# Identity Problems in Physics?

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The particulars encountered in modern physics have struck many as being quite different from ordinary macroscopic things, in ways that make them philosophically problematic. To a first approximation, such putative differences may be grouped as follows:

**thin essences** Elementary particles do not seem to have opaque, substantial and individualising, or even characterising, essences: there is not much, or even nothing, it is to be them, and they seem to be wholly accountable for in general terms.

**brute identity** They do not seem to 'have' an identity, as they seem to differ among themselves brutely and *solo numero*.

**extrinsic nature** They seem to have very few, if any, intrinsic properties, properties that characterise them as they are by themselves; most, or even all of their properties seem relational or extrinsic, accruing to them in a 'top down' way, in virtue of their place in a network of relations.

## Indiscernibles

### Two indiscernible spheres

Consider Max Black's two spheres (Black, 1952). I will assume that there are two, and that they serve as counterexample to some non-trivial principle of the identity of indiscernibles.

While the spheres are distinct, 'nothing tells them apart': they are only weakly discernible, i.e. in virtue of there being irreflexive relations holding between them. Though they are intrinsically indiscernible, we can name them: there is no problem calling one (and only one of them) "$a$" and the other "$b$". Naming requires only an isomorphism between the names and the things named, and that we cannot distinguish the two possible ismorphisms in this situation does not make it impossible for us to arbitrarily decide on one of them.

Though, at least initially, we cannot tell them apart, we may, for other or these reasons, postulate things belong to various ontological categories that will tell them apart for us. We may, e.g., take them to be hylomorphic compounds that differ in their matter, though not in their form; or we may individuate them by their different haecceities; or we may believe that there are states of affairs of the form "$a$ is called "$a$" ", of which only one but not the other is a constituent. We may also tell them apart by formal relations, e.g. by claiming that only $a$, but not $b$ is a truthmaker for "$a$ is a sphere" or that $a$'s sphericity, but not $b$'s partly grounds $a$'s volume.

Hence Stout is perhaps right: "There must ultimately be a qualitative element in the nature of related terms which makes it possible or necessary for them to be related as they are." (Stout, 1918, 537)

Let us call "unscrutable reference" the reference to $a$ by $s$ using $t$, where $s$ does not know and is (perhaps even in principle) not in a position to know what $a$ is or how to distinguish $a$ from other candidate referents of $t$. It is indisputable that inscrutable reference occurs.[1] Its most clear-cut cases occur in what Fine calls "instantiational reasoning", i.e. reasoning that proceeds from the arbitrary introduction of a name as in "let $n$ be a natural number", "let Julius be the inventor of the zip":

1. Indeed, Quine famously argued that *all* reference is unscrutable.

> "Suppose I begin a geometric proof with 'Given a pair of enantiomorphs of type $H$, call them $A$ and $B$ …': will I be reasoning invalidly? Not at all. For the mathematical assertion *that there are two*, when explicated set-theoretically, becomes equivalent to *there exists a function which maps this collection of enantiomorphs one-to-one onto the class* {*'A', 'B'* }. The point […] is therefore *not* that labelling is impossible, but only that the different possible labellings cannot be distinguished by description." (van Fraassen, 1991, 457)

More generally, inscrutable reference results from the multiple realisation of the term-introducing theory.

Sets distinguish indiscernibles, for "the identity of the member of a unit set is an intrinsic property of the set which also determines its identity" from which it follows that "even [if] there can be two exactly similar physical objects $x_1$ and $x_2$, the unit sets $\{x_1\}$ and $\{x_2\}$ are not in the same way exactly similar since they have different intrinsic properties" (Baldwin, 1996, 233)

## My two hands

Consider a left and a right hand. They are not related by an Euclidean motion, so at least weakly discernible. In contrast to Max Black's spheres, the hands much more clearly differ in dispositional properties: one, but not the other will fit a certain glove, e.g. While they do not differ in 'internal' relations, i.e. relations that hold between their parts, they do differ with respect to relations between them, in the sense that there are, between two non-congruent hands, differences that can be made to emerge in bigger world scenarios.[2]

Throughout his career, Kant repeatedly used incongruent counterparts to show that our representations of space and time are intuitional rather than conceptual[3], in effect relativising the intrinsic/extrinsic distinction to the epistemic capacity by which we access the property.[4]

Their apparent possibility may be either taken as an argument for a substantivalist account of spacetime or as showing the need to acknowledge handedness as an intrinsic irreducible properties of spatial objects.

