the plausibility of nominalism. The last part of the chapter begins this exploration by examining how nominalism fares with respect to similarity.

## *1. Suchness and Thisness*

Adams' [1979] distinction between a thing's qualities as *suchnesses* and its individuality as *thisness* was introduced in chapter 1. While the supporters of PII as a criterion of individuation attempt to get rid of the latter notion as otiose, according to the alternative position individuals are such in virtue of their possessing *primitive thisness*, also called *haecceity*.[91] The analysis performed in chapters 2 and 3 has shown that the reduction of the individuality of things to their suchnesses is not supported by *a priori* metaphysical arguments, nor by empirical evidence. Identity and individuality, therefore, could plausibly be intended as rooted in primitive thisnesses, and an assumption to this effect will indeed be taken for granted in the rest of the thesis.

From this perspective, sense is immediately made of the idea that counterexamples to PII can be identified: on this construal, individuality cannot be said always to coincide with discernibility - the Principle of the Identity of the Indiscernibles is false – because primitive thisnesses can make exactly resembling bundles numerically distinct. Of course, letting the quantifier in PII range over thisnesses as well is not an option, for it would contravene the no-trivialisation requirement specified earlier, according to which predicates containing reference to things' identities cannot be considered when establishing facts of identity and distinctness.[92]

One clarification: *to have* primitive thisness/haecceity as a metaphysical property is the same as *to be* an individual. The only difference is that individuality being a brute, primitive fact, it is best understood not as a property, but as a *mode of being*. In Scholastic terminology, a mode is the necessary way in which a thing exists. The

[91] This term derives from the Scholastic notion of *haecceitas*. According to Duns Scotus and his followers, *haecceitates* are additional metaphysical factors that individuate bundles of properties uniquely. It is, that is, the unique nature of instantiated (bundles of) universals. In contemporary use, however, haecceity has become a synonym of primitive thisness, to be considered as a metaphysical property that can be possessed by any particular.

[92] Since primitive thisnesses can be seen as corresponding to predicates expressing self-identity, they are undoubtedly trivialising properties.

difference can be explained by saying, borrowing Gracia's words, that modes

> "are positive determinations over and above the intensions of what they modify, determining its state and way of being, but without adding to it a new entity. [...] The extension of a mode does not go beyond the extension of what it modifies" [1988; 135].

Rejection of the Quinean-Leibnizian view indeed requires commitment to the view that at least some entities are such that individuality is their fundamental mode of being. These entities are said to possess primitive thisness as a metaphysical property.[93]

Specific advantages immediately emerge from the application of this view of identity and individuality to the areas that have been considered in the previous chapters. In general, the problem of accounting for (alleged) unwelcome limitations on the expressive powers of language does not arise. In particular, the idea that identity and individuality are primitive turns out to be relevant with respect to the interpretation of quantum mechanics: if the individuality of the particles is rooted in their thisnesses, then no detailed study of their properties is required for assessing whether or not they are individuals. In fact, it can be assumed that they *are* individuals until further evidence is brought to bear against a 'traditional' ontological understanding of the domain in question.[94]

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[93] The concept of thisness is discussed by Swinburne [1995], who provides an interesting analysis of possible types of individuals and of whether or not thisness is possessed by each of them.

[94] I am not claiming that quantum particles *certainly* are individuals. The weaker claim that is being put forward is that, as long as intuitions to the effect that the basic constituents of reality are individuals – and that the formalism of the theory mirrors this fact – are regarded as compelling, primitive thisnesses provide an acceptable basis to believe that this is truly the case.

But alongside these advantages there are a number of potential difficulties that could be exploited for a reconsideration of the reductionist perspective. In particular, it seems to me, the alleged problems fall into three categories:

1) The notion of primitive thisness arguably violates legitimate empiricist requests;
2) It is arguably impossible to define a consistent ontology of particulars endowed with primitive thisness;
3) It is arguably impossible coherently to account for the elementary constituents of reality (as described by quantum mechanics) on the basis of such an ontology.

This chapter will be devoted to an analysis of the first problem and to the consideration (and rejection) of one classical response to the second, based on a two-category ontology of universals and bare particulars (or *substrata*).

## *2. Primitiveness, Empiricism and the Principle Acquaintance*

The first supposed difficulty above relates to an interesting question that naturally arises at this point of the thesis. The question regards why exactly, if PII is not a necessary truth and there are good reasons not to take it as a true empirical generalization either, the Quinean-Leibnizian perspective should be seen (as it often is) as more natural and intuitively appealing than the competing view based upon primitive thisness. And why, correspondingly, in the light of the conflict between PII and the evidence, what Shimony calls a 'peaceful coexistence' should be sought by sacrificing the idea that our physical theories describe individuals – and, consequently, individuals are what 'populates' the basic level of reality - rather than PII itself, which has not been justified on grounds other than it worked so far and is not violated at the level of commonsense, and in general by classical objects.

In his [2003], Saunders endorses what, following O'Leary-Hawthorne and Cover [1996], he calls the *generalist picture*. The generalist, he explains, endorses

> "a distinctive and uncompromising form of realism, a commitment to the [ontological] adequacy of purely descriptive concepts" [Ib.; 289-290].

Van Fraassen ([1977-8] and [1991]) endorses an analogous *semantic universalism*, that is, the thesis that all factual descriptions can be given completely in terms of general propositions that make no reference to individuals. An exemplary quotation from Van Fraassen is the following:

> "At bottom, everything that can be said about the world, can be said in purely general statements, without modalities. There is no thisness beyond suchness, but every actual individual is individuated already by the properties it has in this world; hence can be denoted in principle by a definite description in which the quantifier ranges over actual existents alone. [In this perspective...] every choice of conventional identifications which does not violate the identity principle that no two existents in world *a* have all the same properties in *a* [is equally good; and... in] a full model, no proposition peculiarly about a particular entity can be necessary" [1977-8; Part IV].

For yet another quotation along these lines, Hintikka remarks that

> "each possible world contains a number of individuals with certain properties and with certain relations to each other. We have to use these properties and relations to decide which

> member (if any) of a given possible world is identical with a given member of another possible world. Individuals do not carry their names on their foreheads; they do not identify themselves" [1970; 410].

All these quotations are clear expressions of the Quine-Leibniz reductionist position. But where do the convictions that they express come from? Why should one believe that our experience and science - which, as we have agreed, should be employed in order to characterise our richest non-logical vocabulary - justify the idea that qualities enjoy such a privileged status? By going so far as to modify our established interpretation of (certain elements of) reality when it clashes with this type of belief, and putting faith in PII ahead of all the rest, some authors in effect seem to embrace the view that there are *a priori* – or at least very strong - reasons never to distrust the Quinean-Leibnizian view. And yet these reasons have not been explicitly formulated.

It seems to me that the reductionists' best argument in this sense is one that is formulated on the basis of an important epistemological criterion first explicitly advocated by Russell in his early writings. Russell ([1912; Ch. 5] and [1917]) endorses a *Principle of Acquaintance* setting empiricist constraints on reasonable beliefs. After distinguishing *knowledge by acquaintance* (direct, non-inferential knowledge) and *knowledge by description* (knowledge that is mediated, inferred from the direct knowledge of something else), Russell claims that a person can refer determinately and with certainty only to things that s/he knows by acquaintance. According to Russell, the only knowledge by acquaintance that we have is that of *sense-data*. Everything else is known by description: a middle-sized physical object, a table for example, is only known indirectly for, in order to say that we know it, we need to rely on the proposition 'the table is the cause of such-and-such sense data', which does not refer to something we are directly acquainted with. The result is that only demonstratives pointing to sense-data can be taken at face value, and not doubted; we can only be certain, that is, about the impressions coming from our senses. The expressions referring to these are defined by Russell as *logically proper names*.

Of course, the Principle of Acquaintance needs to be 'refurbished' for it to satisfy the needs of the present-day empiricist. To begin with, it can be argued that Russell's limitation of knowledge by acquaintance to sense-data is too restrictive, and that the Principle of Acquaintance can be relaxed so as to include at least some of the properties of physical objects in the range of what is known with certainty.[95] Those who support PII as a metaphysical criterion of individuation appear indeed committed to such a move from *phenomenalism* to (at least partial) *direct realism* about material objects. In the context of the present discussion this would entail, among other things, that PII licenses conclusions about things out there, not (only) about complexes of sense data. Moreover, the range of what can be taken as warranted on the basis of a criterion of acquaintance must now necessarily include scientific claims, because it is science rather than direct experience that we take nowadays as the best available description of the properties of things.

These are, to be sure, highly non-trivial commitments, as direct realism is not a completely uncontroversial position; and it is at least unclear in what sense the claims of our best science are so secure that they can be considered as knowledge by acquaintance. However, for the sake of argument, this specific (neo-)Russellian approach to knowledge will be granted the reductionist, while noticing that, if his/her position

[95] See, for example, Brewer [2001; esp. 251-255].

fails when taking these things for granted, then it will all the more fail in the context of a more restrictive empiricism.

The essential point for present purposes is that the Principle of Acquaintance seems to clearly press one to avoid commitment to the existence of things that are not known (or, *a fortiori*, know*able*) directly, and subscribe only to claims about what is known by acquaintance. Since, it is suggested, we are (can be) acquainted with the qualities that things possess and nothing else, these latter claims must be about the things' properties and nothing else. Therefore, we should explain everything about the world surrounding us in terms of (known) properties; and suspend judgment whenever this is not possible. The Principle of the Identity of the Indiscernibles should consequently be seen as the 'best we can get' as regards a criterion of individuation: given the characteristics of our epistemic access to reality, the reduction of facts of identity and individuality to qualitative facts is *not only plausible, but necessary*.

This line of reasoning may appear correct, but I contend that it is in fact fallacious. On the one hand, it is questionable whether only qualities are known by acquaintance. On the other hand, even if this were the case, it would *not* entail a commitment to the bundle theory and PII (nor should it be taken to strongly push towards such a commitment).

As regards the first point, for example, Allaire ([1963] and [1965]) suggests that property-less particulars are known by acquaintance as the source of the numerical distinctness of things. He claims that:

> "When presented together [two qualitatively identical objects...] are presented as numerically different [and *t]hat difference* is presented as is their sameness with respect to shape, (shade of) color, and so on. [And thus...] something other than a character must also be presented. That something

> is what proponents of the realistic analysis call a bare particular" [1963; 4].

And concludes that:

> "Individuals are the carriers of numerical difference as directly presented to us" [Ib.; 8].

It might be objected (as first done by Chappell [1964]) that Allaire's reasoning is not entirely based on phenomenological description, and so should be rejected. This appears indeed correct. However, at the same time, such a reply highlights the key distinction which is essential for my second point.

Suppose one perceives (or, using more specific terminology, 'is presented with') a green spot. Surely, because of this, s/he can say that s/he is acquainted with a green sense-datum, or a green object.[96] Surely, different explanations can be offered as regards the numerical identity of the green spot as *one* spot in the eyes of the observer, including both those stating, *à la* Allaire, that the spot is known directly as one independently of the properties it exhibits; and those suggesting, in Leibnizian-Russellian fashion, that the fact that the spot is one and is distinct from everything else can itself be reduced to relations among instantiated universals. However, in a completely analogous manner, whether 'green' is a universal, or the perceived green is an unrepeatable particular, also remains entirely open. But *only the former alternative can ground PII as a criterion of individuation.*[97] It thus looks as though

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[96] Depending on his/her philosophical inclinations. Strictly speaking, as already explained when discussing Russell, talk of an 'object' that has the property one perceives already goes beyond knowledge by acquaintance. The object is inferred on the basis of one's perceptions. This is the reason for Russell's subscription to phenomenalism, much anticipated in the works of the great British empiricists such as Berkeley, Locke and Hume.
[97] Remember the connection between PII and the bundle theory described in chapter 2.

acquaintance in itself does not allow one to say anything about the ontological categories that underlie one's experience: something additional to the mere data of experience is in fact required in order to formulate *any* ontological explanation. That is, analysis is needed in addition to the data of direct experience not only by the view postulating primitive thisnesses, but by the reductionist position too.

Of course, it is possible to reply that properties can be known directly *as an ontological kind*: for example, the Russell of *The Problems of Philosophy* [1912] took universals to be something we are acquainted with as soon as we experience a property. However, this would be insufficient to establish the truth of the bundle theory, because one also needs to *exclude* the existence of bare particulars; but once it is accepted that universals are known by acquaintance, it is to say the least unclear why one should reject Allaire's analogous hypothesis for bare particulars as 'carriers of numerical difference'.

At any rate, it seems to me much more plausible that an ontological view can only be arrived at by *thinking*; and that it is a very important truth that, while what is being experienced directly can (perhaps) be straightforwardly identified, what sort of ontological categories underlie this experience is not obvious and surely does not immediately follow from perception (as, after all, should be inferred from the general lack of agreement in this respect). A crucial differentiation, therefore, can and must be drawn between one's *object of acquaintance* and *what (in terms of ontological categories) exists*. If it is true that a hypothesis as regards the latter requires *analysis* regardless of whether or not there is a correspondence between the two, it seems correct to claim, along with Clatterbaugh [1965] and Hochberg [1966], that the *Principle of Acquaintance cannot be employed to establish any ontological view* *directly*. Of course, it does so indirectly, as an ontological explanation must not contradict the evidence obtained via perceptual experience and best science. However, an ontological account can never be shown to be true or false by *only* making reference to experience (and science).

Suppose one (believes that one) is directly perceiving two individual objects. When so presented, one is acquainted with both each object's qualitative features *and* with a fact of numerical distinctness. This is something *the reductionist does not reject*. Given the above discussion, though, his/her argument can only be that, since whenever we are acquainted with the latter type of facts we are also acquainted with the former, then *perhaps* it is the case that, by knowing facts about the things' qualities, one *ipso facto* also knows facts about these things' identities. However, with this s/he only offers one among the available ontological explanations of the experienced facts. And one that can only be formulated on the basis of a specific metaphysical hypothesis and conceptual analysis, and is surely not an incontrovertible *datum* of experience.

The foregoing reflections, I hope, have clarified the origins and true strength of the reductionist perspective. As far as I am concerned, in the light of what has been said in chapters 2 and 3, I take them to be sufficient to claim that accounts of reality alternative to the reductionist perspective might turn out to be preferable to the latter and yet remain wholly within the boundaries set by a sensible empiricism.

Before moving on, some remarks on the general perspective on metaphysics assumed in this second part of the thesis can now be formulated. The underdetermination of ontological explanations by empirical data just pointed out could be considered sufficient for avoiding certain questions and hypotheses altogether: this was essentially the basis of the condemnation of metaphysics by the members of the Vienna Circle. I do not think, however, that stressing the need for all our hypotheses, claims and questions to be rooted in reality naturally leads one to dispense with all forms of intellectual inquiry which are not wholly expressible in the form of empirical questions and verifiable/falsifiable statements. To the contrary, hypotheses such as those just considered, connected to actual facts but also containing an irreducible conjectural element, may have both an independent interest in themselves and an important potential with respect to furthering our knowledge of reality. In this connection, Popper's view of metaphysics as playing a heuristic role appears to be more mature than the neopositivist complete rejection of metaphysics, as it leaves room for the purely conjectural to become empirically testable at a later stage, which is a possibility that cannot be discarded *a priori*.[98] When no empirical data at all can be brought to bear, on the other hand, it seems necessary to accept that 'rational' knowledge makes room for some sort of (religious, artistic, or what have you) intuition. It is only once it is intended as scepticism about the latter as a form of knowledge on a par with rational, empirically-based knowledge, it seems to me, that scepticism about metaphysics is justified.

### *3. Bare Particulars*

The traditional alternative to the bundle theory examined in chapter 2 holds that properties are indeed universals, but there also exist

[98] In my terminology, this of course means that I conceive of the boundary between experimental metaphysics (i.e., very general science) and proper metaphysics as blurred and relative to our knowledge and practical possibilities.

individuating bare particulars, or *substrata*,[99] for those properties. This view is intuitively supported by the fact that drawing a distinction between individuals and their properties appears natural at the level of both experience and language. Philosophical analysis should, of course, be able to transcend common sense. However, it is sensible to begin the exploration of the possibility of avoiding acceptance of the bundle theory (and of all its consequences) by looking at what seems to be the most 'natural' ontology from the perspective of the layman.[100]

A particular *x*, the argument in favour of bare particulars goes, must be distinguished from all the properties that *x* exemplifies and taken as a property-less bearer, or 'support' (this is what the word 'substratum' means) for such properties.

The essential idea underlying the concept of a 'substratum' dates back to the works of Aristotle. Reflecting on the notion of substance, Aristotle argued in the *Categories* that all attributes are necessarily attributes *of* some entity that is the subject of predication; and that, for this reason, the subject must be something ontologically distinct from what is predicated. In the *Metaphysics*, Aristotle elaborated on this point and introduced the well-known distinction between *matter* and *form*. Anything in the universe, he claimed, is composed of a quantity of matter, which is 'qualified' by the particular form(s) that inhere(s) in it. Properties, identified with this latter formal element, were seen by Aristotle as dependent on matter, i.e., as in need of a material support and unable to exist without it. At the same time, they were said to be

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[99] These two expressions will be used interchangeably in what follows.

[100] It must be pointed out that it is logically possible to claim that properties are borne by bare particulars but they are themselves particulars and not universals. However, ontologies in which bare particulars are introduced normally assume that properties are universals, as this seems to provide a relatively simple account of both individuation and similarity. In this section, therefore, the notion of a bare particular will be discussed under an assumption of realism about universals.

essential in order for the subject to actually be something, in the sense of *existing as* one specific kind of thing rather than another. According to Aristotle, then, matter needs form to be qualified, and form needs matter to perform its very role of defining the 'way in which things exist'. In the third chapter of Book Z, he writes:

> "When all else is stripped off evidently nothing but matter remains. For the rest are affections, products, and potencies of bodies [...] and not substances" [1029a; 10-25].[101]

The ground for the move from the Aristotelian concept of matter to the notion of a bare particular was prepared in the 17th century by Locke. In his *Essay Concerning Human Understanding* [1690(1975)], he argues that the claim that substrata exist does not require complicated philosophical elaboration and is in fact very simple to justify as compelling. Along lines clearly reminiscent of Aristotle, Locke claims that:

> "Everyone, upon inquiry into his own thoughts, will find that he has no idea of any substance [...and yet will have to admit of the existence of an] unknown support of those qualities we find existing, which we imagine cannot subsist *sine re substante*, without something supporting them [.... W]e call that support *substantia*, which according to the true import of the word is, in plain English, standing under or upholding" [Ib.; Book 2, Ch. 23, Secs. 2-6].

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[101] Notice that Aristotle did not conceive of substances as composed of matter and form as two ontological 'ingredients'. Rather, he believed that matter and form are two inseparable aspects of every substance. It is actually debated whether substances for Aristotle are real composites of matter and form or, instead, what is known as 'substantial forms'; namely, the result of the individualization of universal forms, which is what gives rise to matter. At any rate, this has to do with Aristotelian exegesis rather than with the present discussion. For our purposes, it is enough to point out the matter/form distinction, and the idea that matter is something other than the formal, qualitative element.

Locke generally prefers to use the word 'substance', but he often uses the term 'substratum' in the same sense.[102] For him, a substratum acts as bearer of properties and individuates the latter as the properties of a specific individual. It is debatable whether Locke reluctantly embraced the notion of a substratum or tried instead to emphasise its limitations, and perhaps even its unacceptability. At any rate, it is the distinction itself, rather than the specific convictions entertained by a specific thinker, that we are interested in at present.

Contemporary philosophers in the analytical tradition indeed regard the notion of a bare particular as denoting a well-defined ontological category. According to some, it is in fact a necessary notion in one's ontology.

Martin [1980], for instance, argues that the Lockean (but, we have seen, originally Aristotelian) device of 'partial consideration' - i.e., the thought of a thing under an incomplete description, in this case, *qua* bearer of properties, but deprived of all its qualities - shows that substrata are necessary in order for objects to exist at all. Substrata, he claims, are the element *about* the objects that determines their individuality and, thus, their being what they are [Ib.; 6-9]. In the present context, this suggestion can be formulated as the idea that bare particulars are the *loci* of primitive thisness. In Bergmann's words:

> "Bare particulars neither are nor have natures. Any two of them are not intrinsically but only numerically different" [1967; 22-23].

[102] See, for example, Book 1, Ch. 4, § 18; Book 2, Ch. 23, Sec. 1; Book 2, Ch. 23, Sec. 5; and Book 4, Ch. 6, Sec. 7. Nowadays, following Aristotle's talk of 'primary substances' as opposed to 'secondary substances' as kinds of individuals, the concept of substance is commonly conceived of as denoting individual entities. It is therefore advisable to only use the term 'substratum' (or 'bare particular').

As mentioned, the structure of our language and thought *prima facie* confirms the plausibility of this view. Nevertheless, alleged problems exist for any ontology postulating bare particulars over and above properties that are directly related to the ontological nature of bare particulars themselves.

First of all, there is a supposed epistemological issue. If all we experience of things are properties, how can we get to know substrata? If we cannot, on what basis do we feel compelled to introduce them? We already in fact dealt with these questions in the previous section. The apparent force of this objection only arises from a conflation between levels of the sort described in the previous section. That is, a conflation between the domain of what we know by acquaintance and that of the basic ontological categories. Once one makes the plausible assumption that we are only acquainted with empirical facts but ontology needs more than that, the application of the Principle of Acquaintance as a guide to what facts we must acknowledge does not affect in any way the range of *explanantes* that can appear in our ontological hypotheses.

In other words, scientific/rational method correctly demands that we be suspicious of (alleged) entities that are not only inaccessible in our current epistemic situation, but epistemically inaccessible in principle. However, philosophical analysis might show that postulating such entities is necessary for explaining facts that are within our epistemic reach. In the case being considered, it might turn out to be not only perfectly legitimate but also necessary to postulate the existence of substrata despite Locke's famous *dictum* that a bare substratum is a mysterious 'I know not what'.

LaBossiere [1994; 367-368], for example, argues that we know substrata by inference from the fact that we experience properties as belonging to the same individual and as somehow connected to each other. According to him, the only way to explain this while avoiding an infinite regress of relations is by postulating something ontologically distinct from properties that binds the latter together. This is due to the fact that the postulation of properties binding other properties appears unable to provide a satisfactory answer to the question regarding the nature of the bond; whereas substrata are postulated exactly as capable of binding without being in turn bound by something else.