In Kant's case, the two hands differ by phenomenal properties, but these properties are neither extrinsic, nor relational, nor really response-dependent, but "innerlich, so weit die Sinne lehren". The two hands differ as phenomena, but not as noumena, in the same way as do the two raindrops discussed in the *Ambipholy*. Kant's there says that Leibniz's principle of the identity of indiscernibles holds of "concepts of things as such" ("von Begriffen der Dinge überhaupt gilt", A 272 / B 328):

> …wenn ich einen Tropfen Wasser als ein Ding an sich selbst nach allen seinen innern Bestimmungen kenne, so kann ich keinen derselben von dem anderen für verschieden gelten lassen, wenn der ganze Begriff desselben mit ihm einerlei ist. Ist er aber Erscheinung im Raume, so hat er seinen Ort nicht bloss im Verstande (unter Begriffen), sondern in der sinnlichen äusseren Anschauung (im Raume), und da sind die physischen Örter, in Ansehnung der inneren Bestimmungen der Dinge, ganz gleichgültig…(A 272 / B 328)

2. Two figures are *incongruent counterparts* iff they are congruent, i.e. related by an Euclidean transformation, but not related by a proper motion, i.e. cannot be brought to coincide in space.

3. He says in his inaugural dissertation that "between solid bodies which are perfectly similar and equal but incongruent […] there is a difference, […] in spite of the fact that, in respect of everything which may be expressed by means of characteristic marks intelligible to the mind through speech, they could be substituted for one another. It is, therefore, clear that in these cases the difference, namely, the incongruity, can only be apprehended by a certain pure intuition." (1992, 403; "in solidis perfecte similibus atque aequalibus, sed discongruentibus […] sit diversitas, […] quanquam per omnia, quae notis, menti per sermonem intelligibilibus, efferre licet, sibi substitui possint, patet: hic non nisi quadam intuitione pura diversitatem, nempe discongruentiam, notari posse."; $A_2$ 20, 1983, V, 58)

4. In the *Prolegomena* (A 59, , Kant says that the distinction between the right-hand and the left-hand glove is intrinsic to the senses ("innerlich, so weit die Sinne lehren") but is only possible by the relations of them to the whole of space of which they are a part ("die innere Bestimmung eines jeden Raumes ist nur durch die Bestimmung des äusseren Verhältnsses zu dem ganzen Raume, davon jener ein Teil ist (dem Verhältnisse zum äusseren Sinne), d.i. der Teil ist nur durch das Ganze möglich").

Leibniz's mistake to take the indiscernibility of identicals to hold not just of noumena, but of phenomena as well, is put in terms of forgetting about what was abstracted from:

> Weil aber bei dem blossen Begriffe von irgend einem Dinge von manchen notwendigen Bedingungen einer Anschauung abstrahiert worden, so wird, durch eine sonderbare Übereilung, das, wovon abstrahiert wird, dafür genommen, dass es überall nicht anzutreffen sei, und dem Dinge nichts eingeräumt, als was in seinem Begriffe enthalten ist. (A 281 / B 337-338)

Kant says here that Leibniz, thinking to be able to sensibly talk about noumena, abstracted from the extrinsic (i.e. spatio-temporal) properties that may distinguish intrinsically identical phenomena, took them to be non-existent and thus inferred the identity of things from the identity of their concepts, an inference valid insofar as they are regarded as things in themselves but not valid for appearances.

It seems that handedness is not a property something has in virtue of standing in spatial relations to other things (and neither can it depend on relations to its parts, for these are the same among things differing only in their handedness). Relationists, however, have to deny that for there is in their view no fact of the matter whether a single hand in a universe is a left or a right hand. They cannot, like substantivalists, explain handedness as a relation to the space something occupies.

If the existence of incongruent counterparts (and hence the exemplification of handedness) is contingent, then a relationalist may respond to Kant's thought experiment that a solitary hand would not have any handedness.

This is the reply Ishiguro gives on Leibniz's behalf to Kant about incongruent counterparts:

> "Leibniz would probably have said to such an assertion that, although it is perfectly clear that in a world in which there are both left-hand and right-hand gloves one can make the distinction between the two, in a universe which consists solely of a single glove, this is not the case." (Ishiguro, 1990, 115)

There are two problems with such a reply, however:

1. If we identify the solitary left hand with the solitary right hand, are we not then violating the supposedly metaphysical (and not just mathematical) principle that identicals added to identicals cannot make for a difference? In other words: where does the intrinsic difference between the left-left and the left-right worlds come from?
2. If we identify the solitary left hand with the solitary right hand, how do we explain the fact that only one of them fits a right glove?