Were one to undertake a specific examination of substrata, claims such as these should be assessed in detail.[103] At any rate, arguments such as LaBossiere's suffice to show that the epistemic status of substrata is not in itself a reason to steer clear of ontologies that acknowledge the existence of such entities. However, further objections come from a consideration of the ontological nature of bare particulars.

One idea that is often found in the literature is that the very concept of a bare particular acting as carrier of properties is inconsistent. In his [1952], Sellars argues that the sentence "Universals are exemplified by bare particulars" can only be expressed formally as $\forall x(\exists\Phi(\Phi x)\rightarrow\neg\exists\Phi(\Phi x))$ (with $x$ denoting a particular and $\Phi$ a universal). Sellars stresses that this formula is in effect the claim that "If a particular exemplifies a universal, then there is no universal it exemplifies", which is obviously self-contradictory. This objection is easily answered, however, for of course a bare particular is only bare if it is considered *in abstraction* from the fact that it actually instantiates properties. Bare particulars do exemplify properties, and yet are *in themselves* deprived of any property. Indeed, the response can continue, their condition of

[103] For instance, I will argue later on that the reality of a bond does not necessarily require an actual binding entity, and can instead be conceived of as the holding an internal relation. Were the latter actually the case, LaBossiere's argument would obviously lose force.

intrinsic bareness – far from being contradictory with exemplification - is *necessary* for the latter to occur.

Even less weighty are those arguments that aim to reject truly bare particulars by noticing that if they are truly bare then they have at least the property of 'being absolutely property-less' (and in fact, given their ontological features, many more, such as 'being a constituent of material objects', 'having the capability of exemplifying properties' etc.). Surely, the supporter of bare particulars neither wants nor has to say that no properties *whatsoever* can be attributed to substrata (in which case, one could not speak about them); but just that – in itself - a bare particular does not have any 'first-order' property. Bare particulars, that is, only possess non-empirical features that allow them to be given a metaphysical description. All 'real' properties are exemplified by them as distinct entities to which they get somehow 'attached'.

A slightly more incisive objection is that, if substrata exist as bearers of real properties, then they are real themselves, and must consequently exist in space and time, which entails that at least one empirical property – space-time location - must be attributed to them. This difficulty too, however, can be defused: space-time location is (normally) taken not to be an intrinsic property, but rather a relational property (between material entities and either space-time points or other entities).[104] It is therefore possible to conceive of substrata as existing in some space-time 'setting' that provides them with a specific location, and yet being completely devoid of any intrinsic physical content, as the view requires.

[104] Of course, I am referring here, on the one hand, to the substantivalist (Newtonian) view that takes space-time points as individual entities that have 'ontological priority' over the entities that get located in space-time; and, on the other hand, to the relationalist (Leibnizian) view, according to which space-time is nothing but the 'web' of mutual relationships between the things that exist.

Those who are not convinced by this[105] can just add a specification to the definition of a bare particular - which does not seem crucially to affect its ontological status: bare particulars, they can claim, are fundamental entities that have no properties whatsoever except ('second-order', logico-metaphysical ones and) space-time location.

Another criticism is that bare particulars, that are introduced (among other things) in order to act as individuators, cannot in fact do so. Loux argues that:

> "As they present themselves to the substratum ontologist, substrata are qualitatively indiscernible, so that the entities supposedly guaranteeing the diversity of ordinary objects, are themselves subject to the very problem their introduction was meant to resolve" [1978; 151].

Mertz [2001], after stating the principle according to which two entities having exactly the same constituents are identical (he calls it the "'constituent' analog of the Identity of the Indiscernibles" [Ib.; 48]), similarly concludes that:

> "All bare particulars in having no constituents have exactly the same constituents and so are identical" [Ib.; 52].

These criticisms, of course, cannot be avoided by attributing discerning empirical properties to the bare particulars in themselves, as the latter are assumed to be property-less. Also, even if one makes the (dubious) assumption that bare particulars have simpler constituents, the latter would, at any rate, themselves be bare particulars for which the

[105] See the authors suggesting that space and time are intrinsic properties of physical objects mentioned in chapter 3.

same problem would in turn arise. It seems to me that the above objections are nevertheless mistaken. As regards Loux, he claims that

> "for the same reason the bundle theorist could not appeal to the identity-properties of indiscernible substances in explaining their diversity the substratum theorist cannot appeal to the identity-properties of substrata to explain their diversity" [1978; 151].

But this is plainly wrong. The bundle theorist cannot appeal to putative identity-properties of indiscernible substances because in his/her view the latter are bundles of universals, and universals lack the required identity-properties by definition. The idea of a bare particular is, to the contrary, specifically introduced in order to be able to refer to well-defined identities without the need for a reductionist explanation. The fact that bare particulars can be regarded as possessing primitive thisness undermines the analogy which Loux's argument is based on.

As regards Mertz's objection, the principle invoked by Mertz is certainly correct if it is intended as entailing that things with *numerically the same* constituents are identical. But Mertz is in effect only in a position to claim that bare particulars have *the same number* of constituents. And, given this, one can follow Sider in specifying that to endorse the idea of a bare particular

> "does not mean accepting distinct individuals with the same parts, of course [...], since each individual is its own part" [2006; 394, fn. 1]

and then add that for these parts too (indiscernibility notwithstanding) numerical distinctness is determined by the fact that each one of them is endowed with primitive thisness. Hence, Mertz's 'constituent analogue of the Identity of the Indiscernibles' fails to entail the numerical identity of all bare particulars.

A different attack against bare particulars comes from a consideration of their relationships with properties. Bare particulars are variously said to 'instantiate', 'exemplify', 'be tied to' or 'bind' properties. But is the positing of these relations (which, I take it, can be considered equivalent to each other) enough satisfactorily to explain the nature of things as 'possessing' qualities?

In objecting to what Moreland [1998; 260] calls the 'tied to' relation, Mertz [2001] answers negatively. Mertz argues that, since a bare particular is

> "devoid of all intension or content [...,] there is no reason why both Round and Square could not by tied-to [it]" [Ib.; 50-51].

But the latter scenario must be ruled out as impossible, and so an ontology of bare particulars must be incorrect, for it is incapable of providing an explanation of a basic truth about reality.

I take this to be a weak criticism. Intending to invalidate the reply that the mentioned impossibility is due to the nature of properties, Mertz points out that it is perfectly possible to claim both that 'Round is contrary to Triangle' and that 'Square is contrary to Triangle', so connecting contradictory properties to the same *relatum* via the same relation. Therefore, Mertz concludes, the problem must regard bare particulars. However, this argument is not compelling. Ontologies without substrata must equally explain why certain properties are never bundled together. And if (as suggested by Mertz's reference to the need for some 'content') a satisfactory response can be given along the lines that it is simply a fact about the world that for every *determinable* (say 'Shape') there can only be one *determinate* (say, 'Square') *for each particular*, such a response will suffice independently of one's understanding of 'particular'. That is, it will work in the case of bare particulars as in any other ontological account, for the described 'mutual exclusion' just depends on the way properties 'work'.

A related objection (see, again, Mertz [1996; 163-173]) is that, once one introduces an exemplification relation between particulars and properties, then an infinite regress arises as soon as we attempt to account for the relation between the exemplification relation and each one of its relata. In formulating the objection, Mertz explicitly refers to Russell and Bradley. Bradley's well-known regress [1908; esp. 21-25] appears particularly relevant here. Bradley assumed that

1) Whenever entities stand in a relationship there is a further entity, a relation, in virtue of which these entities are related; and that
2) Relations are universals that are instantiated (exemplified) by their relata.

Since, he claimed, 2) entails that relations are related to their relata, by 1) the existence of one relation requires the existence of two other relations, and so on *ad infinitum*. Since this is unacceptable, Bradley concluded, relations are not real. Mertz applies this reasoning to the exemplification relation, suggesting not that it is not real, but rather that to posit bare particulars exemplifying properties has intolerable consequences, and one should therefore avoid doing so.

However, it seems to me that to assume that substrata can become tied to properties without giving rise to infinite regresses of 'tied to' relations is perfectly possible. Substrata constitute an ontological category of their own, and to attribute this peculiar feature to them is certainly legitimate. Mertz could reply that this is *ad hoc*, but one may respond in turn that the *ad hoc*ness is inevitable, in the sense that substrata *must* be posited as entities with this peculiarity if one wants to have a satisfactory ontological explanation of the fact that particulars have properties at all. Also, having recourse to a '*tu quoque*' type of counter-argument, it can be objected to Mertz that – once the reasoning leading to Bradley's regress is accepted - it is at least equally *ad hoc* to assume that regresses do not arise with respect to the compresence relation which is necessary (in order to explain how distinct property-instances give rise to individuals) in ontologies with properties only.[106]

On the other hand, I take it that a much more satisfactory answer would be simply to deny that the connection is determined by a real entity. As we have seen, LaBossiere, for example, claims that it is perfectly plausible to conceive of bare particulars as possessing primitively a 'binding ability' which is not itself a property to be 'reified' (exactly in the same way as they possess numerical identity primitively) [1994; 364]. Similarly, Sider argues that substratum theorists need not and should not reify instantiation, as they can perfectly well take it as a primitive part of their 'ideology' [2006; 388].

A more interesting problem arises from the fact that if bare particulars constitute an autonomous ontological category, absolutely independent of properties for their existence, then the substratum ontologist must provide an explanation for the impossibility of bare particulars that do not instantiate any properties.

[106] In the latter case, one may add, the 'connecting' relations would be of the same ontological kind as the connected entities, i.e., universals, and the potential for an infinite regress seems even more evident.

Against this, Sider argues that it could be in the essence of a bare particular to instantiate properties; he adds that if this is taken to amount to an *ad hoc* assumption as to the impossibility of truly bare particulars, then the analogous claim that there cannot exist non-bundled universals, necessary for the bundle theorist, must be seen as equally unacceptable [Ib.; 390-392].

My opinion is, at any rate, that truly bare particulars in fact pose no problem for the substratum theorist, independently of any specific metaphysical assumption of (im)possibility, at least once it is denied that bare particulars are known by acquaintance. In this case, it makes perfect sense to claim that bare particulars can exist without exemplifying properties, and yet we only know them when they do. More specifically, one can legitimately claim that bare particulars are the cause of our experiencing numerical distinctness; that is, of our recognizing distinct individuals as such, but they can only be objects of experience when they are parts of complexes also instantiating properties.[107]

The criticisms usually raised against the notion of substratum can, it seems, all be met. Admittedly, though, what has just been said by way of answer to the objection against bare particulars not instantiating any property allows to see that further considerations might, after all, make a commitment to substrata uncomfortable.

In his [1990], Campbell argues that:

[107] Notice that this positing of real but in principle unknowable entities seems to be less problematic than the analogous claim, that the bundle theorists might be forced to make – perhaps in order to avoid counter-objections such as Sider's above, that non-bundled universal-instances can exist and yet we only know them when bundled with other universal-instances. For in this latter case it is, to say the least, unclear why an instance of a universal should only be knowable when compresent with other universal-instances, given that any universal-instance has 'empirical content' and should, consequently, be epistemically accessible independently of the relations it enters into with other instances of universals.

> "All causal action is exerted by way of the properties of things and all effects are effects on the properties of things. The substratum, precisely because it is without properties, including passive powers, ought to be *totally immune* to all causal activity. *A fortiori*, it ought to be unscathed by every destructive process. Yet if we introduce metaphysically indestructible substrata, we are undertaking *a priori* natural philosophy of a most discreditable kind. What items can you produce or postulate, belonging to the natural order, that are *necessarily* immune from destructive alteration?" [Ib.; 9].

One way of formulating a potential problem with bare particulars is, then, to say that by admitting of them as entities not instantiating any property, not only do we accept the possibility that something exists which is in principle unknowable. We are also forced to accept that this something remains forever outside the natural order of things, essentially based on the possibility of change, interaction, creation and destruction.

One may respond that this is by no means a problematic assumption to make. For example, it is possible to hypothesise that whenever an individual ceases to exist, in fact its bare 'core' continues to be an actual entity. After all, we have seen earlier that truly bare particulars do not necessary represent an unconceivable possibility. Still, Campbell has a point in emphasising that bare particulars seem to be endowed with a peculiar feature the avoidance of which in one's ontology is likely to appear welcome to everyone.

While that bare particulars do not have causal efficacy appears to be an unavoidable assumption, one might try to reject Campbell's reasoning by denying that all causal action is on properties. Perhaps it is also the case that properties can causally affect bare particulars. However, it appears difficult to develop even the basic outlines of a theory of causal interaction between bare particulars and properties. It seems that, by the bare particularist's own admission, the *only* relation between properties and bare particulars is that of exemplification. Surely, this cannot mean that the needed account cannot be formulated.[108] For the time being, at any rate, a different response to Campbell's objection appears much more plausible.

LaBossiere suggests that Campbell's argument can be answered by claiming either that each bare particular exemplifies at least one property necessarily, or that each bare particular exemplifies necessarily at least one property (i.e., cannot be property-less, and whenever it loses a property it gains another one) [1994; 370]. This is possible, and indeed re-establishes the acceptability of bare particulars. But at a non-negligible price: that of making bare particulars *existentially dependent* on entities (properties) that are instead commonly regarded as subordinate to them. Such dependence might be considered unproblematic: for instance, Sider (as mentioned before) suggests that - in spite of a widespread understanding of the distinction - what is known as a *thin* (as opposed to a *thick*) particular[109] can and should be conceived of as only bare at the conceptual level. He claims that, despite the fact that it must be thought of in abstraction from the properties it exemplifies,

> "[t]he intrinsic nature of a thin particular is given by the monadic universals it instantiates" [2006; 389].

Questions regarding the plausibility of Sider's understanding of thin particulars aside, however, further analysis shows that this type of response to Campbell's difficulty is in fact unavailable for the bare particular theorist. For, if bare particulars are existentially dependent on

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[108] In which case, the rest of this section would lose its force, but the problem pointed out in the next would remain.

[109] The distinction is due to Armstrong. He takes the thin particular to be the "thing taken in abstraction from all its properties" [1978; 114], and the thick particular to be the "particular taken along with all and only the particular's non-relational properties" [1997; 124].

one or more of their properties, then one has two alternatives, both of which turn out to be unsatisfactory.

If properties are universals, then bare particulars are existentially dependent on specific instances of universals. But since bare particulars act as individuators of concrete particulars and universal-instances are made distinct from other universal-instances by the fact that they belong to a specific concrete particular, it follows that it is the fact of being exemplified by a specific bare particular that individuates universal-instances. Hence, we a have circularity: the bare particularist claims that bare particular *x* exists because of the fact that (or insofar as) it instantiates property-instances a, b, c,.... But s/he is also forced (by the nature of universals and his/her views on individuation) to say that universals A, B, C,... are instantiated as a, b, c,... because the latter instances are exemplified by *x*.

If properties are tropes[110], instead, then on a construal such as that suggested by LaBossiere and Sider the particularity of the tropes attached to the bare particular (particularity which is primitive and not itself caused by the bare particular) grants the existence of the latter. But what role does the bare particular play, then? Perhaps, as LaBossiere contends, a bare particular does not individuate, but unifies tropes in a single concrete particular. The internal unity of substances too, however, appears to be warranted here independently of bare particulars: if bare particulars exist only thanks to *n* tropes being 'glued' to them, then the tropes are 'doing something together', as it were, independently of the bare particular and, specifically, prior to the existence of the latter. The step from this to the idea that bare particulars simply play no additional

[110] That is, particularised qualities which admit of numerical distinctness in spite of exact similarity. See Stout [1921] and [1923], Williams [1953], Campbell [1981] and [1990], Simons [1994].

role to that of tropes at all, and can therefore be dispensed with altogether is, of course, very short.[111]

Thus, we see that the sort of existential dependence of bare particulars on properties envisaged by LaBossiere to overcome Campbell's objection (and also supported by Sider) is not only unappealing for reasons having to do with the usual understanding of thin particularity, but also not viable. The bare particular ontologist who wants coherently to subscribe to the theory must therefore admit that bare particulars exist completely unaffected by change (or, alternatively, provide an account of how properties can causally affect bare particulars, which appears rather difficult, if not impossible, to formulate).

An analogous difficulty comes from the consideration of possible worlds and trans-world identity, and has to do with the idea of a 'bare identity'.

Chisholm [1967] argues that if two individuals *a* and *b* in the actual world do not have any essential properties, then there can be a possible world in which *a* and *b* 'switch roles', that is, exchange all their properties without also exchanging their identities. But then one is forced to admit of 'bare identities', that is, of things whose identities are determined independently of their properties. Truly bare particulars, obviously enough, must possess bare identities, as they (in the established understanding) do not have any properties essentially attached to them. But since according to the ontologies with bare particulars the latter are the 'cause' of the things' identities, it follows that all individuals have bare identities in these ontologies. Is this something we are ready to accept?

[111] The most promising way to make this step is via the postulation of an internal relation connecting the tropes directly (see Simons [1994] and Denkel [1997]). More on this in the next chapter.

The scenario just described is, of course, connected to what is known as *haecceitism*. Kaplan takes the latter as the

> "doctrine that holds that it does make sense to ask – without reference to common attributes and behaviour - whether this is the same individual in another possible world" [1975; 722].[112]

While surely not inconsistent, Chisholm seems to suggest, a commitment to bare identities is unappealing because it entails *strong* haecceitism, which severs the link between the identities of things and their properties *entirely*. *Weak*, or *moderate*, haecceitism leaves instead some space for properties to determine the things' identities and is, for this reason, to be preferred. Would we be ready to accept that, say, Socrates would have been Socrates even if the bare particular constituting him had not been tied to *any* of the properties actually exhibited by Socrates (not even, say, manhood)? It seems not. Indeed, we tend to think that an entity would not have been the same (not only not the same kind of) entity if it did not have at least some of the features it actually has (and especially so in the case of human beings).[113]

The important point for present purposes is that in this case too, in order to avoid what seems to be a clearly undesirable consequence, bare particulars need to be connected to some properties. In the case of

[112] See also Lewis [1986; 221].

[113] See the treatment of haecceitism in Adams [1979] and Ten Elshof [2000]. Davis [2004] formulates a related objection: he argues that if a concrete particular *x* has a specific bare particular as its individuating constituent, this means that the bare particular in question is necessarily the individuator of *x*; but this entails in turn that the bare particular has the property of 'being the individuator of *x*' in every possible world, which makes it essentially connoted by an impure property that presupposes exactly what needs foundation, namely, the identity of *x*. The present difficulty is, however, even more fundamental, as it has to do with the fact that the bare particular can be regarded as *being x*. In other words, while Davis is assuming the weak haecceitistic idea that a bare particular identifies the concrete particular it happens to constitute insofar as the latter is a particular with specific properties, the real problem is that truly bare particulars identify the concrete particulars they constitute *independently of any property*.

Socrates, for instance, one may include manhood, and perhaps other properties (being a philosopher, having been accused by the Athenians, having died on 399 B.C. etc.), in the 'nucleus' of properties essential to him, and so necessarily tied to the bare particular constituting him. However, this entails, again, an ontic dependence of bare particulars on at least some properties.

If this dependence is intended in the existential sense, the difficulty considered in the previous section re-emerges. Perhaps the dependence can be intended not in the sense that the bare particular would not exist at all if it did not exemplify certain properties, but rather in the sense that it would not in that case exist as the entity constituting *that* particular object, i.e., as the individuator of *that* specific entity which it is one of the constituents of. However, since every bare particular *exclusively* exists as a property-less entity provided with a primitive identity thanks to which it individuates the complex it is part of, this is equivalent to the claim that the bare particular does not exist if not connected to certain properties, and we again have the problem of existential dependence.[114]

The only alternative remaining is to maintain that bare particulars are not dependent on any properties for their identity and existence and yet, for some reason, the identity of an object is determined by its bare particular *only once the latter is tied to certain properties.* That is, that although bare particulars are fully autonomous entities, the individuating work is not done by bare particulars alone. But if such work is *not*

[114] For, if an entity only exists as something with a function, the fact that it cannot perform such a function unless certain circumstances are the case makes the entity existentially dependent on those circumstances and their subjects. Since the individuating function of bare particulars depends, obviously enough, on their identities, one can also formulate the present criticism as the claim that bare particulars are existentially dependent on properties because they are dependent on them for their identities. The idea that identity-dependence is constitutive of existential dependence appears very plausible. It is defended, for instance, by Lowe ([1998; esp. Ch. 6] and [2005]).

*entirely* done by bare particulars, why not say that individuation does not require a bare particular *at all*?

As in the case of the previous difficulty, one may object that the things' identities may be determined independently of bare particulars (e.g., by their properties as unique particulars, or by their locations), but bare particulars are still needed as the 'unifying factors' making it possible that scattered properties give rise to unitary objects. However, it is at least unclear why the unifying factor must be reified: both for universals and tropes, internal relations may legitimately be invoked 'gluing' the properties together into a single concrete particular. This becomes especially plausible if a lot of metaphysical work has been already attributed to properties that bare particulars were, on a first instance, expected to do.

In the case of the difficulty with strong haecceitism too, therefore, the bare particularist must either accept a strong metaphysical doctrine entirely *a priori*, or acknowledge a form of dependence between bare particulars and properties that undermines the world-picture s/he subscribes to. Where does all this leave us?

I see the situation as follows. It has been established earlier that any ontological explanation of the basic facts we want our ontology to explain can only be evaluated on the basis of philosophical analysis, not on the basis of a criterion of acquaintance (provided, of course, that such an explanation is compatible with the available empirical evidence). This means that, given the same facts as *explananda*, several ontological views acting as empirically equivalent *explanantes* should be compared on grounds other than explanatory power. That is, on the basis of criteria such as internal consistency, simplicity, economy, entailed consequences and so on. It is exactly an evaluation of different ontological accounts along these lines that this second section of the thesis aims to offer.

Now, in chapters 2 and 3 I suggested that the bundle theory in its canonical (and most plausible) formulation fares badly already at the explanatory level: in particular, as far as an account of individuation is concerned. The bundle theory, as we have seen, is committed to a principle, PII, that has not been convincingly shown to be necessarily true and also appears in conflict with the empirical evidence. To avoid this latter conflict and stick to PII, in particular, the bundle theorist is forced to either re-describe reality in terms of undeniably less intuitive ontological categories; or choose a specific physical theory as the (approximately) true description of reality on the basis of extra-scientific elements.