On the way to an answer to the first question it is useful to distinguish, with Khamara (2006, 65), three versions of the PII:

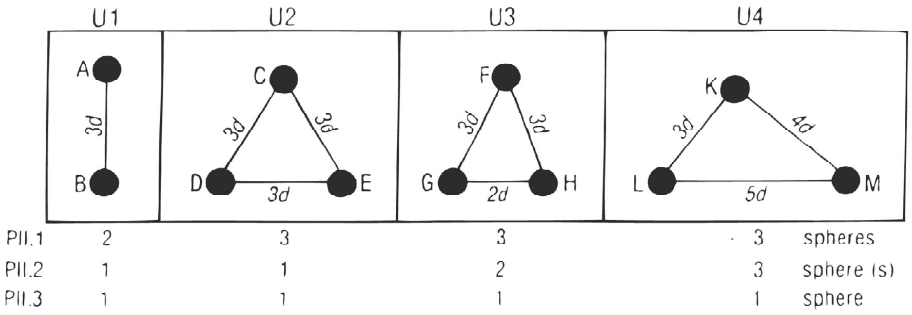
**PII.1** no two things share all their properties

**PII.2** no two things share all their pure properties (i.e.: properties the obtaining of which does not consist in the obtaining of a relation)

**PII.3** no two things share all their intrinsic properties (i.e.: properties invariant under duplication)

With respect to four static universes consisting only of intrinsically identical spheres, the three principles yield the following verdicts (from Khamara (2006, 66)):

Static Universes




The verdicts of PII.1 and PII.3 are clear. For PII.2, the two spheres in U3 are distinguished by the pure property of being 3 diameters away from some sphere. We get an odd result: "how can there be only 2 spheres, 3 diameters apart, if one of them has the property of being 2 diameters away from some sphere, which the other lacks" (Khamara, 2006, 72)? Khamara's diagnosis is apt:

> "...what it shows is not that the 2-sphere verdict is incorrect, but that the correct verdict is incompatible with what the U3 description ["consists of spheres $F$, $G$ and $H$ such that: $G$ and $H$ are each 2 diameters away from some sphere and 3 diameters away from some sphere; and $F$ is 3 diameters away from some sphere and not 2 diameters ways from any sphere"] dictates when it is taken in isolation, namely that U3 has 3 spheres. [...] Now such an inconsistency between the PII.2 verdict and the 'pure' description of a universe to which it is applied, is tantamount to declaring that universe logically impossible." (Khamara, 2006, 72–73)

Worlds can only be individuated holistically, top-down – a price to pay for the upholders of PII.

## Two natural numbers

Consider now two natural numbers, say 2 and 3. In what do they differ? There does not seem much, strictly about how they are in themselves, that tells them apart. Not only do they differ, however, with respect to irreflexive relations and dispositional properties, they are also ordered: 2 is smaller than 3. They're most important difference, in my view, is that they differ *as numbers*, i.e. in what they number; only one of them, for example, correctly numbers the Trinity.

In some ways the numbering relation between 3 and the Trinity resembles the relation between the sphere $a$ and "$a$": there is no telling, for example, whether in them being numbered by 3, the Holy Ghost comes first or third. This connection is nicely brought out by considering numerical quantifiers:

$$\begin{aligned} 0 &\rightsquigarrow \exists_0 x Fx &&:= \forall x \neg Fx \\ 1 &\rightsquigarrow \exists_1 x Fx &&:= \neg\forall x \neg Fx \wedge \forall x \forall y((Fx \wedge Fy) \rightarrow x = y) \\ n+1 &\rightsquigarrow \exists_{n+1} x Fx &&:= \exists x(Fx \wedge \exists_n y(Fy \wedge x \neq y)) \end{aligned}$$

For each numerical quantifier in the series, we need one more variable not already occurring in its predecessor. For the $n$-th numerical quantifier, then, we'll need $n + 1$ variables. Their semantic role is to coordinate argument places, to tell us in what places our assignment of values have to be coordinated. Kit Fine (2003) has studied this coordination in more detail. In his defence of semantic relationalism, the thesis that there are external semantic relations, i.e. semantic relations not supervenient on intrinsic semantic features of their relata, he emphasised the fact that the simultaneous

assignment of values to different variables must provide them with a coordination scheme, i.e. tell which occurrences are to be coordinated with which other occurrences of the same or different variable.