In this chapter, I argued that to have recourse to bare particulars does not appear a very good choice either, this time for reasons having to do with ontological economy and with the nature of the posited entities. On the one hand, an ontology of bare particulars requires commitment to *two* basic categories – particulars and properties; on the other hand, even though it can avoid doing so without inconsistency (by endorsing an *a priori* thesis to the effect that bare particulars are unaffected by change, and strong haecceitism), such an ontology is likely to make one of the posited categories (bare particulars) essentially dependent on the other (properties). But if this is actually the case, then one is led seriously to question the very idea of an ontology with bare particulars (also recall, in connection to this, the traditional doubt concerning bare particulars as unknowable in themselves). Obviously enough, this in turn requires the individuation of plausible alternatives. The option emerges at this point of considering whether the truly best available ontological explanation of reality is a one-category ontology with neither bare particulars nor universals.[115]

A moment's reflection on the available categories suffices to show that this means that it is now necessary to evaluate the viability and strength of a *nominalist* ontology: namely, one that denies that properties are universals, and states instead that only (non-bare) particulars exist. Specifically, we need to see whether it is possible to endorse a nominalist ontology and satisfactorily explain individuation, similarity and the unity of properties in complex entities as is required from any ontology, while avoiding inconsistency and implausibility in the light of the evidence and also maximizing economy, simplicity and avoidance of 'collateral' ontological commitments. Were this the case, one would clearly obtain an overall picture which is preferable to those considered so far.

Of course, nominalism straightforwardly accounts for the dynamics of individuation. In a nominalistic setting, it is just a basic fact that particulars exist; and the fact that they (or at least some of them) are self-identical and numerically distinct from everything else can equally be regarded as fundamental. It is equally obvious, on the other hand, that the main difficulty for a perspective that does away with universals is that of explaining similarity. In the remainder of this chapter, I will argue that universals are in fact not needed in order to account for similarity, and that nominalists have a perfectly plausible story to tell regarding facts of resemblance.[116]

[115] As the bundle theory and ontologies with both bare particulars and universals, considered so far, are the only possible ontologies compatible with realism about universals.

[116] The nature of complex particulars in a nominalist setting will be dealt with in the next chapter, where a specific form of nominalism will be endorsed and articulated.

### *4. Similarity and the Alleged Indispensability of Universals*

The argument in favour of the idea that it is necessary to commit oneself to the existence of universals might be seen as a sort of *indispensability argument.* Such arguments conclude that some kind of entity must exist by showing that the assumption that it does exist cannot be dispensed with without explanatory loss in some domain. A classic example is the argument for the reality of numbers on the basis that eliminating numbers from our postulated ontology would leave physics severely impoverished.[117]

The idea that only the existence of universals can explain the resemblances among things that we experience has indeed been the starting point for the realist view of universals from Plato onwards. However, what sort of indispensability one is talking about, and whether universals are really indispensable are questions that require detailed analysis.

One way of trying to establish the indispensability of universals might be (and has often been claimed to be) through a consideration of ordinary language. Indeed, we use the *same word* to refer to what we consider the *same property* exemplified by many individuals. However, as mentioned in chapter 1, Ramsey [1925] famously argued (in opposition to Russell) that there is in fact no valid argument to the effect that *the structures of our language* show that universals must exist. The fact that our usual way of talking makes a distinction between particulars as subjects and universals as attributes cannot – in itself - be taken to point to an intrinsic difference between two ontological categories. A proposition such as 'Socrates is wise', Ramsey explains, is completely

[117] See, for instance, Quine [1960a] and Putnam [1979].

equivalent to the (albeit less frequently used) proposition 'Wisdom is a property of Socrates'. In this alternative rendering, what is commonly considered to denote a universal becomes the subject of discourse, and so the alleged correspondence between linguistic structures and ontological ones is immediately undermined.

Quine's [1953] argument against the necessity of universals is rooted in a different but related idea, connected to his general views about language and ontological commitment. In his words,

> "*entities of a given sort are assumed by a theory if and only if some of them must be counted among the values of the variables in order that the statements affirmed in the theory be true* [...; one...] frees himself from ontological commitment [...if...] he shows how some particular use which he makes of quantification, involving a prima facie commitment to certain objects, can be expanded into an idiom innocent of such commitments" [Ib.; 103].

In the light of this, it

> "may happen that [...the...] method of abstracting universals is quite reconcilable with nominalism, the philosophy according to which there are really no universals at all. For the universals may be regarded as entering here merely as a manner of speaking – through the metaphorical use of the identity sign for what is really not identity but [qualitative] sameness" [Ib.; 117-118].

Quine's idea is thus that quantification determines the only criterion for ontological commitment; and that, since it is not necessary to quantify over abstract entities (and it is in fact possible systematically to eliminate everything that is abstract from the range of one's quantifications), this criterion fails to provide a basis for realism about universals.

Ramsey's and Quine's analyses complement each other in an interesting way. Ramsey's aim is to undermine the belief in an alleged one-to-one correspondence between linguistic and ontological categories; Quine gives support to the idea that there is no such correspondence by showing that our language can be replaced without cognitive loss by a language where one category (that of abstract nouns) does not play any role whatsoever.[118]

An obvious rejoinder is that language does not *necessarily* mirror reality, and yet the more frequently used structures of language have been shaped in the light of true facts about types of entities: in particular, regardless of language, there appear to exist entities that have the peculiar feature of being *multiply instantiable*, that other entities do not have. As to Ramsey's argument, then, it is true that 'Socrates is wise' can be reformulated as 'Wisdom is a property of Socrates', where 'Wisdom' appears as the subject of the sentence; nonetheless the property denoted by 'Wisdom' retains its peculiarity of being attributable to many individuals besides Socrates. Similarly, against Quine it might be objected that, even though the use of abstract terms can be consistently avoided, an explanation of why we normally use the same words and concepts to refer to entities apparently exemplified by many, distinct individuals - that we take to be *similar in that respect* - is still required.

All this seems to license the conclusion that considerations about language cannot be used for determining conclusions about ontological

[118] It is fair to point out, though, that Quine did not suggest that nominalism is the correct ontology. Despite his general scepticism about abstract entities (see the paper he wrote with Goodman [1947]), his point appears rather to be that *whatever* type of entity can be consistently eliminated from the range of the quantifiers in one's language can accordingly be excluded from one's ontological commitments. As a consequence, there is *in particular* no reason to believe in the reality of universals.

matters of fact, no matter whether they appear to count in favour of an ontological commitment or in support of the dispensability of a certain ontological category.[119] Realism about universals, in particular, is not established by linguistic analysis but neither is it refuted by it. It is thus a direct ontological analysis of facts of similarity, rather than an examination of the ways in which we express them via our language, that must be undertaken in order to establish whether realism about universals is compelling or not.

The basic ontological argument in favour of universals is that the similarities between particular things require the postulation of multiply instantiable entities. It is the celebrated *one-over-many argument*, first devised by Plato.[120] The argument can be formulated as follows:

1) Any property P exemplified by a particular is ontologically distinct from that particular;
2) Since it can (and does in fact) happen that many particulars all have *the same* property P, P can be (is) exemplified by more than one thing at the same time;
3) Therefore, P is separate and distinct from each particular and is a 'one-over-many';
4) Since P must always be available for predication, an entity exists that is the most perfect case of P-ness, and it is everlasting;
5) Whatever is, like P, a one-over-many, separated, and everlasting entity that gets exemplified by concrete particulars is a form (i.e., a universal);

[119] This need not be read as a general statement. Even though I am sceptic about the ontological significance of linguistic analysis *tout court*, it suffices here to regard the presented conclusion as holding in the case of the debate over realism about universals.
[120] It is commonly agreed that Plato first introduced it and what he called Forms in his *Phaedo* [65d4-66a3].

6) Therefore, every actual property is in reality an instantiated form.

In particular, Plato believed in the existence of a world – distinct from ours - constituted only of unchanging, perfect and unique forms, or *Ideas*. It is open to debate whether for Plato forms are predicable of themselves or just 'are what they are' (that is, whether or not self-predication reduces to identity in the case of forms); and whether they are always simple or instead – at least in some cases – complexes that admit of some degree of analysis. However, it is uncontroversial that Plato holds that all the things in the universe we inhabit are related to the forms by a special relation, that of *partaking*. Considering, for instance, the property of being beautiful in its relation to the idea of Beauty, Plato has Socrates say:

> "It seems to me that if anything else is beautiful besides Beauty Itself, it is beautiful on account of nothing else than because it partakes of Beauty Itself. And I speak in the same way about everything else" [100c3-7].

As shown by the reasoning summarized in 1) - 6) above, endorsing such a metaphysical picture allegedly allowed Plato to explain similarity across multiplicity, that is, why the same property can be predicated of many subjects and also be exemplified in different ways by different subjects. The Platonic view of properties, however, meets with well-known problems: if properties are conceived of as ideas actually existing in a heavenly realm distinct from the actual world (more generally, and to use the technical definition, if they exist as *ante res* universals), an explanation of the relation between them and what we experience must be given. But this explanation seems impossible to develop due to the inevitability of infinite regresses of the sort hinted at earlier when discussing the exemplification relation between bare particulars and properties. Plato himself realized this in his *Parmenides*, where [131e-133a] he laid the basis for the argument that, thanks to Aristotle, came to be known as the *third man argument*. The classical rendering of this argument (which gives the name to the argument itself) concerns the universal 'manhood', or 'being a man':

1) If *x* is a man, *x* is a man in virtue of *x*'s participating in the form of manhood, and this form is a paradigm of which *x* is a likeness;
2) Paradigms and their likenesses are similar to one another (to varying degrees);
3) If any two things are similar to one another, they are similar by participating in some one form;
4) Therefore, if *x* and manhood are similar to one another, there is some further form in which they both participate that makes them similar;
5) Therefore, there is another form of manhood, call it level-2 manhood, in which *x* and the initial (call it level-1) manhood both participate, and in virtue of which they are similar;
6) (...and so on *ad infinitum*).

In the light of this reasoning, Aristotle rejected *transcendental*, *ante res* universals and argued that properties should, instead, be understood as *immanent (in rebus)*. That is, that universals are real entities, but they do not have to be – indeed they cannot be - distinct from their instances; instead, they are 'fully present' in those instances.[121] This move avoids the third man argument, since universal forms and particular qualities

[121] For Aristotle, then, *in rebus* universals constitute the formal element that qualifies matter.

(instantiated by real objects) are numerically identical (not just similar) and for this latter type of fact no explanation is required.

Even though several contemporary authors, aptly modifying or defending the Platonic account of the relationships between universals and actual entities, still endorse *ante res* realism about universals[122], it is this Aristotelian perspective that appears more plausible nowadays. The most strenuous current defender of realism about universals along Aristotelian lines is undoubtedly Armstrong (see, for example, his [1978] and [1989]). He presents his position as an *a posteriori* (or 'scientific') immanent realism about universals: he believes that there is no automatic correlation between predicates and universals[123], and that we need to discover which universals really exist (namely, which predicates truly correspond to real properties) through the empirical work of science.

Understood this way, universals do not appear to be clearly dispensable in one's ontology. As a matter of fact, within immanent realism the one-over-many intuition appears to be developed in strong enough a way to suggest that universals might in fact represent the best explanation for facts of resemblance.

On the other hand, the indispensability of universals has not been established yet. Indeed, since the ontological indispensability of entity(-type) $x$ entails that there are some facts that cannot be explained except by appeal to $x$, the non-indispensability of $x$ can still be demonstrated by showing that the same facts can be explained by entities other than $x$

[122] See for example Plantinga [1974], Bealer [1982], Hale [1987], Tooley [1987] and Grossmann [1992]. There exists a further distinction: *Theistic* Platonists, such as Plantinga, hold that Platonic abstract entities exist in God's mind. *Atheist* Platonists, such as Tooley, believe that they exist independently of any mind.

[123] This characterizes what is known as a *sparse*, as opposed to an *abundant*, conception of properties. This distinction was first made explicit by Lewis [1986; 59-69].

without any other disadvantage. If this turned out to be the case, then methodological considerations could be brought to bear (which could take into account the fact that universals constitute a very peculiar ontological category of multiply instantiable entities).

We thus need to ask whether facts of similarity can be accounted for without appeal to universals; that is, whether a plausible nominalist account of similarity can be formulated.

### *5. Similarity and Nominalism*

The realist view of universals, whether Platonic or Aristotelian, has been criticised and rejected in favour of various sorts of nominalism/conceptualism by many thinkers since the Middle Ages. In the 11th/12th century Roscelin said that universals are nothing but a 'flatus vocis'; and nominalism was also supported, in various versions, by Peter Abailard in the same period, John of Salisbury a few decades later and other thinkers. British empiricists of the 17th and 18th century, most notably Locke and Hume, rejected universals as hypostatizations of 'abstract ideas', produced in the mind by the repetition of certain individual sense-perceptions, or 'impressions'. Locke, for instance, claimed that:

> "The mind makes the particular ideas, received from particular objects, to become general; which is done by considering them as they are in the mind such appearances, separate from all other existences, and the circumstances of real existence, as time, place, or any other concomitant ideas. This is called abstraction, whereby ideas taken from particular beings, become general representatives of all of the same kind; and their names, general names, applicable to whatever exists

> conformable to such abstract ideas" [1690(1975); Book II, Ch. 9, Sec. 9].

Currently, there are two forms of nominalism. One claims that all that exists are particular substances, and properties are derivative on the particulars that exist and hence do not constitute an independent ontological category (consequently, it is also denied that bare particulars exist). The other claims that only particular property-instances exist, and all individuals are bundles of such instances. These two proposals are *Resemblance Nominalism* and *Trope Theory*, respectively. The former can be traced to Carnap and was later developed by Price [1953] and, more recently, Rodriguez-Pereyra [2002]. The latter appears in the work of Stout in the 1920s (see Stout [1921] and [1923]), and then of (among others) Williams (see Williams [1953]), Campbell (see Campbell [1981] and [1990]) and Simons [1994]. While the two views will be looked at in more detail in the next chapter, for the time being it is necessary to see how they fare with respect to similarity; to do this, no internal distinction within the nominalist camp needs to be drawn.

Any nominalist must find a way to avoid what is known as 'Russell's regress'. According to Russell [1912; Ch. 9], if properties are not universals, then we need to explain why things resemble each other with respect to properties. If the answer is that there exist specific resemblances among particulars, then an account is needed of what makes each resembling pair exhibit the same relation, i.e., a resemblance relation. However, if positing infinite particular instances of resemblance (among particulars, then among resemblances among particulars, then among resemblances among resemblances among particulars, and so on) is to be avoided, this is likely to be done in terms of resemblance as a universal. But this move is exactly what nominalists attempt to avoid: if they acknowledge the need for one universal, then their basic claim that universals are just useful fictions that can be consistently dispensed with becomes fatally weakened.[124]

My opinion is that Russell's regress does not arise. It is plausible to claim that an ontological explanation of similarity simply does not require a commitment to the existence of additional entities. The claim I wish to defend is, in particular, that *a* resembles *b* exclusively in virtue of *a* and *b* and the way they are, and nothing more needs to be said about the matter. Similarity, that is, is a primitive fact completely supervenient upon the natures of the similar entities.

This account is neither uninformative nor simplistic. It can perhaps be best illustrated *via* a consideration of our epistemic access to similarities among everyday objects. Would we say that we experience things as similar or dissimilar because we experience or fail to experience a similarity relation holding among them? It seems not. The similarity between two objects, it seems, is established by experiencing them separately and acknowledging the fact that they have the same 'causal'[125] powers with respect to the things around them. This latter sameness, however, does not seem to require an analysis, and to be something that can be regarded as completely supervenient on the way each object *is* (which of course does not depend on other objects, or on relations the object enters into). Since there appears to be no reason not to accept this reasoning when it comes to providing an ontological account of similarity, I suggest, all particulars (especially the simplest ones to the

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[124] However, it is possible to claim that commitment to the existence of one universal is different from – and better than – commitment to realism about universals *tout court*. See Rodriguez-Pereyra [2002] and his distinction between quantitative and qualitative economy.
[125] I put terms related to causality among inverted commas in order to avoid endorsing realism about it. If one is sceptical about causation, the latter can be reduced to regularities in the observed world. Nothing in the thesis being put forward hinges upon a particular understanding of causality.

existence of which one is committed on the basis of one's specific ontology) should be regarded as similar to each other in virtue of the fact that they exist and are such-and-such entities, and not because of other entities making them similar.[126]

Of course, this view concerning similarity and the dispensability of universals is essentially based on an intuition, to the effect that resemblance facts do not need a cause and immediately follow from the existence of the resembling things as entities with a specific 'nature'. As such, it cannot be presented as absolutely compelling. However, it seems to me that the realist's idea that, given facts of resemblance, we need to acknowledge the existence of universals is equally based on intuition.

On the other hand, if it is correct to claim that similarity relations are primitive and only require particulars with 'qualitative content', the dispensability of universals is established and it is consequently possible to examine the prospects for a nominalist ontology, dispensing with both bare substrata and multiply instantiable universals, in more detail.

### *Conclusions*

In this chapter, I critically assessed the claim, central to the defence of the Leibiniz-Quine reductionist view of identity and individuality, that the notion of primitive thisness must be discarded because it is in conflict with sensible empiricism. I argued that only a confused understanding of empiricism (and, in particular, of the Principle of Acquaintance) can lead to the conclusion that the bundle theory and PII represent the most appealing (or even the only) possible understanding

[126] Rodriguez-Pereyra [2002; 115] similarly claims that the truth-makers of '*a* and *b* resemble each other' (R) are just *a* and *b*, and therefore the existence of *a* and *b* is sufficient for the truth of R. However, as will be seen in the next chapter, he develops this claim into an ontology different from the one I endorse.

of the ontological structure of the world and, in particular, of identity and individuality. The possibility was explored of endorsing an alternative ontological account, in which primitive thisness is explicitly accepted, in the form of the substratum ontology of Aristotelian-Lockean derivation. This ontology can, I argued, overcome most of the objections traditionally raised against it. However, it is a dualist ontology of bare particulars and properties, with the former being a mysterious 'something' which is never known (or, better, experienced) alone and appears in fact existentially dependent on (at least some) qualities. The idea consequently suggests itself that one should assess the viability of an ontological framework in which primitive thisness is retained but is also detached from the notion of a bare particular. To endorse a non-dualist ontology without bare particulars means to opt for some form of *nominalism*. This view puts individuality directly into the particulars (be they complex particulars with properties or property-instances), and so straightforwardly accounts for individuation. It has been argued here that it can also account for similarity, once the latter is taken as a direct consequence of the particulars' natures rather than of the holding of some relation between particulars and universals that should be reified as the cause of the resemblance among things. Having said this, it is now time to say something more in detail with a view to

i) Addressing the remaining general criticisms moved against the notion of primitive thisness (see section 1 of the present chapter);

ii) Completing the evaluation of the explanatory power and overall appeal of nominalism (see section 3).

# *Chapter 5*

# *Which Nominalism? In Defence of Trope Ontology*

In this chapter, the answer to the second potential problem for the supporters of primitive thisness identified in the first section of the previous chapter - i.e., that a consistent ontology based on primitive individuals cannot be formulated - is completed. Earlier, I have suggested that some form of nominalism is the preferable ontological view, as it allows one to account for individuation and similarity within a one-category ontology. Arguments are offered here in support of the thesis that, within the nominalist camp, trope ontology is preferable to resemblance nominalism. Trope theory is shown to be able to respond to the objections commonly raised against it, and satisfactorily to account for the constitution of complex particulars.

## *1. Resemblance Nominalism*

The central idea of resemblance nominalism has already been explained in the previous chapter. It is fair to summarize that idea by saying that it consists of the claim that the initial step in Plato's one-over-many argument for realism about universals is flawed. Realists believe that properties are ontologically distinct from the particulars exemplifying them, and that things resemble each other because each one of them instantiates literally the same entity, i.e., the universal corresponding to the property that the things have in common.

Resemblance nominalists, on the other hand, deny that properties constitute an autonomous ontological category. They reverse the customary order of explanation and take properties to be 'by-products' of the fact that resemblance relations hold among 'ordinary particulars'. Such relations, crucially, are considered primitive and not in need of further analysis (nor capable of further analysis). It is clear that such a view not only can account for similarity and individuation, but also provides an immediate and natural explanation of the internal unity of complex particulars.

The first explicitly to endorse this position was Price [1953]. According to him, resemblance classes are determined by similarities between particulars and *paradigms*, intended in the sense of 'privileged' entities that possess properties independently of other particulars. The view is, then, that paradigms (or 'exemplars') determine similarity classes and "hold a class together" [Ib.; 21-22].[127] However, the rather obvious question: "What determines that the paradigm is to count as a paradigm, and what makes it a paradigm for a specific property?" led the majority of resemblance nominalists to opt for a different view. Namely, one in which no paradigm is required, but only similarities which hold between any particular and any other (the key assumption remains, at any rate, that properties are derivative on primitive facts of resemblance). This specific version of resemblance nominalism will be analysed in what follows, making reference to the author who did the most in recent times to elaborate it and make it a sophisticated and consistent ontological view.

In some recent work, Rodriguez-Pereyra ([2001], [2002] and [2003]) revives resemblance nominalism by suggesting interesting ways to

[127] A Pricean position has been defended in more recent times by Cargile [2003].

overcome traditional difficulties. First, of all, he endorses the claim, presented in the previous chapter, that similarities supervene on the existence of things [2002; Ch. 6].[128]

Rodriguez-Pereyra makes it clear, though, that making the resembling particulars the sole truth-makers of similarity claims requires a specific, non-negligible metaphysical commitment. For, he admits, if the existence of *a* and *b* is sufficient for the truth of the claim that '*a* resembles *b*', then the claim should be true also in possible worlds in which *a* and *b* are not similar and yet they both exist. Dispensing with possible worlds talk, it looks as though *a* and *b* might have existed without being similar, or cease to be similar while continuing to exist. But then similarity and existence do not go hand in hand as needed, and similarity still requires an explanation. Rodriguez-Pereyra argues that this difficulty is overcome by taking the things that exist as necessarily being the way they are. In the language of possible worlds, this amounts to denying trans-world identities, namely that things in different worlds can be identical. This is exactly what is obtained by endorsing Lewis's ([1968], [1986; 192-263]) *Counterpart Theory*, which is essentially the claim that individuals only exist in one world, and correspond to individuals in other worlds via a relation that is weaker than identity. Rodriguez-Pereyra thus embraces counterpart theory.

Bearing in mind this commitment, it is possible to accept Rodriguez-Pereyra's account of resemblance, and move on to a consideration of the other problems allegedly making resemblance nominalism unviable. Resemblance nominalists are traditionally required to overcome four fundamental obstacles (the last two of which were first pointed out by

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[128] Rodriguez-Pereyra also explains that, once it is specified that only sparse and non-conjunctive properties are considered, it is possible to claim that resemblance is the *unique* relation made true by the existence of the resembling particulars *together* [2001; Sec. V].

Goodman [1972] as criticisms of Carnap's resemblance nominalist intuitions expressed in the *Aufbau* [1928(1967)]):

1) The *many-over-one* difficulty: If particulars are not analysable in terms of properties that they exemplify, and properties do not in fact constitute an independent ontological category, how can a *single* particular, which is to be understood as 'non-composite' with respect to qualities, resemble different sets of other particulars, and *consequently* possess many different properties?

2) The *coextension* problem: assuming that similarities determine the properties that exist, if the sets of resembling particulars determining properties A and B are constituted by the same individuals, what is it that makes property A distinct from property B?

3) The *companionship* difficulty: according to resemblance nominalism, maximality is required for the set of resembling particulars determining property A. That is, the set must comprise all individuals said to possess property A, and no individual resembling all those particulars can fail to be in the set (otherwise it would resemble all A-particulars without being one). If this is the case, though, how can one account for the possibility that, for instance, all individuals with property A also have property B but not vice versa? In such a scenario, there would indeed exist particulars which are similar to every A-particular (albeit with respect to B) and yet fail to belong to the property set for A.

4) The *imperfect community* problem: since it is possible that a certain group of particulars all resemble each other but do not

all have the same property, how is the resemblance nominalist to distinguish genuine from non-genuine resemblances?[129]

The first difficulty is overcome as soon as one recalls that – in a resemblance nominalist framework - properties supervene on resemblance facts, and not vice versa. That is, one should not conceive of different 'aspects' of things, in virtue of which the latter belong to various similarity sets. This is exactly the assumption that leads towards the sort of realism about properties that the position under discussion rejects. Rather, if resemblances are primitive one *should not* seek an explanation for the fact that an individual belongs (or can belong) to more than one property set, and should instead acknowledge that this fact is just due to the way things are. This thesis might not convince everybody, but appears nonetheless consistent. More on what it entails (and on why one might want to avoid accepting it) will be said later.

As for the coextension problem, this is solved, claims Rodriguez-Pereyra, if one takes property sets as comprising individuals in all possible worlds. According to this perspective, an individual has property P if and only if it resembles all *possible* P-particulars. Especially under the assumption that properties are sparse (which excludes the possibility of 'concocting' predicates automatically corresponding to alleged coextensive actual properties), Rodriguez-Pereyra explains [2002; Ch. 5], it must be possible to tell any two distinct properties A and B apart in this way. As an example, with respect to the well-known 'having a heart' and 'having a kidney' scenario (and similar ones), it can be argued that it is a mere contingency that all animals that have one organ also have the other (it might even be just false, given the possibility of temporary lack

[129] If one wants to avoid talk of 'same property', the problem might be formulated as that of explaining why the sum of the non-empty and non-overlapping intersections of any three (or more) distinct property classes does not constitute a property class.

of heart or kidney during a transplant). As a consequence, the property of having a kidney and the property of having a heart fail to be identical according to the proposed construal. What about *necessarily coextensive* distinct properties? Is it not possible that two properties are necessarily compresent in all the individuals in which one of them is exemplified? It seems to me that Rodriguez-Pereyra is correct in rejecting this scenario. In all putative counterexamples one can come up with (for instance 'is triangular' and 'is trilateral') it appears to be possible to individuate what is common and define *that* as the real property, the existence of which one must be committed to (in this case, something like 'has the shape of a triangle').[130]

I take it, then, that Rodriguez-Pereyra can provide a satisfactory answer to the coextension problem. However, he can only do so at the cost of making another surely not insignificant metaphysical commitment. Since properties are entirely defined in terms of resemblance sets, and these, as we have just seen, need to comprise particulars in all possible worlds, the resemblance nominalist is forced to endorse realism about possible worlds.

Rodriguez-Pereyra overcomes the *companionship* problem by refining the notion of resemblance and making it 'come in degrees'. The key idea is that two particulars *a* and *b* share *n* properties if and only if '*a* resembles *b* to degree *n*' is true [Ib.; Ch. 10, Sec. 2]. This involves identifying resemblance sets with *maximal perfect communities*, that is, with groups of particulars that all resemble each other to the same degree. In a case of companionship where all F-particulars are also G-particulars but not the other way around (and no other similarities are involved), the G-particulars form a maximal perfect community of degree 2 (since

[130] Remember, once again, the assumption of a sparse account of properties.

all the G-particulars have property F as well as G), whereas the F-particulars form a maximal perfect community of degree 1. Hence we can distinguish between a property and its companion. To use a concrete example (which, of course, assumes the existence of properties in a way that is illegitimate for the resemblance nominalist), take particulars *a*, *b*, and *c* to be all red, but only *a* and *b* to be square, while *c* is round. Particulars *a*, *b* and *c* constitute a perfect community of degree 1 of red things, and particulars *a* and *b* a perfect community of degree 2 of square things that are also red (roundness is, by contrast, shared by *c* with particulars other than *a* and *b*).

Once again, the proposed solution works, but only at a price. That is, that of substituting the reasonably intuitive notion of primitive resemblance with a more complex relation that is made relative to degrees. The resemblance nominalist does not possess criteria of property individuation other than resemblance itself, and so cannot understand the above bi-conditional (*n* shared properties↔resemblance to degree *n*) as a definition of resemblance to a degree. Instead, s/he must take the latter notion as primitive.

As for the problem of imperfect community, of course the resemblance nominalist cannot speak of 'resemblance in the same respect', as this would assume the existence of properties as 'respects'. Rodriguez-Pereyra's proposal [Ib.; Ch. 9, esp. 169-172] is to replace resemblance with an iterative relation. This relation, call it R*, is defined as follows: two particulars are related by R* if and only if they share a property; two ordered pairs of particulars <*a*, *b*> and <*c*, *d*> are related by R* if *a* and *b* share a property that *c* and *d* also share[131]; two ordered pairs of pairs <<*a*, *b*>, <*c*, *d*>> and <<*e*, *f*>, <*g*, *h*>> are related by R* if the

[131] That is, if the R* relation gives rise to the same property when it holds between *a* and *b* and when it connects *c* and *d*.

property shared by <*a*, *b*> and <*c*, *d*> is also shared by <*e*, *f*> and <*g*, *h*>, and so on. A perfect community, on this construal, is such that its members are related by R* to each other and, moreover, pairs of members, pairs of pairs of members, pairs of pairs of pairs of members and so on also are all in the relation R* to each other.

This effectively guarantees that only perfect communities (in which the same property is shared by all members) are individuated by the resemblance relation. But again, and in this case perhaps in the most patent way, the price to pay for a consistent resemblance nominalism is high. What must be taken as the essential fact about things in the world, accounting for all their properties, turns out to be a rather abstract and complex relation, and not similarity as it is commonly intended.[132]

Looking at the overall picture that emerges, Rodriguez-Pereyra's resemblance nominalism does not appear entirely convincing. Although he manages to revive the basic intuition that was already present in Carnap's writings, in fact developing the latter into a consistent ontological view, his proposal is subject to a number of criticisms.

The immediate criticism is, as might be expected, that the resemblance relation that is invoked is very different from the similarity between things that is experienced by human beings, and thus the alleged plausibility of resemblance nominalism is inevitably reduced. This difficulty should not be intended in the *epistemological* sense: namely, in the sense that resemblance nominalism should be rejected because it has the consequence that to perceive a similarity between two

[132] After having offered solutions to the traditional problems affecting resemblance nominalism, Rodriguez-Pereyra also deals with one remaining problem [2002; Ch. 11], consisting of the fact that the conditions he individuates for sets of resembling particulars are also met by what he calls 'mere intersections'. That is, the particulars in the intersection of two perfect communities determining properties A and B also form a perfect community, as they all possess property A&B and no other particular has such a property. To get rid of this problem, Rodriguez-Pereyra makes the (sensible) assumption that there exist no sparse conjunctive properties.

particulars requires the capability to perceive a complex relation holding among all particulars with that property. It seems indeed fair to say that this is not the case, since what *makes* a set of particulars all have the same property by no means needs to be the same thing as what is *perceived* when specific similarities among particulars are *recognized*. It is at the *ontological* level that the increased complexity of the resemblance relation cannot be ignored. Rodriguez-Pereyra claims that:

> "The superiority of Resemblance Nominalism lies in its avoiding to postulate ad hoc entities. [...] Universalism and Trope Theory postulate ad hoc entities because they postulate entities, universals and tropes respectively, whose main or only claim to credence is that they provide a solution to the Problem of Universals" [Ib.; 13].

This charge of *ad hoc*ness appears based on the idea that we should opt for an ontological construal that appears plausible because it is as close as possible to our familiar picture of the world, and 'qualitied' particulars are what we experience around us. But why should the same criterion not apply to resemblance (regardless of the fact that it is not an entity but a relation)? As construed in the framework of Rodriguez-Pereyra's resemblance nominalism, resemblance becomes an iterative relation among not only particulars but pairs of particulars, pairs of pairs of particulars and so on; it needs to range over particulars in all possible worlds, with the latter realistically intended; and it requires a commitment to counterpart theory. It seems undeniable, in the light of this, that Rodriguez-Pereyra too defines the crucial element of his ontology in an *ad hoc* way, exclusively with a view to defending the ontological construal itself. True, he can claim that, since he had set himself exactly the task of defining a consistent resemblance nominalism, his attempt is successful; however, it is quite another thing to consider - because of this – resemblance nominalism compelling as compared to other ontological options. And it is the latter issue that is relevant here.

In addition, other more specific problems can be identified for Rodriguez-Pereyra's proposal. The notion of 'resemblance to degree *n*', for instance, that he employs to solve the companionship difficulty, presupposes that every entity can have only a finite number of properties. It would be impossible to distinguish a property from another on the basis of the 'resembles to degree *n*' relation if the degree of similarity were equal to infinity in both the resemblance set determining one of these properties and in that determining the other.

Moreover, properties with only one instance, which are surely conceivable, must also be defined by the resemblance nominalist in terms of resembling particulars. And this has the consequence, suggested by Rodriguez-Pereyra himself [Ib.; 90-91], that it must be accepted as a possibility that the fact that a particular in the actual world has a property is explained *exclusively* on the basis of a resemblance between that particular and particulars *in other worlds*.

In the light of all this, I suggest, it is worth exploring the option that resemblance nominalism is wrong, or at least modifiable, in one or more of its basic assumptions.

I believe that amending it in the light of the above criticisms in order to avoid the complexity and costly ontological commitments Rodriguez-Pereyra is forced to make *amounts to endorsing trope theory*. In the remainder of this section I will show why this is the case.

The reasoning underpinning resemblance nominalism can be summarised as follows:

1) Facts of resemblance ground the exemplification of properties;

2) Resemblance requires at least two particulars;

3) Since particulars can enter into many resemblance relations without this entailing that they are analysable, the multiplicity of properties exhibited by things can be accounted for by making reference exclusively to particulars;

4) Therefore, the *n*>1 particulars involved in a resemblance relation are the sole truth-makers of claims about their similarity;

5) Therefore, the *n*>1 particulars involved in a resemblance relation are the sole truth-makers of claims regarding properties and their exemplification.

In the previous chapter, I committed myself to 4). What else, if anything, can be modified?

A key idea is expressed by 3): that the same concrete particular can belong to different resemblance classes without this entailing that the particular is analysable any further (let alone in terms of properties). Rodriguez-Pereyra claims that this assumption is necessary because it provides with the ability to solve the many-over-one problem, and this must be considered as an important advantage. He rejects what is known as *Ostrich Nominalism* (the position that predication does not need an explanation and *a* is the truth-maker of every claim of the form '*a* is P') exactly because, according to him, the latter is unable to account for the multiplicity of properties in particulars [2002; 43-46].[133]

However, I believe that to allow for the analysability of complex particulars in terms of simple components by no means affects one's

[133] The definition 'Ostrich Nominalism' is due to Armstrong [1978; Vol. I, 16] who coined it on the basis of the fact that the position acknowledges that there are facts of property-exemplification, but then refuses – in ostrich fashion - to accept that these need an explanation. An ostrich nominalist position is defended by Devitt [1980] and Van Cleve [1994].

ability to account for the multiplicity of properties in concrete particulars. And that, therefore, 3) can be given up without explanatory loss. In fact, my contention is that doing this determines an evident gain at the level of ontological commitment.

Suppose that ordinary particulars can in fact be analysed in terms of simpler elements, where 'simple' and 'complex' are intended as synonymous with 'with one property only' and 'with $n$>1 properties', respectively (that is, in resemblance nominalist jargon, to 'belonging to one resemblance class' and 'belonging to $n$>1 resemblance classes'). This in itself is by no means excluded by a resemblance nominalist ontological perspective.

It can be immediately seen, though, that with this supposition many of the problems affecting resemblance nominalism disappear: the many-over-one problem is not simply 'explained away' anymore, as every ontologically basic particular belongs to only one resemblance class, and every particular with many properties is (as noted) *analysed* in terms of such basic components. Moreover, once one takes only simple particulars into account, there is no subset of any property class which is also a (different) property class, for any subset is composed by particulars with only one property, and the same as that of the particulars in the initial property class. Hence, the companionship problem is overcome. For analogous reasons, at the level of simple particulars there do not exist imperfect communities (since each particular only has one aspect, a set of particulars all resemble each other if and only if they all have the same property); and the coextension of different property classes is also impossible (for the coextension of two - or more - different property classes requires at least some particulars to belong to more than one such class, which is being assumed here to never be the case).

In short, by identifying sparse properties with those determined by resemblances between simple particulars - only belonging to one resemblance class[134], *most* of the traditional problems for resemblance nominalism would be solved without the need to construct a complex (analogue to the) resemblance relation as Rodriguez-Pereyra is compelled to do. The possibility is therefore definitely worth exploring that the only properties the existence of which one should be committed to are those determined by resemblances between simple particulars; and that every particular which is not simple should be analysed in terms of simple particulars.

As I said, to accept the analysability of particulars just hypothesised does not entail the rejection of resemblance nominalism, for the basic simples are still particulars with properties. Nonetheless, *here is where two fundamental facts emerge that render trope ontology preferable.* These are related to two remaining difficulties.

First, as we have seen, the resemblance nominalist invokes realistically intended possible worlds in order to avoid the coextension problem (by saying that contingent coextensions are not sufficient for defining properties); *and* the problem with properties with only one instance (by saying that the unique actual particular instantiating that property does so in virtue of its similarities with particulars in other possible worlds). Now, although to limit the similarities determining properties to those holding among particulars only belonging to one resemblance class allows one to prevent coextensions from arising, the other difficulty must still be faced by the resemblance nominalist. That is, one-instance properties still demand realism about possible worlds.

[134] In Rodriguez-Pereyra's terms, I am in effect hypothesizing that only properties determined by resemblance classes of degree 1 are real properties.

Moreover, since s/he takes the particulars belonging to property classes to be concrete particulars, the resemblance nominalist (at least according to Rodriguez-Pereyra's depiction of the theory) must still avoid the possibility that the existence of *a* is not sufficient for *a*'s being P by endorsing counterpart theory (for it is still conceivable that the *same* – simple or not - concrete particular does *not* have a given property, that is, that *a* does not necessarily belong to the resemblance class for P).

The trope theorist, however, who *identifies* the simple particulars with their qualitative content, *can dispense with both possible worlds and counterpart theory*. As for one-instance properties, they 'explain themselves', as it were, and do not require any similarities holding between particulars: a trope P is *necessarily* a trope with the specific 'qualitative content' it happens to have, independently of any similarities holding between it and other particulars. In addition, the possibility of a P-trope not *having* property P is discarded at the outset without subscribing to any specific metaphysical thesis, because a P-trope *is* a property (of type) P.[135]

We are thus in a situation in which an initial hypothesis of analysability of particulars in terms of simple components - belonging to one resemblance class only - allows the nominalist to overcome most of the difficulties besetting resemblance nominalism without postulating such a complex relation as Rodriguez-Pereyra's R*; and in which, moreover, understanding these simple particulars as tropes rather than concrete particulars additionally allows one to avoid a commitment to

[135] This, incidentally, allows one to make sense of Ostrich nominalism. As explained, the central idea behind Ostrich nominalism is that '*a* is P' can be true and yet require no explanation other than that *a* exists. It seems to me that such a position becomes convincing as soon as it is assumed that property classes are composed of tropes rather than concrete particulars. If *a* is a trope, it follows that it is a particular property. But this means that '*a* is P' is to be intended as an identity claim rather than a predication. From which it follows that, given *a*, it is necessarily true that '*a* is P' (at least as long as one assumes that all tropes are determinately self-identical).

certain strong ontological theses (counterpart theory and realism about possible worlds) that Rodriguez-Pereyra was forced to subscribe to.

As for 4) above, which – as I recalled – is a claim that I subscribed to when discussing similarity, notice a crucial difference: according to resemblance nominalism, 4) must be intended as the claim that the two or more concrete particulars involved in a resemblance relation are together the sole truth-makers for the sentence expressing it and, *as a consequence* the truth-makers for statements attributing a specific property to them. In a trope ontology, 4) is equally true, but as the claim that the two or more particulars that are the sole truth-makers for certain resemblance claims are such *in virtue of* the following fact: that, each one of them by itself, they are the sole truth-makers for the property attributions that regard them. This is exactly why predication is only possible with more than one individual in resemblance nominalism but not in the trope-based perspective being proposed; and why, consequently, only the former is committed to the existence of possible worlds. Therefore, the thesis expressed in 4) can be endorsed without having to face the difficulties faced by resemblance nominalism.

Another thing deserves mentioning. Emergent properties, I contend, find a better explanation in trope ontology than in resemblance nominalism. Consider one specific case that was already mentioned in chapter 3, and will be considered more extensively in the next chapter. In (standardly interpreted) quantum mechanics, so-called 'entangled' particles appear to be such that there is a real physical fact true of them which is not determined by the monadic and/or relational properties they have separately. This fact corresponds to an emergent property of the entangled system as a whole. Surely, the resemblance nominalist can claim that emergent properties such as this can be explained in terms of resemblances between particulars exactly in the same way as other properties. However, entangled systems appear to exhibit emergent *relations* among pairs of particles, and so it is the composite of two particulars that should be considered as the member of a resemblance class. That more or less *ad hoc* 'composite particulars' constituting resemblance classes have to be postulated on the basis of the *n*-adicity of the emergent relation that must be accounted for might not be a lethal problem. Nonetheless, on the resemblance nominalist construal, one must accept the following possibility: that of two particulars which enter into the same system and then, *since the system happens to resemble* other physically analogous systems, become related by a new property. This undoubtedly adds to the unnaturalness of the resemblance nominalist construal. The trope-theoretic account appears, instead, closer to what physical theory tells us. It allows one to say that two bundles of tropes become related by an emergent relation *because the bundles* become parts of the same physical system and, at that point, one further property (a trope) is exemplified by the whole. In general, trope ontology makes room for properties that do not supervene on more basic ones and instead constitute further, non-reducible, sets of basic particulars.[136]

Two potential objections must now be considered. On the one hand, it might be claimed that the postulation of simple particulars with only one aspect is itself *ad hoc*, as once it is accepted the road to trope theory is necessarily very short, but in fact it simply need not be accepted. On the other hand, it could be maintained that physics tells us that the basic entities constituting reality are particles with more than one property, and so the postulation of simple particulars can be rejected on the basis of science. To the first objection, I respond that the idea that simple

[136] A trope-theoretic interpretation of the mentioned emergent relations in quantum mechanics will indeed be suggested in the next chapter.

particulars with only one aspect exist has *exclusively* been put forward with a view to avoiding certain undeniable complications that arise for resemblance nominalism in terms of ontological commitment. That such an idea leads one towards trope theory is just an (of course, not completely unexpected, nor unwanted) consequence of the fact that it does in fact avoid such complications. As for the second objection, my answer is that the standard model of elementary particles can be interpreted as describing what the most fundamental concrete particulars are, as the imaginary critic would have us do; but it can equally be understood as describing the basic properties of physical reality as independent simples, and the way they exist together in our world. In this second understanding, the 'precedence' of concrete particulars over tropes would not be ontological (that is, to be explained in terms of the non-analyzability of the former), but epistemic (in that it would follow from certain mutual relationships invariably holding in our world among the latter).[137]

In the light of the foregoing arguments, it seems to me that the possibility should be contemplated, both for specific reasons having to do with resemblance nominalism's pros and cons, and for more intuitive motivations[138], that resemblance nominalism is mistaken in its central

[137] Arguments against the idea that particles as concrete particulars with many properties should be considered as the basic 'building blocks' of reality come from quantum field theory and quantum gravity, but I believe it is not necessary to refer to these theories in order to formulate my point. Much more on the perspective being suggested will be said in the next chapter.

[138] True, Rodriguez-Pereyra can object that "with metaphysical theories about the basic structure of the world, like Resemblance Nominalism, Trope Theory and Realism about Universals, there is no reason to expect that our intuitions will be true. Intuitions are the product of evolution and so metaphysical intuitions, which have little if any survival value, are unlikely to lead us to metaphysical truth" [2003; 232]. Despite the fact that this appears correct as a general claim, it still looks as though - all the rest being equal - intuitions can in fact lead one to prefer one metaphysical hypothesis to another. In the present case, at any rate, intuitions in favour of the view that similarities are dependent on properties and not the other way around are coupled with explicit ontological arguments for choosing trope theory over resemblance nominalism.

assumption; and that things resemble each other because they have (in actual fact, so far as the basic elements of reality are concerned, they *are*) properties, and not the other way around. This means to say that trope ontology is preferable to resemblance nominalism.[139]

## *2. Trope Ontology*

Trope ontology, as mentioned earlier, is the view that the whole of reality is composed of particular qualities, endowed with primitive thisness.