In his earlier work on neutral relations, Fine (2000) has argued that for some relations, the coordination scheme has to be distinguished from the relation itself. *Greater than*, the order of the number series, may provide an example of such a neutral relation: we do not want to say that, whenever some number $n$ is greater than some other number $m$, we have two relational complexes, $n$ and $m$ together with the relation *greater than* and $n$ and $m$ together with the relation *smaller than*. Instead, we have to distinguish the relation from the order it imposes on its relata.

Fine discusses two ways to achieve this and opts for the second. The first, which he dismisses, is positionalism, which reifies argument places, and explicitly correlates them with the relata of the relation. Exemplification of the relation must then be understood to be relative to an assignment of objects to argument-places (Fine, 2000, 11). The main problem of this view is that it is not clear what argument places might be.

In the arithmetical case, however, we do have an answer to this worry, or so it seems to me: argument places may just *be* numbers, and we have independent reasons, I hope, to believe in numbers. Hence Russell is perhaps wrong: "[I]t is impossible that the ordinals should be, as Dedekind suggests, nothing but the terms of such relations as constitute a progression. If they are to be anything at all, they must be intrinsically something; they must differ from other entities as points from instants, or colours from sounds. What Dedekind intended to indicate was probably a definition by means of a the principle of abstraction…But a definition so made always indicates some class of entities having …a genuine nature of their own." (Russell, 1903, 249)

## Two particles

Two electrons in the orbital of a helium atom: weakly discernible, e.g. by "has the opposite spin of" – but distinct? distinct *individuals*?

> "If two electrons really are two distinct individuals, and it is true that they share all the same properties, then it seems that there must be some principle of individuation that transcends everything that can be expressed by the formalism in virtue of which they are individuals." (Ladyman & Ross, 2007, 135)

Can we infer that "entangled states are not constituted by the entities that enter into them" (Ladyman & Ross, 2007, 41, n. 40)? Two questions here:

1. Does there have to be such a principle of individuation?
2. If there has to be such a principle of individuation, does it have to be transcendent?

In both cases, the answer is no.

1. There is nothing wrong about brute numerical diversity as in the case of Max Black's indiscernible spheres. There is a problem about truthbearers, but perhaps some considerations about naming can help.

2. The two electrons satisfy the irreflexive relation expressed by "$x$ is of opposite spin to $y$". Contra Russell, purely relational individuation is possible. There is a problem about matching up of structures, but perhaps some considerations about the successive 'enlargement' of our ontology of arithmetics might help.

"No intrinsic nature" – what does this mean?

1. **external relations**: "By *relational holism* I will mean the claim that objects which in at least some circumstances we can identify as separate individuals have inherent relations, that is, relations which do not supervene on the non-relational properties of the distinct individuals. Relational holism is free of the incoherence which threatens less clearly stated forms of holism.

It is sufficient for an object to be a distinct individual that it have a non-relational property." (Teller, 1986, 73)

2. **no need**: "...if there are space-time points, one can maintain that all the qualitative properties of any space-time point consist in relations to other space-time points. There is no need for an intrinsic nature of space-time points. (The same is arguably true of numbers). Imagine a world in which all physical properties are realized as geometrical properties of space-time points. In such a world, we can in principle know all the types of physical properties, they are all relational, and there is no need for intrinsic properties, because the relata are space-time points." (Esfeld, 2001, 401)
3. **non-existence**: "...one can maintain that (a) relations require relata, that is, things which stand in the relations, but that (not b) these things do not have any intrinsic properties that underlie the relations in which they stand." (Esfeld, 2004, 602)
4. **full dependence**: "as far as the physical world is concerned, there is a mutual ontological as well as conceptual dependence between objects and structure (relations): objects can neither exist nor be conceived without relations in which they stand, and relations can neither exist in the physical world nor be conceived as the structure of the physical world without objects that stand in the relations." (Esfeld & Lam, 2008, 32)
5. **only conceptually different** from relations: "The question of the ontological relationship between objects and relations is ill-posed. We predicate properties, including relations, of something, we quantify over objects, and we define a structure on a domain of objects by indicating how these objects are related to each other. However, this is the way in which we represent the world...[...]. It does not match a real distinction in the world. Consequently, there is no point in enquiring into the relationship between objects and properties, including relations or structures, and, in particular, to talk in terms of a mutual ontological dependence between objects and properties, including relations or structures, or an ontological priority of the one over the others. There are not two types of entities, objects and properties including relations or structures, that entertain a certain relationship of ontological dependence. The dependence is only conceptual.