In his [1953], Williams starts from the suggestion that partial similarities between things can be accounted for in terms of complete similarity among component parts of these things. And that these parts can be understood as *abstract particulars*, i.e., particular qualities. He suggests that:

> "Entities like our fine parts or abstract components are the primary constituents of this or any possible world, the very alphabet of being" [Ib.; 7].

According to Williams, more specifically, such entities

> "not only are actual but are the only actualities, in just this sense, that whereas entities of all other categories are literally composed of them, they are not in general composed of any other sort of entity" [Ib.].

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[139] As for the role of universals, Van Cleve, making reference to Sellars [1963], argues that "the formula '∃F(Jack and Jill are both F)' need not be read as 'there is a quality that Jack and Jill both have', but may be read instead as 'there is something that Jack and Jill both are' – to which one could append [the word allegedly denoting a universal, but in fact describing Jack 's and Jill's nature]" [1994; 587-588]. This seems to me absolutely correct from the viewpoint of trope theory.

It is abstract particulars understood this way that the more recent literature refers to as 'tropes'. But what does it mean to take abstract particulars as the basic 'building blocks' of reality? One criticism often moved against property-based ontologies is that properties are said to be abstract because they are not ontologically autonomous entities, and so the prospects are dim for trope ontology as a one-category nominalist ontology. If properties are by definition things which get predicated of something else (which is not itself a property), the criticism goes, then they cannot - *in principle* - be autonomous, let alone fundamental, entities. In his [1998], for example, Lowe claims that tropes

> "lack the fully determinate identity conditions characteristic of objects proper [...because they are...] *adjectival* rather than *objectual* in nature" [Ib.; 156].

It is evident, though, that – at least as they have been conceived of in the previous section - tropes do in fact meet the requirements for being attributed an 'objectual' nature. For, contrary to what is commonly thought, and also mirrored by Lowe's quotation, according to the suggested perspective tropes are not dependent on, but rather required for, the identity of the complexes to which they belong, as they simply are the fundamental components of the latter.

The whole project of trope theory is, indeed, based on the conviction that (certain) properties can be seen as autonomous entities. That they are inevitably dependent on something else that belongs to a different category and acts as 'subject' is, according to this view, just a pre-theoretical intuition which can (and must) be overcome upon philosophical analysis. For instance, emphasising that the dualist substance-property paradigm and the related idea that properties are dependent on their bearers are entrenched in our way of speaking and thinking about reality, but should nevertheless not be taken for granted at the ontological level, Campbell declares that:

> "We must overcome a long-standing and deeply ingrained prejudice to the effect that concrete particulars, atoms or molecules or larger swarms, are the minimal beings logically capable of independent existence [;...o] n the view that tropes are the basic particulars [it is in fact the...] concrete particulars, the whole man and the whole piece of cloth, [that] count as dependent entities" [1981; 479].

The 'abstractness' of tropes must thus be understood as consisting of the fact that they are always experienced as parts of complexes, and so each one of them can only be 'isolated' by an act of conceptual abstraction from the particulars it belongs to. That they are abstract in this sense by no means entails that tropes are not concrete in the sense of constitutive of material reality, which indeed they are.[140]

In short, once tropes are identified with the basic simples making up reality, Williams' claim that tropes are 'the alphabet of being' seems justified.

One might reply that this may perhaps be true of some properties, but others certainly cannot be so understood: it is impossible, for example, to conceive of a 'shape' trope if not as inhering in something else which is a material 'thing', ontologically prior to it, shaped in some specific way. Therefore, at least some tropes are not independent. Also, not all tropes seem to qualify as concrete in the sense defined above: in what sense can, say, 'colour' properties constitute material reality?

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140 Simons [1994; 557] suggests modifying the customary definitions and take tropes as *dependent concrete particulars*. I take it that 'dependent' must be understood here as dependent on other tropes (together with which each specific trope gives rise to the complex particulars it is part of), not on entities belonging to other ontological categories.

This objection appears indeed quite dangerous, at least for those trope ontologies that take *all* properties as basic tropes.[141] However, a trope ontologist can avoid doing so, *provided that s/he can offer a reductionist account of all the properties whose existence s/he acknowledges* in terms of simpler properties which are immune to the suggested difficulty and 'qualify' as tropes. A generally valid answer to the question whether the trope theorist can solve the present difficulty in this way can only come from a detailed examination of our best relevant scientific theories and what they tell us about what counts as fundamental. Such an examination will be carried out in the next chapter. At this stage, however, it is useful preliminarily to suggest a classification of types of properties that captures the key intuition; and to provide answers to other traditional objections against trope theory.

### *3. Tropes, Other Properties, and Replies to Some Objections*

First of all, I believe that it is correct to say is that there exist *three* distinct types of properties, which can be categorized as follows:

1) TROPES: tropes proper, to be identified with the basic, simple elements of material reality, which are concrete entities only dependent on other entities of the same type;
2) D-PROPERTIES: derivative properties, that is, complex structures of tropes that are not primitive and yet are physically efficacious. Properties like colour, or shape, are D-properties;

[141] That all properties are ontologically on a par seems to have been Williams' position, but is not a shared assumption nowadays. It is explicitly abandoned, for example, in Campbell [1990].

3) C-PROPERTIES: Non-material conceptual/logical properties. These exist in our minds, i.e., only have a *conceptual* status, but are (at any rate, can be) nevertheless based on objective facts. Exemplification, or resemblance, are such properties.

The distinction between tropes and derivative properties is particularly important, because it is what allows one to overcome the difficulty mentioned at the end of the previous section. The basic claim is that only D-properties can fail to be concrete and/or existentially independent of the complexes they belong to. To provide an example of the way D-properties are constructed out of tropes, consider the case of an object exemplifying the property of being of some specific colour. For a thing to be of a certain colour, science tells us, means that that thing reflects and absorbs light waves in a particular way. But the modality of this reflection is related to the kind of surface that thing happens to have. And this, in turn, is reducible to the structure of the set of molecules the thing is composed of and, further, to the specific arrangement of the particles that constitute the thing. My contention is that scientifically-informed analysis ultimately leads us to (what we currently see as) the most basic physical level, where the property of being coloured 'dissolves', as it were, into more basic physical facts; and that these facts exclusively concern *entities that can be regarded as tropes.*[142]

The discrimination between tropes and D-properties allows the trope theorist to dispose of another traditional 'difficulty' for trope ontology, known as the *boundary problem.* The alleged problem, discussed for instance by Campbell [1990; 142-145], is that if every property is a trope, then it looks as though every time a particular possessing a property P is divided, its P-trope also splits. For example, consider this white sheet of

[142] See the next chapter for further details.

paper. The whiteness of it is a particular instance of white, or so it appears to be: this seems rather uncontroversial as soon as we distinguish this whiteness from that, say, of the stool over there. As such, on a 'naive' trope-theoretic construal, it should be considered as a trope. But what happens if we tear this sheet into two parts, each one of these in two again and so on? It looks like we get as many white tropes as the number of pieces we tear the original sheet into, without any actual multiplication of the original stuff. This hardly supports the view that tropes are the fundamental constituents of reality. Where exactly is the boundary between one trope and another? What should we take to be truly fundamental?

The problem is easily solved on the basis of the suggested distinction among types of properties. The claim can be put forward that it is only D-properties as defined above that can be 'divided into parts', and this avoids ontological inflation. As explained, derivative properties are structures of tropes, while tropes are simple and indecomposable. It can thus be maintained with plausibility that what appears to be a partition of a trope into two or more others is actually just a division internal to a complex structure of tropes. And that the division necessarily terminates when one gets to the tropes themselves. In the above example, the whiteness of this sheet of paper would be a non-fundamental D-property (not a trope), to be conceived of as a complex organisation of simpler ontic units (ultimately, tropes). If this is the case, as one tears the sheet one obtains two (or more) white things, and yet no 'ontological proliferation' takes place but, rather, just a re-organization of the relations internal to the trope-structure that gave rise to the original sheet. Therefore, since basic tropes cannot be divided multiplied as pieces of paper can, no boundary problem arises for the really fundamental constituents of reality; whereas for the entities that are derivative on these the problem is not, in fact, a problem at all, but rather exactly what we should expect.[143]

Other objections to trope theory have to do with their identity conditions and ontological nature.

A criticism to the effect that trope theory appears unappealing in the light of the possibility of 'swapping' identical tropes was raised by Armstrong [1989; 131-132]. Since tropes are independent entities with primitive identity conditions, Armstrong claims, given two particulars *a* and *b* with the property P, *a*'s P-trope and *b*'s P-trope (which, obviously enough, are exactly similar) could be swapped without this making any difference. Hence, trope ontology leaves room for certain ontological possibilities that appear 'empty' and should be consequently discarded. However, it is not clear to me why the scenario just described should represent a problem. If the charge of 'emptiness' is to be intended in the ontological sense that trope swaps cannot occur, it is false. So-called haecceitistic differences[144], merely involving things' identities, may or may not be accepted in one's ontology. But they are not, by themselves, impossible.[145]

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[143] It is worth noticing that the distinction between tropes, D-properties and C-properties also allows one to dispose of another difficulty, raised by Levinson [1980]. Levinson distinguishes *qualities*, capable of being divided into parts that are also qualities of the same type (e.g., whiteness: a white thing can be divided into smaller white parts); and *properties*, that are instead indivisible (e.g., manhood). He claims (ignoring, by the way, the boundary problem) that only qualities can be tropes, for tropes are particularized attributes but a particularized, say, manhood is a man and not another manhood. This allegedly weakens the appeal of trope ontology. I suggest that properties such as 'manhood' are in effect C-properties, rooted in tropes and/or D-properties (that is, in Levinson's terminology, in qualities), but not themselves to be expected to have all the features of tropes.

[144] Already discussed in chapter 4.

[145] Notice that the problem here is not that, as emphasised in the previous chapter with respect to bare particulars, one must acknowledge *bare* identities. Armstrong claims that the tropes' *primitive* identities, although essentially connected with a 'qualitative content', determine possibilities that we should feel compelled to exclude.

If the alleged problem is, instead, that the trope swap does not coincide with something 'real', this must be established on the basis of observation and/or science. At that level, the argument is either that a swap can never be observed, or that it in fact never obtains. As argued in chapter 4, that something is in principle incapable of determining a directly perceived empirical difference does not entail that that something is not real. Moreover, even assuming that trope exchanges do not in fact occur, the trope ontologist can perfectly take this as an empirical fact suggesting a constraint on the possibilities allowed for by his/her ontology. At any rate, it is surely not obvious that realism about universals – with its claim that the swap is ruled out in principle by the numerical identity of the two instances of P - would represent a better option as Armstrong would have us believe.

It was also Armstrong who raised what is known as the 'piling objection'. According to him, trope theory countenances the seemingly empty possibility that a particular contains two identical tropes. He claims that:

> "It seems clear that the very same particular cannot instantiate a property more than once. To say that a is F *and* that a is F is simply to say that a is F. Given the Identity view of properties, this is immediately explicable. For a Particularist, however, an ordinary concrete particular is a collection of Stoutian particulars. Why should not this collection contain two Stoutian particulars which resemble exactly?" [1978; 86].

To this, I reply by reiterating the point made earlier[146] as regards determinable and determinate properties. It is just a fact about properties, regardless of whether they are universals or not, that only one

[146] See section 3 of chapter 4.

determinate for each determinable can be exemplified by a particular (or, bundled with other universal-instances, tied to other tropes or what have you). One who believes in universals can of course *provide an explanation* for this, and say that two instances of the same universals possessed by one particular (or, at any rate, bundled together) would be co-located and consequently be identical and count as only one instance. However, the trope theorist can perfectly well just stick to the determinate/determinable distinction. Especially in the light of the other difficulties affecting the bundle theory, it certainly does not seem to be the case that we are forced to follow Armstrong in endorsing such a controversial ontological view because of the piling objection.[147]

Another alleged difficulty regards the simplicity of tropes. Some authors (Mertz [1996], Moreland [1985], Hochberg [2004] and Armstrong [2005]) have argued that the trope nominalist is forced to claim that each trope has (at least) two aspects - one that makes it resemble other tropes (its nature), and another that makes it the abstract particular it is (its primitive particularity); and that this immediately makes the theory inconsistent, as an internal complexity is acknowledged in the entity that was instead presented as a basic simple 'building block' of reality. Put in terms of truth-making, the same trope(s) can make logically independent propositions true such as "*a* and *b* are exactly similar" and "*a* and *b* are numerically distinct". The supposed difficulty is that since a single trope is the truth-maker for a number of sentences, the trope is likely to be a complex entity. To this, it can be replied that if one accepts (as, for one, Armstrong himself does in his paper) that truth-making theory rejects the idea of a 1-to-1

[147] Also, it should not be ignored that the piling objection too should be supported by empirical evidence, which it in fact is not. At least for what I call tropes, it is by no means obvious that two of them cannot belong to the same particular. Simons [1994; 572] explicitly considers this possibility with respect to certain microphysical systems.

correlation between truths and truth-makers, there is no need to see trope theory as weakened in any way by the fact that many things can be truthfully said of one single trope. For, if it is possible for a simple entity to be a truth-maker for a number of truths, then ontological arguments must be provided against the simplicity of tropes. However, in ontological terms, it is possible to claim that a trope surely has two 'aspects', and perhaps even more if we consider the entirety of its metaphysical features. But all these aspects are *numerically identical*: that is, it is by just being the simple entity it is that a trope counts as one, is similar to other tropes in its nature, is distinct from other things, affects and interacts with other tropes, and so on. It is mistaken to take each of these aspects to be a distinct metaphysical component of the given trope, for they are distinguished numerically from each other merely by conceptual analysis. Tropes, that is, are ontologically simple units, provided with primitive thisness as a metaphysical feature which is not an addition to their 'empirical content'.

Let us now move on to a different type of difficulties, having to do not with the ontological nature of tropes in themselves, but rather with the relations obtaining between them. Trope theory, we have seen, has it that tropes are all there is, and everything is constituted by sets of tropes. Williams claims that:

> "We observe two fundamental ways in which tropes may be connected with one another: the way of location and the way of similarity" [1953; 7].

The similarity issue has already been dealt with. Here, it must only be explained in addition how the suggested account of similarity fits with the proposed distinction between tropes and derivative properties.

Whenever similarity does not hold among basic tropes, I claim, facts of resemblance can be cashed out in terms of structural analogies between complexes of tropes. Taking again the example of colours, similarity with respect to colour amounts to equality in the way the surfaces of things reflect light; this, in turn, entails that two things have the same colour if they have identical (at any rate functionally) physical structures. The definition of such similarity of structures is likely to be achieved by appealing to sameness of constituents (i.e., ultimately, tropes) and to geometrical-topological features. This reasoning appears to be generally applicable. Hence, the claim is that the basic similarities are, as suggested earlier, those among the natures (causal powers) of tropes, and that resemblances between 'higher-order' properties can be reconstructed on the basis of such similarities.

I next look at Williams' 'way of location'. Can compresent tropes give rise to complex particulars? If so, how?

The alleged difficulties that arise when considering the nature of the compresence of tropes have to do with the sort of Russellian-Bradleian regresses already discussed, which ultimately go back to the Platonic/Arisotelian third man argument. Daly [1994; 258-260] considers the relation of compresence in the context of trope theory along these lines, and concludes that the trope ontologist who wants to avoid the regress becomes fatally involved in what he calls the *infiltration of instantiation*. Suppose that, says Daly, in the spirit of trope nominalism one attempts to explain the compresence of two tropes by referring to tropes only. If one says that trope *t* and trope *u* are compresent, one then needs to say that they are because of a third trope *c* that causes them to be so. But then one has to explain the relation between *t* and *c*, and that between *u* and *c*, in turn. And if, as it seems sensible, one does not want to talk about compresence again, one must say that *t* and *u* 'instantiate' *c*. The problem of explicating this notion of instantiation, though, seems to have the same structure as the initial problem. In particular, claims Daly, the fact that trope theory needs, after all, the instantiation relation makes its alleged greater appeal with respect to substratum ontologies (where instantiation is posited explicitly as a fundamental relation) disappear; and ultimately leads to the defeat of trope ontology, for substratum theorists can legitimately see instantiation as a primitive feature of substrata as an ontological category on their own, while trope theorists cannot.

My solution to this problem is of the 'deflationary' type. It consists in conceiving of compresence as an uncontroversial primitive, and following another route for explaining the constitution of complex particulars out of tropes. First of all, it seems to me that not only is it possible to avoid hypostatising the compresence relation, but plainly wrong to suppose that it must be hypostatised. Compresence, my contention is, is not a property or relation exemplified by certain tropes, and in virtue of which the latter are located at the same place, but rather just *a fact about their existence* that can be thought of as a C-property. More precisely, tropes are not compresent because they exemplify a certain (real) property; rather, they can be attributed such a property (conceptually) because they 'exist together' or 'co-exist'. Facts of co-existence, that is, are basic ontological facts that do not need a cause external to the compresent entities. Notice, moreover, that the claim that co-existence is all there is to compresence makes sense regardless of whether the tropes' existing in such-and-such a way determines space-time relations (as in relationism about space-time); or is set against the background of a pre-existing space-time 'stage' (as in substantivalism); or 'comes into existence' together with space-time as an absolute and yet non-substantival structure (as in the structural understanding of space and time suggested, for example, by Auyang [1995] and [2000]). In all these cases, I contend, nothing more than the things' existence is required in order for them to be (or fail to be) compresent.

The more pressing problem concerns the connection (if any) existing among the compresent tropes. Its consideration will allow us to evaluate the explanatory efficacy of trope theory with respect to the last *explanandum* that was individuated for any ontological account of reality (the others being similarity and individuation): that is, the internal unity of complex particulars. Mere compresence does not appear to be sufficient for explaining what makes a complex particular out of certain tropes; namely, of what distinguishes full-blown 'things' from mere sets of tropes existing at the same place. As we have seen when discussing indistinguishable particles in quantum mechanics, this is far from being of merely philosophical interest. As a matter of fact, the present question may be interestingly put in terms of what distinguishes *distinct but compresent individuals* from each other: the mereological part-whole relation must be founded on something more than mere compresence if the possibility – described by our best current physical theory – of two (or more) complex individuals existing at the same place is to be underwritten.

The need for some 'unifying factor' might be taken as suggesting that individual substrata are required. LaBossiere [1994; 364], for instance, argues that since in a one-category trope ontology all the work must be done by tropes, and a consistent nominalism cannot assume the existence of universal relations, the 'gluing' should naturally be performed by individual 'binding tropes'. But, since the latter are just tropes like all the others, one is forced to acknowledge that the binding tropes should be bound to the tropes they bind by other binding tropes, and so on – along by now familiar lines - *ad infinitum*. As mentioned in chapter 4, it can be argued that substrata – i.e., bare particulars endowed with the power to attach to many tropes, bind them together and give them unity – do not meet with the same problem. LaBossiere does in fact posit substrata as fundamental 'unifiers'. He gives a justification of the positing of substrata in terms of a principle that he traces back to some Platonic passages (in the *Sophist*), according to which if something has a real power, then it is real. In the present case, since ties between tropes have certain causal consequences, they must be real. From the contention that – on pain of an infinite regress - the only thing that can coherently be said to determine such ties is a substratum, LaBossiere then concludes that substrata must be real too.

This argument is invalid, though, and in fact indicates the correct strategy for the trope ontologist in connection to the present problem. Obviously, if we postulate a bind*er* then it must be a real entity. But we can just postulate a bind, that is, a relation between things, as something actual without having to believe in a further entity that 'does' the binding. If, for example, John and Jack hug each other, we can say that they constituted a clear and tight relation, but by no means do we have to hypostatize the 'hug-between-John-and-Jack' as a third real entity. There is a difference between the case in which a relation holds and that in which it does not, but such a difference by no means automatically implies an ontological addition.

The relevant distinction that, in the light of this, can be invoked by the trope ontologist is that between *internal* and *external* relations – a distinction that is indeed presented by some trope theorists exactly with a view to defusing the present objection regarding the need for something 'holding tropes together'. Denkel, for example, argues as follows:

> "For those who do not wish to maintain the existence of independent, but empirically inaccessible bonds, internal relations present themselves as ideal candidates for cohesive relations" [1997; 600].

Roughly speaking, while an external relation is distinct from its relata, and 'adds something' to them, an internal relation is essential to its bearers, in the sense that it is fully reducible to the way the latter exist at the moment of the holding of the relation, and expresses a fundamental mutual relationship among them. Having recourse to a relation of this type, obviously enough, allows one to account for the sort of dependence existing between tropes in the same complex particular without giving rise to infinite regresses or other problematic consequences.

Simons [1994] argues that we must understand the internal relations that are constitutive of complex particulars as Husserlian *foundation relations*. According to him, these serve

> "to bind things into a unity without requiring any further glue" [1994; 559].

Husserl [1911-1917(1970)] maintained that an entity *t* is *founded* on another entity *s* if *s*'s existence is necessary for *t*'s existence. And *s* and *t* are *directly foundationally related* if and only if each one is founded on the other. Tropes, Simons claims, can be such that given a collection of them, each one is foundationally related to every other in the collection and nothing else. Bundles of foundationally related tropes are called *foundational systems* by Simons, and he identifies these as the fundamental constituents of physical reality. Objects are just entities that can be partitioned into elements forming foundational systems.[148]

Simons' proposal appears interesting, but it meets with a difficulty. To account for change, Simons proposes what he calls a 'nuclear account' [Ib.; 567-569]. He takes nuclei of foundationally related tropes (in his terminology, 'kernels') to constitute the substratum to which peripheral layers of tropes become attached. While the nucleus is the essence of each individual bundle of tropes and does not change, Simons argues, peripheral tropes can be lost, added and replaced: Simons' account thus satisfactorily explains the difference between essential and accidental properties, and the notion of change in the latter. However, as pointed out by Denkel [1997], it is unable to provide room for *substantial* change, that is, for the type of change that involves partial or total loss of an object's essence. In Simons' framework, this would require a change in the nucleus of foundationally related tropes constituting the 'core' of each individual. However, if every individual substance is constituted by a nucleus of mutually dependent (foundationally related) tropes and outer layers of non-essential tropes dependent on the nucleus, it follows that the identity of a substance is entirely dependent on all the tropes in the nucleus and exactly those. Consequently, any conceivable change of *that* entity can only concern the external tropes 'added' to the nucleus. In Denkel's words:

> "If the tropes in the outer layer depend for their existence upon each trope in the nucleus, the destruction of any of the latter should have exactly the same effect as destroying the

[148] Of course, while in the example of the hug given above the obtaining of the relation can be explained by making reference to the internal structure of the relata, here one has a fundamental non-physical modal property.

> substratum of an object, thereby leaving its qualities without a support" [Ib.; 601].

Denkel gives the example of (a part of) an animal becoming boxed mince. A more effective (and less gory) example might be the decay of a type of particle into one or more particles of other types, typically described by elementary particle physics. Denkel says that:

> "These are situations in which the so-called kernel of the object changes (or is lost) without the peripheral layer of contingent properties being lost, and it is hard to understand how Simons' theory, which endows essences with the function of a substratum, will permit such a thing" [Ib.].

Denkel therefore replaces Simons' foundation relation with a relation, which he calls a *saturation relation*, expressing a weaker sort of dependence. Simons' (Husserl's) foundation relations are such that they render certain *specific* tropes existentially dependent on each other. According to Denkel's view, instead, compresent tropes constitute a complex particular provided with a definite identity only as determinates for certain determinables. That is, coexisting tropes 'complete each other's existence', as it were, only insofar as they are tropes *of a certain kind* (internally related in the required way, of course), and not because they are *exactly those* tropes. It follows that any change is permitted (does not affect, that is, the identity and unity of the particular in question throughout the change involving it) that can be accounted for in terms of the substitution of a trope with another trope which acts as determinate for the same determinable. For instance, given an actual bundle *x* of tropes ABC saturating each other, *x* can become a different bundle ABD even if C is part of *x*'s 'core', provided that C and D are determinates for the same determinable, and that ABD is an admissible particular in all worlds nomologically similar to the actual world.

We will see what the relevance of this with respect to actual physical possibilities is in the next chapter. What is important to stress for the time being is that the metaphysical relation of saturation expresses the fact that tropes belonging to different 'families' can be mutually dependent on each other *and nothing else*. It is physics that must be looked at in order to individuate what the different families of basic tropes *actually* are, and what mutual dependencies *actually* hold. On the other hand, it seems to me that the saturation relation should not be regarded as akin to the infamous 'dormitive virtues' and consequently entirely dispensable. For physics by itself only describes the fact that certain fundamental properties are invariably found together, and does not (cannot) account for the nature of the relationships connecting them into unitary complexes (we have already seen that mere compresence is not enough). To add to the physical description the claim that the properties in question are entities of a specific type that are existentially dependent on each other does not seem to be an empty claim; and to be, in fact, all that is needed here from the metaphysical point of view.[149]

### *4. Tropes: an Assessment*

I have argued that trope theory can satisfactorily account for individuation, similarity and the dynamics according to which unitary

[149] Of course, one may take the nature of the saturation relation to suggest the dispensability of metaphysical explanation (at least in this case), as nothing 'tangible' and informative seems to be pointed to. But once a metaphysical explanation *is* sought, the present claim of mutual dependence does not seem less explanatory than the claim that substrata are tied to their properties, or that there exist external compresence relations among properties. For, one may legitimately ask what the 'actual' connection between substrata, or compresence relations, and properties, or between 'tied to' relations and their relata, is.

complex particulars arise out of simpler components; and that it can be rendered immune to the objections customarily made against it.

As regards the empiricist demand for a factual basis for every knowledge claim, tropes not only satisfy the request, but appear to be in a privileged position. Since they are particular qualities, they are always (in principle if not in practice) directly knowable. And once one sees them as endowed with primitive thisness, it can be maintained in a trope-theoretic perspective that, by being acquainted with the things' properties, one is *ipso facto* acquainted with their individuality.

This, of course, leads to an immediate rejection of PII. To use Adams' terms, in a trope ontology suchnesses and thisnesses get identified; but this must be understood in the sense that they are distinct aspects of the same ontological simples, not that the latter gets reduced to the former. It follows that individuality is not the result of a sum of suchnesses, and that numerically distinct but qualitatively identical tropes can exist, and the same holds for complex particulars. This allows us to make sense of the intuition that everything is made out of properties while denying the legitimacy of the further step taken by the followers of Leibniz and Quine, that of *reducing* identities to qualities.

On the other hand, trope ontology also avoids talk of bare identities and the related problems, discussed in the section about substrata. In particular, we have seen that distinguishing bare particulars from their properties appears to entail a commitment to strong haecceitism as the thesis that things can be the same in possible worlds in which they do not have any property that they possess in the actual world. While not in itself inconsistent, this view might be regarded as unappealing. Trope theory avoids it, as it does not make sense to speak of a trope being the same in another possible world in which it does not have the same empirical content. And, once again, the same is also true for complex particulars: since complex particulars owe their identities to the tropes composing them, strong haecceitism is not true for them either, for an individual losing all its properties (i.e., its tropes) would lose its own identity too (in fact, it would vanish altogether).[150]

Trope ontology, in actual fact, appears to lead not to the complete rejection of haecceitism, but rather to the endorsement of the sort of *moderate haecceitism* defended by Adams [1979]. Adams claims that it is reasonable to believe that

> "thisnesses and transworld identities are primitive but logically connected with suchnesses" [1979; 25-26].

Trope theory allows one to make room for such a connection, and so embrace haecceitism in its moderate variant, because, as explained, it is essentially the claim that the things' (fundamental) suchnesses are also the *loci* of the things' identities.

Relatedly, another problem with bare particulars (that they appear in principle immune to change and destruction because property-less) also disappears. For tropes being the basic constituents of reality and having an essential qualitative content, they are the subjects and means of every change that occurs in the world.

Once the discussion of resemblance nominalism and the ontological commitments it requires is also taken into account, it appears fair to

[150] The question remains of when a complex particular ceases to be *that* particular when it progressively loses its component tropes. This, however, appears to be largely a matter of convention. At any rate, as I will argue in detail in the next chapter, I contend that for the basic elements of physical reality, all their tropes (identified with their intrinsic, state-independent properties) are essential for their identity, in the sense that any change affecting their tropes is a substantial change.

claim that trope ontology is explanatory efficacious, simple, and also more economical and less committal than the existing alternatives.

Moving from this to a consideration of physical reality, it is obvious where the advantages of embracing trope ontology lie. First, no problem arises with putative many-particle systems turning out to be composed of indiscernibles. This is because individuality is given regardless of the things' indiscernibility. Consequently, one does not need to subscribe to the thesis that things can be weakly discernible in order to account for the quantum domain (at least parts of it) in terms of individuals. Nor is it necessary to re-describe the things that violate PII as 'non-individuals'.[151]

### *Conclusions*

In the present chapter, a version of trope ontology (that is, a one-category ontology of so-called abstract particulars) has been argued for and defended against traditional criticisms. The version of trope theory that has been endorsed avoids the problems individuated in the course of the thesis and those traditionally raised against trope ontologies; and also satisfies sensible empiricist criteria. As a consequence, it represents a plausible way of fleshing out the intuition underlying the Scotus-Kant-Adams view of individuality as fundamental and irreducible to qualitative facts. Having suggested a classification of types of properties, and an ontological account of the way tropes constitute complex entities, it is now time to deal with the last important task left open in this thesis. Namely, that of assessing whether a trope-theoretic account of the basic

[151] One may object that it is in fact *impossible* to make sense of non-individuality within trope ontology. If this is regarded as a potential problem, however, the trope theorist can say that not all tropes have both determinate self-identity and numerical distinctness from all other things. Although this modification is by no means negligible, it would not entail that one must abandon the theory altogether.

elements of physical reality along the lines suggested in this chapter can in fact be given. This means to identify those actual entities that we can regard as tropes properly understood; and to assess whether they truly are concrete and autonomous entities that can be conceived of as the basic constituents of everything else in the world. The allegedly ultimate constituents of reality are, obviously enough, those studied by contemporary physics. As a consequence, it is now necessary to examine whether these, as they appear in our best description of them, can be conceived of as tropes in the precise sense that has been defined here. If so, a reconstruction of the way in which the fundamental tropes constitute the whole of reality must then be suggested. All this will be done in the next, concluding chapter.

# *Chapter 6*

# *A Trope-Based Reconstruction of the Quantum World*

In this chapter, I apply trope theory in the version outlined earlier to the quantum domain with a view to dealing with the third and last (alleged) difficulty for the supporter of primitive thisness identified in chapter 4: namely, that s/he cannot coherently account for reality as it is described by our best theories in the terms of his/her ontology. The essential elements of reality (as tropes) are identified with the state-independent properties of elementary particles as described by the so-called Standard Model. It is argued that these (and certain additional emergent properties) constitute all the existing entities and determine all their qualities. State-dependent properties, which become relevant at the level of the many-particle systems described by quantum statistics (traditionally taken to clash with an understanding of particles as individuals), are considered in detail.

## *1. Fundamental Tropes*

While the literature on tropes is by now sizeable, very few authors have attempted to substantiate the claim that the basic constituents of reality are tropes by indicating actual physical entities capable of playing this role.

In attempting to answer, in the light of his own ontology of abstract particulars, the question of what the essential components of reality are, Campbell [1990; Ch. 6] suggests taking physical *fields* as the basic tropes. He considers this option independently appealing because in harmony with the developments of physical science. But he also takes it to represent a useful hypothesis in the context of trope theory because it makes it possible to deal with certain problems such an ontological view is usually taken to meet with. Campbell says:

> "Taking our clue from space-time [...], we now propose that all the basic tropes are partless and edgeless in the ways that space is, and that they change only in space-time's innocent way. All basic tropes are space-filling fields, each one of them distributes some quantity, in perhaps varying intensities, across all of space-time" [Ib.; 146].

In particular, Campbell takes it that there exists a field for each one of the basic forces in nature plus one matter field and one space-time field. And he supposes that the varying intensities of the fields and their combinations give rise to reality. According to him, this allows us to deal with the abovementioned *boundary problem* [Ib.; esp. 136-141], consisting of the fact that tropes – despite their being taken to be fundamental constituents – appear to be divisible into other tropes of the same type. The problem is readily solved within his proposal, he argues, because field-tropes as he envisages them are basic and indivisible. The problem of explaining the *compresence* of tropes and their constituting the same entity, explains Campbell, is also solved, because each field is endless and necessarily compresent with space-time at all points. The compresence of field-parts becomes therefore an internal relation and, as such, does not require an explanation. This proposal is surely interesting but, nevertheless, faces some problems.

First, it is simply not true that a field must be compresent with the whole of space-time: already in classical field theory there exists the possibility for fields not to be present at certain points of space-time. But suppose this problem is overcome, for instance by postulating that the basic fields are indeed extended across the entirety of space-time but have (or may have) intensity zero at some points. The true difficulty regards whether Campbell's field tropes can truly be regarded as tropes.

Campbell speaks of extended fields with varying intensities at various points of space (which is indeed the canonical formulation of physical fields). But is this what the trope ontologist wants? One could go as far as to suggest that extended entities with varying 'intensities' *cannot* be tropes. This could be justified on the basis of the fact, for example, that the different intensities of the same field must be similar or dissimilar to some extent and these (dis)similarities should be explained in the terms of the ontology being put forward: namely, in terms of resembling tropes. If this is correct, it entails that fields are not tropes but only complex trope-structures. At the very least, it is *possible* to claim that there appear to exist elements within Campbell's fields which are simpler than the fields but equally capable of qualifying as basic tropes.[152]

Similar criticisms can be formulated against Von Wachter [2000], whose proposal has perhaps different motivations and fine-grained features, but generally goes along lines very similar to Campbell's. Von Wachter starts from the consideration that common sense properties do not have definite boundaries and, instead, constitute a continuum. On

[152] Campbell himself appears uncertain in this respect, for example when he claims that the fields he postulates *change* in the space-time's 'innocent' (?) way, and that 'perhaps' they have varying *intensities*. It is clear that both these 'softening' terms are in fact meaningless, and that either something changes or not, and either something has varying intensities or not. But if, as acknowledged by Campbell, fields do change and have varying intensities (Campbell speaks of quasi-causal transmission of field-quantities across the field [Ib.; 148]), this seems to prevent one from taking them as fundamental entities.

the basis of this, he postulates basic unitary and ubiquitous fields on which all those things that we take to be properties are derivative.[153] Again, the internal complexity of the field tropes, this time together with the explicit talk of properties as *subdivisions* of these, again appears to suggest a tension between the basic intuition of trope ontology (that is, that certain particulars are the basic constituents of everything and, as such, must be simple) and the claim that the fundamental fields are extended tropes. Von Wachter's claim that the field intensities are determinates and the fields determinables further strengthens the feeling that what is really basic is something simpler than the entire field. How can a determin*able* be a fundamental component of reality in its actuality?

Given the above, it seems advisable to follow an alternative route, first suggested by Simons [1994]. According to Simons, we should look for basic tropes at the level of fundamental particles. Fundamental particles, he says, are entities with kernels constituted by

> "a number of nuclear or essential properties like rest mass, charge, and quantum of spin [...and outer layers of...] contingent properties, e.g. their relative position, kinetic energy, momentum, direction of spin (all *at a time*) and so on" [Ib.; 570].

It is these properties, described by physical theory, that according to Simons we should regard as tropes. Simons' position is indeed attractive and – I believe – goes some way in the right direction, especially because it posits as basic tropes elements that indeed appear as fundamental and simple, and are so described by our best science. However, it too remains insufficient. The basic reason for this claim is that Simons overtly

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[153] In particular, Von Wachter argues that all properties correspond to either constant field intensities or to changes in these intensities, or to integrals over field intensities.

acknowledges his perplexity as to how exactly to deal with quantum properties (in particular, as regards the fact that the basic properties of particles are described via probabilities, and allow for superposition [Ib.; 573-574]), and warily leaves the definition of the fundamental tropes vague.[154]

What can be done to improve on Simons' proposal? In what follows, I offer a suggestion.

The best description of the basic constituents of reality and their interactions available nowadays is the so-called Standard Model. It was first developed in the early 1970s to account for three of the four known fundamental interactions among elementary particles (with the exception of gravity, which is still not treated adequately by microphysics). To date, it has had an impressive series of experimental confirmations. In particular, it successfully predicted the existence of a number of particles and approximately the exact values of certain physical quantities.[155]

According to the Standard Model, the fundamental particles are 12 fermions constituting matter and 12 bosons mediating forces. Fermions can be either quarks (distinguished into six types, or 'flavours') or leptons

[154] Also, although less importantly, Simons' account of indistinguishable bosons seems unconvincing from a trope-theoretic perspective. He suggests that in the case of many-particle systems of identical bosons "[p]erhaps what happens is that two or more trope packages, when they get into proximity, expire [...] in favor of a single trope package whose properties are not really, but only apparently inherited from their predecessors" [Ib.; 573]. However, it is unclear why the trope theorist should subscribe to such a view, especially in the form according to which the new 'package' is composed of distinct tropes from those of its components. Simons appears here not to fully appreciate the fact that one of the advantages of trope theory (in particular, with respect to the bundle theory with its commitment to the Identity of the Indiscernibles) is exactly that it allows one to avoid certain ontological conclusions that are often drawn about the identity of things on empirical grounds.

[155] On the other hand, the Standard Model does have shortcomings: it has a high number of free parameters that cannot be calculated independently of empirical observation; it conflicts with the cosmological hypothesis of the Big Bang in certain respects (matter/antimatter ratio, initial cosmic inflation); and it predicts the existence of a particle (the Higgs boson) which has not been observed yet.

(six more flavours). Bosons comprise photons, $W^+$, $W^-$ and $Z^0$ gauge bosons, and eight gluons. Each of these particles carries charges determining the precise nature of its interactions with others. In addition to fermions and bosons, there exist antiparticles; namely, particles identical to each fermion but with opposite charges (each boson-type constitutes instead its own antiparticle, except for the $W^+$ and $W^-$ bosons, which are each other's antiparticle).[156]

Each quark has mass, any of three 'colour' charges (red, green or blue) enabling it to take part in strong interactions (that is, to constitute protons and neutrons) and electric charge, which makes them subject to electromagnetic interactions as well. Leptons also have mass, but not colour charge, and so they do not take part in strong interactions. They do however experience the weak force and (if electrically charged) the electromagnetic force. $W^+$, $W^-$ and $Z^0$ gauge bosons have mass and electric charge, and mediate the weak nuclear interactions. Gluons are mass-less and electrically neutral, but carry colour charge, in virtue of which they interact among themselves and bind quarks together into protons and neutrons.[157] Lastly, photons, the particles making up all forms of light and responsible for electromagnetic phenomena, do not seem to have any of these properties - nor any other property. However, each photon possesses energy, and this entails that it can in fact be attributed *relativistic* mass. True, the latter is distinct from the masses of

[156] Note, however, that neutrinos only have mass, and so cannot be distinguished from the corresponding antiparticles on the basis of this criterion. While it is possible to say that neutrinos have left-handed and antineutrinos right-handed *chirality* (that is, component of spin along the direction of motion, left-handed if negative and right-handed if positive), some suggest that they are the same family of particles, much like in the case of electrically neutral bosons. Neutrinos and antineutrinos are sometimes referred as a whole as 'Majorana particles'.

[157] In particular, they can be thought of as having both colour and anti-colour (the property of the antiparticles of quarks corresponding to the quarks' colour), and their number is directly derivable from the mathematical structure of the theory of strong interactions, quantum chromodynamics.

the other types of particles, which are *invariant* masses, and is essentially the same as the total energy of the system. Nevertheless, the difference is one of 'form' rather than 'substance': as is well-known, according to relativity theory energy and mass are two 'aspects' of the same thing. Hence, I take it that tropes belonging to the same 'family' can be attributed to photons and to the other particles as their 'masses' (broadly understood).

In addition to these particles, there may be others. The Higgs boson is predicted to exist by the Standard Model, but has not been experimentally detected so far. It is, in fact, described as a spin-less and electrically neutral massive particle essential in explaining the actual masses of the other particles and, therefore, the dynamics of physical interactions. The graviton has also been conjecturally added to the Standard Model (as a particle with zero mass, zero electric charge and spin 2) in order to account for the mediation of gravity; but without success, due to theoretical problems consisting of the fact that infinities emerge in the formalism at high energies.[158]

Are there any other properties to be considered? Certain properties normally associated with particles - for instance, momentum (explicitly mentioned, as we have seen, by Simons) - are in fact excluded from the Standard Model. The reason is that they are state-dependent properties not essential for the constitution of particles. In fact, properties such as position and momentum are not ontologically 'concrete', in the sense that they do not count as material constituents of particles, and just describe the particles' dynamic behaviour. On the other hand, all

[158] Gravitation is said to be 'non-renormalizable'. This led some to adopt string theory, in which gravitons are states of strings rather than particles. Of course, like Higgs bosons, gravitons have not been found experimentally. The real problem with them in this respect is, however, that gravity is the weakest force and, because of this, given our current technology there is not even hope of detecting the graviton any time soon.

particles are commonly said – on the basis of the Standard Model itself - to possess spin as an intrinsic property. Fermions have an absolute magnitude of spin of ½, while bosons have spin 1. However, the actual spin (in one of three possible directions) for each particle can assume one of two values (±½ or ±1) and, consequently, only the absolute spin magnitude is fixed for each particle type. This is what Simons has in mind when he distinguishes 'quantum of spin' and 'direction of spin', and takes the former as an essential property and the latter as a contingent property (see above). However, it seems to me incorrect to talk of two properties here, for there is only one spin observable (along each direction) for each quantum particle; but also unconvincing to take absolute spin as an essential property, as the latter is just an abstraction from the actual spin values of particles. For this reason, I keep spin out of the range of the essential properties of particles, and limit the latter to the particles' 'fully state-independent' properties. One might object that spin is in fact an essential property of particles, as it determines the 'behaviour' of the particle as a particle of a specific kind via the spin-statistics link. But the latter connection can in fact be questioned. Hilborn and Yuca [2002], for example, consider the theoretical possibility of small violations of the Symmetrization Postulate and the spin-statistics link as suggesting that the statistical behaviour of particles (as captured by the Indistinguishability Postulate) should be regarded as a formal feature of the state function describing systems of many particles rather than as essentially encoded in the individual particles. In general, spin does not seem to be a well-defined, intrinsic, essential property of an individual elementary particle in the same way as, say, its mass. Hence, I will keep excluding it from the domain of the basic constituents of reality in what follows.

In the light of the above, I suggest that *the level of the fundamental components of reality consists of a set of colour tropes, a set of mass tropes and a set of electric charge tropes, to be defined in detail on the basis of the empirically detected properties of elementary particles.* These properties are summarised in the table below (notice that masses are calculated by coupling left-handed and right-handed particles. Also, for neutrinos, the masses are not specifiable with certainty: they are known to be non-zero because of *neutrino oscillation*, the phenomenon that a neutrino created of a certain type (flavour) can be detected to be of another type at a later time. In general, the measures indicated are deduced from those of more complex particles; and this is inevitable in the case of quarks, which are always confined into composites because of the fact that (due to the self-interacting nature of gluons) it would take an infinite amount of energy to split them apart).[159]

[159] For a detailed treatment of the Standard Model, see Kane [1987], Nachtmann [1990] or Novaes [2000]. In the table, the unit measure of mass is the MeV, the mega-electronvolt, where the electronvolt is equal to the amount of kinetic energy gained by a single unbound electron when it passes through an electrostatic potential difference of one volt in vacuum. In other words, it is equal to one volt (1 volt=1 joule per coulomb) times the charge of a single electron. Of course, the unit measure of electric charge corresponds to the charge of an electron.

| *Particle Type (Flavour)* | *Mass* | *Electric Charge* | *Colour* |
|---|---|---|---|
| Up/Antiup Quark | 1.5 to 4 MeV, probably around 3 MeV | +/-2/3 | R, G or B/ AntiR, AntiG or AntiB |
| Down/Antidown Quark | 4 to 8 MeV, probably around 6 MeV | -/+1/3 | R, G or B/ AntiR, AntiG or AntiB |
| Strange/Antistrange Quark | 80 to 130 MeV, probably around 100 MeV | -/+1/3 | R, G or B/ AntiR, AntiG or AntiB |
| Charm/Anticharm Quark | 1150 to 1350 MeV, probably around 1300 MeV | +/-2/3 | R, G or B/ AntiR, AntiG or AntiB |
| Bottom/Antibottom Quark | 4100 to 4400 MeV | -/+1/3 | R, G or B/ AntiR, AntiG or AntiB |
| Top/Antitop Quark | 171400 ± 2100 MeV | +/-2/3 | R, G or B/ AntiR, AntiG or AntiB |
| Electron/Positron | 0.511 MeV | -/+1 | - |
| Muon/Antimuon | 105.7 MeV | -/+1 | - |
| Tau Lepton/Antititau | 1777 MeV | -/+1 | - |
| Electron Neutrino/ Electron Antineutrino | <0.0000022 MeV | - | - |
| Muon neutrino/Muon Antineutrino | <0.17 MeV | - | - |
| Tau Neutrino/Tau Antineutrino | <5.5 MeV | - | - |
| Photon | Energy $E=cp$ (speed of light times momentum) | - | - |
| $W^-/W^+$ Boson | 0.0804 MeV | -/+1 | - |
| $Z^0$ Boson | 0.0912 MeV | - | - |
| Gluons | - | - | Combinations of R, G and B and AntiR, AntiG and AntiB |
| Higgs Boson | >0.112 MeV | - | - |

**The elementary particles and their state-independent properties according to the Standard Model**

Taking the properties summarized in the table as the basic tropes, the constitution of fundamental particles out of tropes is readily reconstructed.[160] The connection between the tropes within elementary

[160] To this purpose, one might find it congenial to employ a formal framework such as, for example, that suggested in Mormann [1995], or that put forward by Fuhrmann [1991]. Mormann argues that trope ontology can be implemented via what is known as *sheaf* theory: a sheaf is a geometrical space in which a function can be defined mapping particulars in one space onto particulars onto another space according to specific constraints. Mormann describes how it is possible to take the former space as the space of tropes, and the latter as the space of actual entities (in our case, these would be particles). And to explain universals away on the basis of formal features of the sheaf (universals correspond

particles can be conceived of as a relation of saturation in the sense defined in the previous chapter. Physical necessity legislates how actual tropes (as determinates of the determinables of electric charge, mass and colour charge) saturate each other in our world (and in worlds sufficiently nomologically similar to it); and sets the constraints that they obey when doing so (for example, that only the particles with the smallest masses fail to exhibit a charge, or that every charge trope needs to be saturated by a mass trope).