   There is no ontological distinction between objects and their properties in the sense of modes: the modes are the way in which the objects exist. Objects do not have any existence in distinction to their ways of existence, and their ways of existence do not have any existence in distinction to the objects. One can draw a conceptual distinction between objects and their ways of existence, but not an ontological one, applying to reality. In reality, there is only one type of entity, namely objects that exist in particular ways." (Esfeld & Lam, 2011, §8.3)

**Back to the spheres.** Why is this not just the standard Aristotelian conception of universals as immanent?

## Relational individuation

Many philosophers have been attracted to the thought that there is no, and cannot be any, purely relational individuation:

> "If any one asserts or implies that a difference between this and that can be established by the fact that this is related to one thing whereas that is related to something different, he cannot without contradiction deny numerical difference. For this and that cannot have different relations, unless the relation possessed by the one is not possessed by the other. Unless, therefore, the one has a difference from the other over and above the difference of relations, it will be true of one and the same thing that it both has and has not a given relation to something else." (Moore, 1900, 110)
>
> "There must ultimately be a qualitative element in the nature of related terms which makes it possible or necessary for them to be related as they are." (Stout, 1918, 537)
>
> "To account for the possibility of objects agreeing in all their non-relational characters,

> we must grant that each object is constituted not only by a set of characters, but also by some non-repeatable entity (a bare particular) to which we can attribute the identity of that object." (Loux, 1972, 129)

I agree that relational differences cannot be brute and must be grounded in intrinsic properties of something. But I do not agree with the atomistic bias of these authors, their (implicit) view that the intrinsic properties grounding relational differences must be had by the relata or their proper parts. Relational differentiation always happens *within* something bigger something which is intrinsically structured.

## Mere numerical difference

What is purely structurally individuated? particles or their states? Cf. what Kripke says about dice worlds:

> "The thirty-six possibilities, the one that is actual included, are (abstract) *states* of the [two] dice, not complex physical entities. Nor should any school pupil receive high marks for the question 'How do we know, in the state where die $A$ is six and die $B$ is five, whether it is die $A$ or die $B$ which is six? Don't we need a "criterion of transstate identtiy" to identify the die with a six – not the die with a five – with our die $A$?' The answer is, of course, that the state (die $A$, 6; die $B$, 5) is *given* as such (and distinguished from the state (die $B$, 6; die $A$, 5)). [...] The 'possibilities' simply are not given purely qualitatively (as in: one die, 6, the other, 5). If they had been, there would have been just twenty-two distinct possibilities, not thirty-six. [...] Nor, when we regard such qualitatively identical states as ($A$,6; $B$, 5) and ($A$, 5; $B$, 6) as distinct, need we suppose that $A$ and $B$ are qualitatively distinguishable in some other respect, say, color. [...] Finally, in setting up this innocent little exercise regarding the fall of the dice, with possibilities that are not described purely qualitatively, we make no obscure metaphysical commitment to dice as 'bare particulars', whatever that might mean." (Kripke, 1980, 17–18)

He adds in a footnote:

> "With respect to possible states of the entire world, I do not mean to assert categorically that, just as in the case of the dice, there are qualitatively identical but distinct (counterfactual) states. What I do assert is that *if* there is a philosophical argument excluding qualitatively identical but distinct worlds, it cannot be based simply on the supposition that worlds must be stipulated purely qualitatively. What I defend is the *propriety* of giving possible worlds in terms of certain particulars as well as qualitatively, whether or not there are in fact qualitatively identical but distinct worlds." (Kripke, 1980, 18, n. 17)

Importantly, we are talking about the individuation of physical states, not physical objects.

Teller (1992, 144) says that the entangled states are "[n]on-relational properties of a whole which do not even supervene upon the non-relational properties of the parts", and Silberstein & McGeever (1999, 187) say that the holistic nature of quantum statistics is best explained by supposing that "the parts exhibit a holistic (emergent) correlation property possessed by the system but not locally carried by the separate parts".