So, for example, a trope of electric charge 0.511 MeV (more precisely, one whose causal power as regards electromagnetic interaction coincides in our 'classifications' with the magnitude 0.511 MeV) can coexist with a +1 charge trope. The individual resulting from the reciprocal saturation of the charge trope and the mass trope in question is a positron. The same applies *mutatis mutandis* for the other elementary particles.

As tropes build up fundamental particles, structures of progressively more complex particulars can in turn be constituted. For instance, suppose an appropriate mass trope, a +2/3 electric charge trope and a red colour trope compose an up quark *a*; and similarly (of course, with different tropes) for two down quarks *b* and *c*. These quarks are among the fundamental elements at the next level of entity constitution (I use 'entity constitution' as a technical definition indicating the composition of complex entities out of more basic ones). They determine, in particular, the formation of a neutron. The latter is colour-less and electrically

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to 'global sections', that is, roughly, mappings of similar tropes onto similar individuals). Fuhrmann, instead, conceives of trope structures as semilattices (algebraic structures consisting of a set of entities and a binary operation applying to them that obeys associativity, commutativity and idempotency). He defines an operation of composition, allegedly allowing one to account for the constitution of actual individuals out of abstract particulars, and for the laws of nature (which Fuhrmann sees as expressing the necessary coexistence of certain tropes).

neutral, and has a mass which is the result of the sum of the masses of the constituent quarks increased by the energy involved in the bond among the latter. The tropes, however, remain the same, i.e., those of the original quarks: the properties of the neutron are, that is, just D-properties produced by trope composition.

Families of electrons, protons and neutrons are the basic constituents at the following level, that of the chemical elements. For instance, 79 electrons, 79 protons and 118 neutrons give rise to an atom of stable gold. And many such atoms determine molecules and bigger pieces of gold. The properties of the latter, such as those that we express via the predicates 'melts at a temperature of 1064.18 C', or 'is a good conductor of heat' are, once again, D-properties determined by the way in which the initial tropes are structured together.

It is easy to see that the same 'dynamics' can be invoked at each level of higher complexity.

As regards substantial change, discussed in the previous chapter, it is worth briefly describing it in terms of tropes at the basic level of entity constitution, that of elementary particles. It is possible, for instance, for a neutron to decay into a proton plus an electron and an electron antineutrino. This transformation can be described as one of the down quarks in the neutron having its electric charge –1/3 trope replaced by one –2/3 trope, and its mass trope of 6 MeV replaced by a mass trope of 3 MeV[161], so becoming an up quark. The details can again be accounted for in terms of physical necessity: for example, one can say that a

[161] One might suggest instead that there are basic tropes corresponding to 'basic units' of the relevant properties, and that all the others are in fact composed out of these. In this case, one would not have a replacement, but rather a loss of three 'units' on the part of the initial mass-complex. This might be the case but, on the other hand, there is no evidence in favour of this hypothesis. On the other hand, this would be significant with respect to Armstrong's 'piling objection', considered in the previous chapter. At any rate, these are details about the 'truly fundamental' tropes that are irrelevant for the present discussion, as they do not affect the proposal being formulated.

'replacement' of electric charge tropes of the type described above determines the production of a particle with electric charge equal to the difference between the initial and final charges, and of a neutral antiparticle. Indeed, neutron decays of the sort described (called neutron β–decays) have an electron and an electron antineutrino as by-products. The masses of these can be connected to the difference in mass between the neutron and the proton (in particular, between the down and up quark) and changes in internal bonds.[162]

The foregoing discussion makes it (hopefully) clear that tropes as intended here are indeed *concrete*, in the sense that they are material constituents of physical reality; and that they are *autonomous* entities, in the sense that they are not existentially dependent on entities belonging to other categories (even though they *can* be so dependent on other tropes in the sense that, at least in some cases, certain tropes only exist together with other tropes in bundles of mutually saturated tropes). The important issue left open in the previous chapter is thus eventually solved: it is possible consistently to describe reality in terms of tropes and nothing else.

It is worth emphasising that nothing in the suggested picture relies on an assumption of physicalist reductionism. Physics plays an essential role in identifying the fundamental properties of material things, and is consequently indispensable in defining one's ontology. However, no denial of the possibility of genuinely non-physical properties is implied at any point. In general, trope theory leaves room for non-supervenient properties, and these can be properties of any kind. If a property other than the fundamental state-independent properties of elementary particles which is not derivative on these turns out to be likely to exist

[162] In addition, the transformation is mediated by a $W^-$ boson.

according to science, one just needs to posit, at the relevant level of entity constitution, one or more non-reducible (types of) properties that 'get added' to the complex particulars existing at that level as further basic tropes.

Going back for a moment to the discussion of quantum mechanics in chapter 3, for example, consider spin correlations in entangled systems as genuinely non-supervenient on properties of the entangled particles. Such correlations can be regarded as tropes that count as 'ontological additions' at the level of elementary particles. In this perspective, particles are built out of tropes (their state-independent properties). Then, systems of particles (can) arise in which particles so constituted additionally exhibit spin correlations in the sense of having an additional concrete constituent literally 'attached' to them.

This consideration leads us to a more general discussion of state-dependent properties and quantum statistics.

## *2. State-Dependent Properties and Quantum Statistics*

Claiming that particles are individuals in virtue of the primitive thisness of the tropes coinciding with their state-independent properties, I argued, allows us to take quantum particles as individuals in spite of the possibility of their indiscernibility.

However, the question arises at this point of what treatment is to be given, in the context of trope ontology and of an interpretation of quantum particles as individuals, of *state-dependent* properties. This is connected to specific problems that arise for the view that quantum entities are individuals with respect to quantum statistics.

Indeed, when the state-dependent properties of systems of many particles are considered from the perspective of the 'arrangements' available to such systems, and of the probabilities of each one of these arrangements being actualised, the resulting statistics has undeniably peculiar features. In actual fact, the claim that since quantum particles obey a non-classical statistics they should be considered as non-individuals can be found as early as Born ([1926], [1943]) and Schrödinger [1952] and is generally regarded as quite plausible. It is therefore certainly necessary to defend the idea that particles are individuals from the threat represented by the peculiar statistics holding in quantum mechanics.

I first summarize the sort of statistics obeyed by classical and quantum particles.[163]

Statistics as it is applied to systems of many particles is of course primarily connected to statistical mechanics as the study of the motions of particles in space and of the ways in which these particles occupy energy states.

In CM, Maxwell-Boltzmann statistics (MB) holds. According to it, the number $n_j$ of material particles in energy state j – given energy states in thermal equilibrium - is given by[164]

$$n_j=g_j e^{-(\varepsilon_j-\mu)/kT}$$

In the case of bosons, Bose-Einstein statistics (BE) applies. It has it that

$$n_j=g_j/e^{(\varepsilon_j-\mu)/kT}-1$$

In the case of fermions, instead, one has

[163] For details, see for instance Reif [1965] and Park [1992].

[164] In the equation, $g_j$ the number of microstates with energy $\varepsilon_j$ (the energy of state j), k is the Boltzmann constant (relating temperature to energy), T is temperature and $\mu$ is the chemical potential (roughly speaking, a measure of the particles' tendency to diffuse).

$n_j = g_j / e^{(\varepsilon_j - \mu)/kT} + 1$

The latter expresses so-called Fermi-Dirac statistics (FD).

Generalizing to all observables, and focusing on the number of possible arrangements rather than on the number of particles in a given state, one has three different ways of counting the number of *a priori* equiprobable ways in which particles can occupy available states with respect to any of their observables.

Suppose one has N particles distributed over M possible single-particle microstates. In classical mechanics (with distinguishable particles)[165], the number of possible distributions W is

$W = M^N$

This is not true in the case of quantum particles, for which a smaller number of arrangements is available. For bosons, one has

$W = (N+M-1)!/N!(M-1)!$

In the case of fermions, EP applies and further reduces the number of possible states, that becomes equal to

$W = M!/N!(M-N)!$

On the basis of these equations, one can calculate the probability for a specific configuration being realized. This is given by

Prob($s$)=T/W

with $s$ being the arrangement in question, and T the number of ways in which $s$ can be realized (obviously, to be calculated via the type of statistics appropriate for the type of entities being dealt with).

The difference among the three statistics can be described by using simple examples such as the following: classically one has four possible arrangements for every macrostate composed of two individuals to each

[165] Whether and, if so, with what ontological import indistinguishability can be traced in CM is an open question that it is not necessary to delve into here.

one of which two states are available – and equiprobable - and each arrangement (since it can only be realized in one way) has probability ¼; in quantum mechanics, instead, there are only either three such arrangements (for bosons) or one (for fermions) – and the probabilities are 1/3 and 1, respectively.

The key difference is that permutations of qualitatively identical particles lead to statistically distinct configurations in the classical but not in the quantum case. In particular, classical systems can be in *non-symmetric states* (that is, states in which individuals have definite but different values separately, and so permutations do make a difference), while quantum systems cannot. Instead, given the nature of quantum reality, entangled states (which are also (anti-)symmetric) are available to quantum systems, while they are not a possibility in CM. Using the customary notation, and considering again a two-particle system and a (generic) two-valued observable, the available possibilities can be represented as follows (with $x$ and $y$ representing the available values for the observable, and the subscripts indicating the – alleged - particle identities):

$|x\rangle_1|x\rangle_2$ (C1-Q1)

$|y\rangle_1|y\rangle_2$ (C2-Q2)

$|x\rangle_1|y\rangle_2$ (C3)

$|y\rangle_1|x\rangle_2$ (C4)

$1/\sqrt{2}(|x\rangle_1|y\rangle_2 \pm |y\rangle_1|x\rangle_2)$ (Q3)

C1-C4 are the states available in CM, Q1-Q3 those available in QM (in particular, Q1, Q2 and Q3 - with a negative sign - are accessible states for bosons, while only Q3 - with a positive sign - is a possible state for fermions).

Why exactly is the fact that non-symmetric states are not an option in QM supposed to count as evidence of the particles' non-individuality? Because, the argument goes, given a set of identical particles in the same system, it is impossible for *a specific one* of them to have a certain value for an observable, and for *another specific one* to have a different value for that observable, as would be required for a non-symmetric state to obtain, because *these particles simply do not have determinate identities* allowing for such property-attributions.

Indeed, quantum statistics does find an immediate explanation if it is regarded as applying to non-individual entities. For, clearly, particle permutations cannot possibly make a difference when one counts possible arrangements if there are no particle identities to be exchanged. What can be said from the point of view of particles as individuals?

It is customary to look for an explanation of quantum statistics from the perspective according to which particles are individuals by making reference to *restrictions on the states available to physical systems*. That is, by assuming the existence of constraints on what particles in many-particle systems 'can do', rather than suggesting their non-individuality. Quantum systems, on this construal, are said never to be found in non-symmetric states[166] just because this is a fundamental feature of the microscopic world; and one that has nothing to do with the particles' individuality. This line is taken, for example, by Huggett [1995] and by French and Krause [2006].

Redhead and Teller ([1991] and [1992]) emphasise a potential difficulty for this approach. One can certainly assume the alleged state-accessibility restrictions as primitive and non-explicable. But it is simply

[166] One must be careful to stress that only completely non-symmetric states are to be excluded, while states other than the usual bosonic and fermionic ones are allowed by the theory.

not possible to make such an assumption and keep all the rest unchanged, because this would contradict an essential requirement. Namely, that when some meaningful part of a theory does not seem to represent anything, one should try to further elaborate on the theory and its applications, and eventually find the real-world counterpart of the bit of formalism apparently devoid of content. Otherwise, the problem would arise that the theory describes something that neither is actual nor can ever be actualised: using Redhead's terminology, one would have *surplus structure* that cannot be hoped to be convertible into something informative and provided with content.

In the present case, though, non-symmetric states can plausibly be said not to correspond to actual physical situations: not only are they never experienced; nature would be entirely different if they were realized, and so one can exclude them in principle. Therefore, the description of non-symmetric states in the theory does indeed seem to represent an in principle useless surplus structure that one had better get rid of.

The only way to do so, Redhead and Teller argue, is by opting for a formalism without 'particle labels'. The obvious candidate for performing such a change is the *Fock space* formalism of quantum field theory (QFT), where, roughly speaking, only information about 'how many' entities are in a certain state is conveyed, and not about 'which entity is what'. Within this approach, however, one appears compelled to dispense not only with the labels, but with what they express at the ontological level too: namely, the particles' primitive numerical identity. Therefore, Redhead and Teller seem to suggest, the mere presence in the theory of states which are physically meaningful and yet never actualised (nor actualisable) is sufficient to take the statistical behaviour of quantum particles as pointing to their non-individuality.

French and Krause [2006; 193-197] argue that Redhead and Teller's argument is not convincing because there is a tension between the heuristic role of surplus structure and the use of it as a methodological rule having an effect on one's ontological beliefs. In more detail, French and Krause emphasise that recent work in physics has made it clear that a complete description of the world may require more than the canonical (anti)symmetric representations; and that, in connection to this, the richness of the formalism has indeed played an important role in the exploration of the actual world. As a consequence, French and Krause deny that the claim that there are primitive restrictions on state-accessibility in the quantum domain is inherently problematic, and contend that the assumption of specific initial conditions together with the impossibility of states of a given symmetry evolving into states of a different symmetry is sufficient for explaining the statistical evidence.

It seems to me that French and Krause are right in allowing for some degree of flexibility with respect to the interpretation of the formalism. On the other hand, however, it appears to be a fact that, while types of quantum systems other than (anti)symmetric ones could exist, non-symmetric states seem to be ruled out in principle. And it is the latter that Redhead and Teller focus their attention on. Moreover, one may legitimately regard the postulation of primitive restrictions and non-further-specified claims concerning initial conditions and constraints on the evolution of physical systems as not completely satisfactory. So, it seems, we are in an *impasse*.

Is an alternative explanation, not departing from the idea that particles are individuals, but also avoiding the mere postulation of restrictions on the accessible states possible?

My answer is affirmative.[167] The idea that will be articulated in the rest of the paper is that those who want to defend the position according to which quantum particles are individuals must make a precise *ontological* claim: they must argue that particles in quantum many-particle systems *never* possess their state-dependent properties as intrinsic, and that such properties are, instead, always *emergent properties of the whole*.[168]

In particular, given *any* many-particle quantum system, they must regard the following as being the case. The total system possesses actual values for *its* state-dependent properties. The component particles, though, are only related to each other at the level of their *dispositions* to have specific values for those properties upon measurement. These dispositions, crucially, are not possessed by the particles and are instead

[167] Other proposals have been put forward which, however, for a reason or another do not seem to deliver what they claim. See, in particular, Huggett's ([1995], [1997] and [1999]) denial that haecceitism must be taken as a necessary manifestation of individuality, and the replies in Teller [2001] and Gordon ([2002] and [2003]). And Belousek's [2000] attempt to put the fundamental postulate of statistical mechanics – attributing equal *a priori* probabilities to each possible state – into question, and the response in Teller and Redhead [2000]. Indeed, if individuality is not reducible to qualities, then some form of haecceitism must be accepted; and an assumption of equal *a priori* probabilities is in fact sensible in the majority of cases. Saunders [2006a] also contains an explanation of quantum statistics. He, however, develops his argument on the basis of an assumption of indistinguishability extended to classical particles which I do not want to commit myself to here.

[168] One may point to a potential inconsistency here. When discussing Saunders' proposal concerning fermions and weak discernibility, I argued that there exists a degree of underdetermination as regards the ontological interpretation of entangled states. Here, instead, I am putting forward a view which is clearly a form of property holism, with separate individuals and emergent relations holding among them. I take it, however, that the positive arguments provided in the previous chapter and in the preceding sections of this chapter provide sufficient reasons for endorsing property holism. If particles are individuals thanks to their unique state-independent properties, it seems to me, they should be regarded as individuals independently of the systems they enter into. That is, while it is possible to claim - along the lines of ontological holism - that quantum particles are individuals unless they partake in systems of many identical particles (in which case, as we have seen is suggested by Simons, they give rise to a single, new 'trope package'), I consider a view according to which particles remain individuals all along more attractive from the perspective of identity and individuality as primitives.

'encoded' in emergent relations holding between them. In a nutshell, the total system exhibits *both* actual properties and what one may call '*emergent dispositional relations*'.

That the statistics is a description of the latter is a natural thing to claim: statistics can be generally intended as a description of possible outcomes of measurements (broadly understood), and it is a widely shared opinion that in quantum mechanics the latter do not *uncover* already possessed properties but rather *determine*, in some sense, the possession of actual properties. Here, in particular, I endorse the claim that measurements actualise certain propensities by making emergent dispositional relations 'evolve into' monadic actual (in philosophical vocabulary, 'categorical' as opposed to 'dispositional') properties of their relata.

The philosophical literature on emergence is large[169], but for present purposes it suffices to take an emergent property to be a property P with the following characteristics:

i) P is the property of a whole constituted of simpler components;

ii) If P is a property of the whole composed by parts *a* and *b*, P is not reducible to the separate properties of *a* and *b*, but has instead - partly or entirely - 'new content'.

Emergence can thus be regarded here as the denial of mereological supervenience for properties. For a traditional example, think of the property of 'being in mental state *x*'. For mind-body dualists, this property is an emergent property of the physical wholes that we call 'persons'. Such a property has the two features above: i) it is attributed to a person as a whole, and a person is an entity with simpler component

[169] For a recent collection of essays on the subject, see Clayton and Davies [2006].

parts; ii) the contents of one's mental states are not reducible to the properties of one's physical parts.[170]

For emergent *relations*, the following also holds:

iii) An emergent relation R is an emergent $n$-adic property of the whole composed of $n$ parts which has parts $x_1, x_2, ..., x_n$ as its relata.

So defined, R is a property exhibited by a whole (call it S) which is *about* the components of S (as R's relata) but is not reducible to their properties.

In addition, crucially, assume that R's 'content' does not include reference to the *identities* of its relata either. To illustrate this with a useful example, think about two fair coins: of course, since these are classical objects a property of the whole such as, for instance, 'one heads and one tails' is always reducible to two monadic intrinsic properties ('heads' and 'tails') possessed by the coins separately. As a consequence, the property of the whole does in fact say *which* coin is what, and thus includes a reference to specific identities. But if it were possible to have the 'one heads and one tails' property of the two-coin system *without having separate properties for the two coins* (perhaps because, one could imagine, the former only describes the outcome of a future coin toss), then the property of the whole would be an emergent property that would not say anything about *any specific* coin.[171] Note that, *in this latter*

[170] In what follows, obviously enough, only physical components, wholes and properties will be considered.

[171] It seems, on the other hand, that emergent relations are not *necessarily* independent in their 'qualitative content' of the identities of their relata. For instance, to stick to the coin example, one may have a relation saying that *coin 1* will be heads and *coin 2* will be tails, even though at the time in which the relation holds the coins possess neither a heads or tails value nor a disposition to have one in the future. Alternatively, one may have two coins with well-defined properties, but also additional content in the relation holding between them. For instance, in the form 'coin 1 heads, coin 2 tails and total mass increased by 0.5 MeV with respect to the sum of the coins' separate masses'. Notice, incidentally, the role played by time-asymmetry in defining these relations.

*case, switching the coins would not give rise to a new total state*: whatever happens to the coins' identities, it is the case that one (without any specification as to which one) will be heads and the other tails. Still, it makes perfect sense to regard the coins as individuals.

This, it is claimed here, is exactly what happens in the case of quantum many-particle systems. For these systems, one *only* has information about the particles in the form (assuming again two-particle and two-value systems) '1 has the same value as 2 for property P, namely, *x*', '1 has the same value as 2 for property P, namely, *y*' or '1 has opposite value to 2 for property P'.[172] According to the present proposal, all these qualitative descriptions, *including the first two*, correspond to emergent relations of the sort just illustrated. And here too, as for the strange coins above, the descriptions can be taken to be descriptions of individuals.

The idea that *all* statistically relevant properties of quantum systems are emergent relations is not as 'exotic' as it may seem at first: it essentially consists of *an extension to other quantum states of certain widely shared views regarding entangled states*. It is commonly claimed that quantum entanglement consists of some form of non-separability, coinciding with the existence of emergent properties that belong to the entire system and not to the system's component particles. Teller [1989] designates as *particularism* the view that the world is composed of individuals possessing non-relational properties, and relations among which supervene on their non-relational properties. He claims that the differences between classical and quantum mechanics are due to the fact that particularism is true of the entities dealt with at the level of the former, but not of those described by the latter. In the quantum domain,

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172 For simplicity, the properties are expressed as if they were categorical and not dispositional here (and below). Strictly speaking, one finds properties such as '1 and 2 *will* (be measured to) have the same value for property P, namely, *x*' etc.

Teller argues, one must endorse *relational holism*: that is, the view that certain properties of the total system are emergent relations entirely independent of the properties of the system's component parts. In particular, Teller considers as a reason to embrace relational holism the failure of outcome-independence in the case of the experimental confirmations of the violation of Bell's inequalities. Relational holism, he holds, allows one to dispense with a tacit assumption of 'ontological locality of values', and consequently renders quantum mechanics compatible with relativity (see Teller [1989; 214-215]).[173]

It can be seen that entangled states, once interpreted from the viewpoint of Teller's relational holism, exhibit emergent relations of the type described above. Consider the singlet state of spin of two fermions. There is a property (the total spin) of a composite system reducible to the properties of the system's parts, which are not in *any* specific state with respect to their state-dependent properties. The total spin property, however, *coincides* with a relation describing the future spin-outcomes for the separate fermions in a precise way (as opposite). This latter relation is independent of the fermions' identities, as it does not depict either of them as being in a specific state, nor conveys information as to which fermion will have which value for spin.[174]

Teller's perspective can, therefore, be taken as the starting point here. The crucial addition to it - anticipated above - can be formulated as the

[173] The idea is that non-locality is avoided in a relational holist context because, according to the latter, in EPR-like settings one does not have a causal relation between two space-like separated events; rather, one has a causal influence on a single entity (the emergent relation), which then 'propagates' to others (its relata) via a causally continuous process (which is immediate in time but also transmitted through a physical continuum – the relation itself - rather than at-a-distance).

[174] There certainly is much to ask about the suggested 'coincidence' between the property of the whole and the relation between the (future) properties of the components. I am assuming here that there exist two distinct properties, one actual and the other dispositional, but perhaps one may put forward a stronger claim of identity and see the two as different 'aspects' of the same property? In any event, nothing hinges on this in the rest of the paper.

suggestion that there is no reason for saying that the particularist perspective, which is agreed to fail for entangled systems, is valid for non-entangled ones. Indeed, the extension being proposed consists of the claim that *quantum relational holism concerns not only entangled but also non-entangled systems*; and that, as a consequence, the independence of the entire system's properties (as emergent relations) of the identities of its components (as individuals) *generalises* to *all* properties and states.[175]

Eventually getting to the problem being discussed, it can be maintained that the above is all that is needed in order to provide an account of quantum statistics in the context of an ontology of individuals.

First of all, the perspective just envisaged entails that for *all* many-particle systems and state-dependent properties particle exchanges do not give rise to new arrangements (i.e., the identities of the particles are not statistically relevant) *not* because particles are not individuals and consequently do not have well-defined identities. Rather, because *the particles' identities do not play any role in the determination of the states that are described by the statistics*, which are *always* states that exhibit emergent dispositional relations understood in the precise sense specified in this paper. As in the case of our two imaginary coins, switching the identities of the relata does not affect the qualitative content of the relation that characterises a many-particle quantum system.

A closely related consequence is that one should not expect 'quantum analogues' of classical states such as C4 (that is, non-symmetric quantum states) to exist, because these would require a property-structure different from the one that – it is being claimed – is exhibited by quantum systems. That is, they would require individual particles that

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[175] Also, but less importantly, the dispositional element emphasised here is not given the same relevance in Teller's work.

possess well-defined values for their observables *separately from each other*, which is exactly what is ruled out in the present framework.

Another way to see this point is the following. If relational holism is true of all quantum many-particle systems, it means that the correspondence between states C1 and C2 on the one hand and states Q1 and Q2 on the other is only an appearance due to the formalism employed. While the former two effectively are states in which each particle is in a determinate state (that is, possesses a value for the property under consideration as intrinsic), the latter two are instead states in which there is an emergent relation but no determinate states for the relata, exactly in the same way as in the states described by Q3 and Q4. This reading of the situation makes entangled states look immediately much more 'natural' than non-symmetric ones in the quantum case: for, if Q1 and Q2 were states in which each specific particle possesses a specific property, then Q3 and Q4 would be 'farther removed', as it were, from them than states analogous to C3 and C4, and so there would indeed be a reason to expect the latter to be realized. But if one has instead only emergent relations, then states exhibiting relations attributing equal values to their relata are unsurprisingly 'complemented' by states describing 'opposite value' relations, i.e., by entangled states. As a matter of fact, other kinds of states are *necessarily* excluded.[176]

What has just been conjectured can hold for all systems, independently of the number of their individual components. To see this, one just needs to conceive of the right emergent relations. For instance, considering three particles and two states, one has (N+M-1)!/N!(M-1)! possible states, namely 4. These are readily described by two 'same value'

[176] Recall the question about non-symmetric states asked in section 1, and the relative footnote regarding the 'tacit assumption' of intrinsic properties for the separate particles.

relations of the sort already encountered, plus *two* 'different values' relations: 'two particles have the same value for property P, namely, *x*, and one particle has the other value, *y*, for property P'; and 'two particles have the same value for property P, namely, *y*, and one particle has the other value, *x*, for property P'.[177]

In fact, if one thinks about it, one can see that the explanation[178] of quantum statistics suggested here *must* be deemed satisfactory if an account based on non-individuality is. Because the former differs from the latter only with respect to 'where identity is taken out of the picture', so to speak: property-type rather than property-bearers.

In the light of the preceding discussion, questions regarding the 'mysterious non-classicality' of quantum statistics eventually turn out to be less problematic for the supporter of individuality than commonly thought. The specific identities of the separate *individual* particles, it is possible to claim, are simply *irrelevant* for the determination of *any* of the states that the statistics describes, due to the peculiar property-structure exhibited by quantum entities in such states.[179]

Let us now consider some possible reactions, and add a few remarks.

i) One may dislike an ontology according to which non-supervenient relations invariably emerge in quantum many-particle systems out of particles that possess separate actual (or, 'categorical') properties when they do not belong to the same system. In reply to this sentiment, the following remark can be formulated (again). The fact of emergence being

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[177] Again, this neglects the dispositional element for simplicity. Here, the essential fact is that there are only two possible ways for three particles not to have all the same value for a two-valued observable if the relevant information is entirely encoded in emergent (dispositional) relations in the sense assumed here.

[178] It is important to emphasise that here we have an ontological *explanation* of why there are state-accessibility restrictions that apply to the particles as individuals, not (anymore) an *a priori denial* of the possibility of certain states being actualised.

[179] Notice that such a property-structure might demand in turn an explanation. But this does not involve the particles' identities and, therefore, it does not have to do with (non-)individuality any longer. See point i) in the next section.

pointed at is something peculiar about the quantum domain in general, and the present proposal simply extends to other systems claims that are already widely accepted for certain physical composites (i.e., entangled systems) *under any interpretation of the theory.* If an explanation must be sought at all, it must regard the nature of entanglement rather than (or at least before) the present suggestion concerning quantum statistics.

ii) The results (mentioned in chapter 3) showing that quantum correlations cannot be regarded as real and local properties of composite systems on pain of violating Bell's inequalities for pairs of correlated pairs of particles[180] may be taken to prevent one from understanding quantum correlations in the way suggested here. However, it seems to me that to describe correlations as dispositions rather than actual properties allows one to draw the needed distinction. If an objective local property of a system is one that cannot change in response to what is done to another system which is not interacting with the first, and correlations do in fact change in this way, then one just needs to discard the assumption of 'objectivity and locality' for dispositions. After all, of course the authors presenting the mentioned impossibility results do not want to deny the existence of correlations altogether, which are undoubtedly real[181]; thus, perhaps regarding these correlations as dispositions is the way to go in order to make sense of both quantum holism and the violation of Bell's inequalities by more complex systems.[182]

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[180] Cabello [1999], Jordan [1999] and Seevinck [2006], in particular, aim to refute Mermin's (see, for instance, his [1999]) suggestion that quantum mechanics is only about correlations, and correlations – to be intended as realistically as possible - are all there is to quantum systems.

[181] In fact, they stress the fundamental role of correlations in the context of quantum information.

[182] To answer someone not happy with this, I think, I would have to retreat to the claim that in quantum many-particle systems state-dependent properties are not possessed by individual particles as their monadic properties, but only by the whole systems as correlations *of some sort* among their parts; and, as a consequence, quantum statistics is *exclusively* concerned with correlations, *whatever the ontological nature of the latter may*

iii) One might insist on the presence of in principle meaningless surplus structure in the formalism of quantum mechanics. This response could in that case be given: it can equally be maintained that classical mechanics is inadequate as a description of the objects in its domain because it is possible to describe the latter entities as entangled but entangled states are never realised in the classical world. In general, given any physical theory and its formalism, it appears always possible to 'cook up' some form of surplus structure. In fact, it seems correct to claim that what counts as surplus structure is not immediately determined and ontological presuppositions are fundamental for interpreting the theory. This is essentially the reason why it is contended here that the ontological explanation provided in this paper succeeds where talk of inexplicable state-accessibility restrictions failed.[183]

iv) It could be maintained that the picture delineated in this paper essentially amounts to an endorsement of Bohmian mechanics: the attribution of state-dependent properties to the 'whole system', that is, could be regarded as basically the same as the attribution of them to a 'guiding wave'. There might be something to this criticism, in the sense that the basic idea is in some way inspired by the De Broglie-Bohm view and by the thought that there may be a clear-cut ontological difference between types of quantum properties.[184] But of course, the important difference exists that no assumption has been made here about

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*be*. The basic idea would anyway be preserved which I consider sufficient for explaining quantum statistics in an individual-based setting.

[183] It is interesting to notice that Huggett [1995] makes the same claim about surplus structure (using the example of the description in the 'language' of classical mechanics of a body moving faster than the speed of light) but by way of conclusion of a paper that attempts to deflate the relevance of metaphysics entirely.

[184] As is well-known, Bohmian mechanics takes the particles' state-independent properties and their positions as essential to the particles themselves, while it attributes all the state-dependent properties to a wave component, 'guiding' the particles in space. The exact position occupied by the particles with respect to the wave determines their behaviour including, crucially, the outcomes of measurements of state-dependent properties.

uniqueness of positions and initial particle distribution in agreement with $|\Psi|^2$, which are two distinguishing features of Bohmian mechanics. Also, crucially, unlike in Bohmian mechanics the notion of collapse is retained in the present framework. Therefore, the analogy is only superficial.

A closely related objection could be that the suggested proposal aims to achieve something which is already obtained by endorsing Bohmian mechanics, and consequently turns out to be superfluous. This criticism, however, can easily turned on its head: the suggested picture of quantum reality, one could argue, achieves some of the allegedly important results of Bohmian mechanics (possibility to describe particles as (quasi-)classical objects, reconstruction of the statistics within an ontology of individuals) without departing from what many see as the correct theory of the quantum world and the correct interpretation of it (namely, the so-called 'orthodox' interpretation of quantum mechanics based on Von Neumann's mathematical formalism and on the notion of collapse of the wave-function). True, if one is happy with Bohmian mechanics, one will presumably find no reason to embrace the perspective defined in this paper. But the present work is primarily directed to those who are, to the contrary, not particularly fascinated by Bohm's theory and would rather stick to standard quantum mechanics (perhaps, *provided* that the latter could be shown to be consistently interpretable in terms of individuals).

v) A more important thing to say regards a consequence of the present proposal for the interpretation of quantum mechanics. Usually, as we have seen in chapter 3, the Eigenstate-Eigenvalue Link is employed when interpreting the quantum formalism. It licenses inferences such as the following:

[Prob(particle *x* has property P with value *v*)=1]⇒[(Particle *x actually* has property P with value *v*)]

However, it was denied earlier that in states such as, for instance, Q1 one has two particles each actually possessing a specific value for the given observable as an intrinsic property: the consequent in the above conditional must thus be deemed false. But in such states, the component particles have probability 1 of being detected as having that property (as they are in an eigenstate for that observable): the antecedent is true. Therefore, EEL seems to be made invalid by the present proposal.

The response to this is that, according to the ontological hypothesis that was put forward in this paper, one must indeed make an amendment to EEL, and regard it as *only applying to the total system*. According to this interpretation, each separate particle in a many-particle system can be seen as possessing a property as intrinsic *only after measurement* (when the system will be split into distinct sub-systems), even if it has probability 1 of possessing that property before being measured. Before measurement, it is maintained, such a probability only follows from the description of a disposition of the entire system and cannot therefore be regarded as corresponding to an actual property that can be attributed to the specific particle. This modification to the link - which is at any rate not an integral part of quantum theory and is modified or even abandoned also in other contexts such as, for instance, modal interpretations of quantum mechanics – should appear acceptable. Especially so once one realizes that, although essential from the perspective of one's ontological interpretation of quantum theory, such a modification does not make any difference *in practice*: we can still *attribute* separate properties to the particles that compose a non-entangled state before measurement exactly because we know from the quantum probabilities that upon measurement they will *necessarily* possess such properties. Since measurement is the *only* way to check whether a given quantum particle has a certain (state-dependent) property, to ask whether the particle already has the detected properties before measurement is simply otiose, and no empirical difference can possibly emerge between the two scenarios (i.e., with dispositions encoded in emergent relations and with intrinsic properties – be they dispositional or categorical – respectively).

### *Conclusions*

Looking at the description of the elementary particles provided by the Standard Model permitted the individuation of the tropes making up the whole of reality (of course, on the assumption that our current knowledge of physical reality is an at least approximately correct representation of reality). These have been identified with the elementary particles' essential state-independent properties. That is, with their mass, charge and colour.[185] As for state-dependent properties and the peculiarities of quantum statistics, they have been accounted for by emphasising that these peculiarities only emerge before measurement; and by taking all state-dependent properties of identical particles in the same system before measurement as emergent relations. This allowed for a reconstruction of quantum statistics as involving entities which are full-blown individuals, although with peculiarly non-classical properties.

[185] It must be borne in mind that not all particles have all these properties.

## *Appendix: Statistics and State-Dependent Properties in Other Interpretations of the Quantum Domain*

As in chapter 3, I assumed the standard interpretation of QM in this chapter. And as in chapter 3, here too it might be useful briefly to consider how what has been said would need to be modified within the context of other interpretations.

In Bohmian mechanics, no particular treatment needs to be given of state-dependent properties, as these are properties of the wavefunction, and the corresponding probabilities are purely epistemic.[186] As for the statistics, the predictions of Bohmian mechanics agree with those of quantum mechanics because of a *quantum equilibrium hypothesis* according to which particle configurations are random with a distribution that coincides with the probability density of finding a system in a given configuration according to the standard quantum formalism. This might appear *ad hoc*, but is certainly effective. And it is particularly significant in the present context, because it allows one to reconstruct quantum statistics on the basis of an explicitly classical ontology. Bohmian mechanics can indeed be said to reduce quantum statistics to the quantum analogue of statistical mechanics for classical mechanics.

As regards modal interpretations, generally speaking these reduce the non-classicality of quantum statistics to an ignorance-based approach to what can be conceived of as an essentially classical domain. Arguments

[186] It is true, on the other hand, that property-attributions in Bohmian mechanics become contextual. They violate, that is, the assumption "that measurements of an observable must yield the same value independently of what other measurements may be made simultaneously" (Bell [1987; 9]). This poses some difficulties for the interpretation of the theory, but is certainly consistent with the idea that particles are individuals.

and proofs in support of this claim are provided by Van Fraassen [1991; 327-335].

Lastly, the ensemble, or statistical, interpretation has clear consequences on one's understanding of properties of many-particle systems. The wavefunction, according to such a view, must be taken as an abstract statistical function, only applicable to the statistics of repeated preparation procedures, in a way analogous to what occurs in classical statistical mechanics. Within this interpretation, it can perfectly be claimed that before the measurement the system was in the measured state, and that the observed statistical behaviour does not mirror any deep-seated ontological fact but, instead, just describes the specific behaviour of ensembles of systems of large numbers of (possibly wholly individual) particles.[187]

[187] In this connection, it is interesting to notice that arguments exist to the effect that quantum statistics can be reproduced by operating on systems of entirely classical particles. See Gottesman [2005].

# *Conclusions and Outlook*

In this thesis, a specific case study, having to do with the metaphysical nature of individuality and the ontological interpretation of the fundamental constituents of reality as they are described by quantum mechanics, has been shown to be an exemplar of the two-way interaction between philosophy and the natural sciences. Relevant results have been obtained both in metaphysics (plausibility of the view of individuality as primitive thisness; appeal of trope theory and moderate haecceitism) and in physics (orthodox quantum mechanics as interpretable from an ontologically 'conservative' perspective, with particles as (quasi-)classical individuals).

In relation to the metaphysical side of the arguments presented, it is worth emphasising that the recourse to the notion of primitiveness must not be understood as a 'cheap way out' of the crucial difficulties. First, while issues such as individuality and resemblance have indeed been in the end presented as facts that require (and allow) no further explanation beyond the ostensive reference to the things' nature and existence, this conclusion has been reached via a detailed conceptual analysis, and argued to constitute the best conjecture in view of the evidence and the problems at hand. Secondly, all philosophical explanations must end at some point, and are inevitably rooted in something that is presented as primitive (for instance, the multiple instantiability of universals within the bundle theory – why should *this* be accepted as a primitive metaphysical posit?); consequently, the present account only differs from others with respect to what it takes as a fundamental fact.

As regards the thesis' 'results', while some definite answers, or at least suggestions, have been formulated, some other topics and areas present themselves as natural candidates for further research. The connection between primitive thisness and linguistic notions of direct reference and rigid designation, or between trope ontology and truth-making theory; or the possibility of extending certain results so as to include a consideration of identity in time, for instance, may be worth exploring.[188]

However, it is my conviction that, before moving beyond the domain discussed here, it is necessary to have an even closer look at the physics. As shown in chapter 3, orthodox quantum theory and Bohmian mechanics, although empirically equivalent, have radically different ontological consequences. This suffices to show that a careful comparative evaluation of all the existing alternatives is essential in order to have a clear idea of what can (or should) be said at the level of ontology in view of (non-relativistic) quantum mechanics broadly understood.

Once the study of non-relativistic quantum mechanics is so completed, it will then be possible to move on to different types of physical theories. For instance, it is a possibility that the conclusions and

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[188] It is interesting to notice the potential relevance of the discussion in this thesis for the topic of scientific realism. Worrall [1989] argued that, by distinguishing the intrinsic nature of things and the structure of their relationships with each other, the realist becomes capable of identifying the sort of cumulativity in the history of science that s/he needs in order to substantiate his/her claims. What persists across theory change, Worrall argues, is the structure of things, mirrored by that formal structure that theories substituting each other in the development of science turn out to share. This position came to be known as epistemic structural realism (ESR). Other authors (in particular, Ladyman [1998]) endorse ontic structural realism (OSR), the position according to which not only is structure what is preserved across theory-changes; the grounds also exist for formulating a radical metaphysical thesis to the effect that reality is entirely made out of structures. One fundamental reason for which OSR is regarded as compelling by its proponents is the alleged complete underdetermination between individuality and non-individuality in quantum mechanics. The results of this work are therefore clearly relevant to the debate over structural realism. On the one hand, they could be taken to support the OSRist's claim of underdetermination, by providing further reasons to opt for individuality in spite of the well-established general opinion going in the direction of non-individuality. On the other hand, the ESRist (and the opponents of OSR in general) may insist that, since individuality is, so to speak, the default option supported by intuition and commonsense, insofar as it can be shown that existing arguments for non-individuality are not as compelling as they are commonly taken to be, individuality comes out as a winner. Further study of these issues may give interesting results.

proposals formulated in this thesis, explicitly set against the background of non-relativistic quantum mechanics, do not carry over (at least not in an unqualified form) to the domain of other, more advanced, theories that are possibly more reliable as 'true descriptions' of reality. Some authors, for instance, take quantum field theory to require (or at least strongly suggest) an ontology of non-individuals.[189] Even supposing that this is not the case, and that quantum field theory simply mirrors the issues arising at the level of canonical quantum mechanics, additional results appear at the relativistic level that it is certainly important to look at in some detail from the present perspective, aiming to do metaphysics in a scientifically-informed way.

Relativistic quantum field theory gives rise, in particular, to:

1) No-go theorems on the localizability of particles, according to which it is impossible to describe particles as localized in finite regions of space-time, for doing so would violate basic relativistic postulates such as the impossibility of superluminal speed (see Malament [1996] and Halvorson and Clifton [2002]);
2) The Reeh-Schlieder theorem (Reeh and Schlieder [1961], see also Redhead [1995]), which asserts that local measurements never permit us to distinguish a state with no particles ('vacuum state') from any *n*-particle state;
3) The fact that expectation values for certain quantities do not vanish for the vacuum state, so that energy is not zero and

[189] For the first explicit formulation of the idea that the basic constituents of quantum fields are non-individual *quanta*, see Teller [1983]. Other suggestions depart more radically from the 'thing-with-qualities' paradigm. To mention a few: event ontologies (Auyang [1995] and Bartels [1999]), occurrent-/process-based ontologies (Stapp [1979] and Seibt [2002]), and factored ontologies (Simons [2002]). But see the notion of 'ephemeral' suggested by Redhead [1983]. Ephemerals, Redhead claims, are full-blown individuals that only exist in between creation- and annihilation-events.

there are physical 'happenings' even when no particles are there;

4) The fact that the prediction of the so-called 'Unruh effect', namely, that a uniformly accelerated observer in a vacuum will detect a 'thermal bath' of particles (the so-called 'Rindler quanta') - so that a change in the frame of reference causes a change in the number of particles - has been experimentally 'verified'.

Without entering in the details of these arguments, it can be said that they appear *prima facie* to represent a threat for the concept of an individual particle. It is therefore interesting to see whether the features that they put into doubt (e.g., localizability, constant number, independence of frames of reference, absence in vacuum) should in effect be dispensed with; and whether the modifications one may consequently be required to make in one's ontology compromise the project of developing trope theory along the lines suggested in the second part of the thesis.

For the time being, at any rate, it appears fair to claim that the approach to questions of identity and individuality, and to metaphysics and science in general, endorsed in this work has a number of interesting consequences and relevant potential applications. The future appears promising for the development of the study of at least some of those questions that lie at the boundary between traditional metaphysics and the most advanced empirical study of the world around us.

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