# References


Baldwin, Thomas (1996). There might be nothing. *Analysis*, 56(4): 231–238.

Black, Max (1952). The Identity of Indiscernibles. *Mind*, 61: 152–164. Reprinted in Black (1954, 80–92) and in Loux (1970, 250–262).

Black, Max (1954). *Problems of Analysis: Philosophical Essays*. Ithaca, New York: Cornell University Press.

Esfeld, Michael (2001). Review of Langton (1998). *Erkenntnis*, 54: 399–403.

Esfeld, Michael (2004). Quantum Entanglement and a Metaphysics of Relations. *Studies in History and Philosophy of Science. Part B: Studies in History and Philosophy of Modern Physics*, 35(4): 601–617.

Esfeld, Michael & Vincent Lam (2008). Moderate Structural Realism About Space-Time. *Synthèse*, 160: 27–46.

Esfeld, Michael & Vincent Lam (2011). Ontic Structural Realism as a Metaphysics of Objects. In Bokulich, Alisa & Peter Bokulich, eds., *Scientific Structuralism*, Boston Studies in the Philosophy of Science 281, pp. 143–160. Dordrecht: Springer Verlag.

Fine, Kit (2000). Neutral Relations. *The Philosophical Review*, 109(1): 1–33.

Fine, Kit (2003). The Role of Variables. *The Journal of Philosophy*, 100(12): 605–631. Revised version: Fine (2009).

Fine, Kit (2009). The Role of Variables. In Almog, Joseph & Paolo Leonardi, eds., *The Philosophy of David Kaplan*, pp. 109–135. Oxford: Oxford University Press.

van Fraassen, Bas C. (1991). *Quantum Mechanics: An Empiricist View*. Oxford: Oxford University Press.

Ishiguro, Hidé (1990). *Leibniz's Philosophy of Logic and Language*. Cambridge: Cambridge University Press, 2nd edition.

Kant, Immanuel (1983). *Werke in zehn Bänden*. Darmstadt: Wissenschaftliche Buchgesellschaft. Herausgegeben von Wilhelm Weischedel.

Kant, Immanuel (1992). *Lectures on Logic*. The Cambridge Edition of the Works of Immanuel Kant. Cambridge: Cambridge University Press. Translated and edited by J. Michael Young.

Khamara, Edward J. (2006). *Space, Time, and Theology in the Leibniz-Newton Controversy*. Heusenstamm b. Frankfurt: Ontos Verlag.

Kripke, Saul A. (1980). *Naming and Necessity*. Oxford: Basil Blackwell Publishers.

Ladyman, James & Don Ross (2007). *Every Thing Must Go. Metaphysics Naturalized*. Oxford: Oxford University Press. With David Spurrett and John Collier.

Langton, Rae (1998). *Kantian Humility: Our Ignorance of Things in Themselves*. Oxford: Oxford University Press.

Loux, Michael J., ed. (1970). *Universals and Particulars: Readings in Ontology*. Notre Dame, Indiana: University of Notre Dame Press. Second edition: **?**.

Loux, Michael J. (1972). Recent Work in Ontology. *American Philosophical Quarterly*, 9(2): 119–138.

Moore, George Edward (1900). Identity. *Proceedings of the Aristotelian Society*, 1: 103–127.

Russell, Bertrand Arthur William (1903). *The Principles of Mathematics*. Cambridge: Cambridge University Press. 2nd edition: Russell (1937).

Russell, Bertrand Arthur William (1937). *The Principles of Mathematics*. London: George Allen & Unwin, 2nd edition.

Silberstein, Michael & J. McGeever (1999). The search for ontological emergence. *The Philosophical Quarterly*, 49(195): 182–200.

Stout, George F. (1918). Do Finite Individuals Possess a Substantive or an Adjectival Mode of Being? *Proceedings of the Aristotelian Society*, 18: 530–551. Also published in the Supplementary Volume I.

Teller, Paul (1986). Relational Holism and Quantum Mechanics. *The British Journal for the Philosophy of Science*, 37: 71–81.

Teller, Paul (1992). A contemporary look at emergence. In Beckermann, Ansgar/ Hans Flohr & Jaegwon Kim, eds., *Emergence or Reduction?: Prospects for Nonreductive Physicalism*, pp. 139–155. Berlin: Walter de Gruyter.