Primitive ontology, structural realism and the laws of nature

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(for Project Nomos Volume, https://metaphysicsofscience.wixsite.com/nomosproject)
(8 January 2025)

Abstract

This essay sets out how a primitive ontology that replaces intrinsic properties with structures in the sense of relations – distance being the natural, world-making relation that individuates basic physical objects such as point particles – leads to a view of laws of nature being grounded in a primitive ontology that implements nomological constraints. The essay explains how this view is distinct from both standard Humeanism (Lewis's Humean supervenience) and dispositionalism.

Keywords: dispositions, distance relations, Humean mosaic, intrinsic properties, Leibnizian relationalism, location, ontic structural realism, primitive ontology, Super-Humeanism, supervenience

1. The primitive ontology approach

This article enquires into the relationship between the primitive ontology approach and the metaphysics of laws of nature. The primitive ontology approach arose in the context of the debate about the ontology of quantum mechanics, pleading to shift the focus to an ontology of ordinary physical objects rather than an ontology of the wave function.[1] But this approach is of general application in the philosophy of the natural world. The idea is that scientific theories ultimately refer to a domain of basic physical objects that can no longer be conceived in terms of playing a role for something else. That is why subscribing to an ontological commitment to these objects is firmly justified. Obviously, what these objects are taken to be depends on what the best scientific theories are (and possibly, as in quantum mechanics, on what one regards as the best mathematical formulation of these theories; what is known under the somewhat misleading term of "interpretations" of quantum mechanics are in fact different mathematical formulations of a quantum theory that agree in their predictions of measurement outcome statistics, but disagree both on the formalism and the ontology).

Point particles that are spatio-temporally arranged are the best-known candidate for basic physical objects. But basic physical objects in the vein of the primitive ontology can be any sort of concrete physical objects. They do not have to be discrete or enduring objects. They could, for instance, also be point-events (flashes) or some sort of continuous stuff, or whatever other concrete entities future physical theories may come up with. The primitive

1 See Bell (1987, ch. 7) and Dürr et al. (2013, ch. 2.2).

ontology approach only implements a commitment to scientific realism and to concrete physical in contrast to abstract mathematical entities.

In the first place, this essay argues for conceiving the primitive ontology in terms of structural realism – more precisely, in terms of moderate ontic structural realism – and illustrates this claim by means of Leibnizian relationalism. This means settling for featureless point particles that are individuated by the distance relations in which they stand and, furthermore, admitting change of these relations as primitive. Against this background, the essay then brings in functionalism, arguing that all the other parameters figuring in a physical theory apart from those defining the primitive ontology can be introduced in terms of their function in the sense of the causal role that they play for the evolution of the configuration of the basic physical objects. They can thereby be located in that configuration. Consequently, one can endorse scientific realism with respect to them without subscribing to additional ontological commitments going beyond the basic physical objects as defined by the primitive ontology. This applies to dynamical parameters such as mass, charge, energy, fields, the wave function, etc.

To stress again, the primitive ontology is identified in terms of those parameters that are not introduced through their function for something else, thus referring to what there simply exists in the world according to the theory under consideration. All the parameters that a theory introduces over and above those ones that define the primitive ontology can be considered as constituting the dynamical structure of the theory, consisting in a geometry and dynamical parameters that are introduced in terms of their functional role for the evolution of what simply exists in the world and resulting in laws of motion.

This procedure links the primitive ontology approach up with Humeanism: the thesis of Humean supervenience (more precisely location) applies to all the dynamical parameters that figure in a physical theory apart from those ones that make up the primitive ontology. This stance is known as Super-Humeanism. It suggests itself to extend this stance also to Humeanism about laws of nature and thus to tie the primitive ontology approach to Humean reductionism about laws (for instance, as in the best system analysis). This article indeed argues for going that way. But it then brings in a non-Humean twist. *The primitive ontology approach, at least if construed in terms of structural realism, includes constraints on the motion of matter that amount to nomological constraints that enter into the supervenience basis for the laws*. Hence, the laws supervene, but their supervenience basis is not simply a Humean mosaic. The supervenience basis includes a sort of primitive modality that puts global constraints on the possible motion of matter without entailing necessary connections among distinct entities.

Nonetheless, the laws of nature are thus located in the primitive ontology. Indeed, there is no ontology over and above the primitive ontology. It makes no sense to talk in terms of a secondary ontology or something like that, since there are no degrees of existence. For whatever entity, it either exists, or it does not exist. If it exists, it either figures explicitly in the primitive ontology, or it is implicitly included in it by being located or placed in it (in the sense of being identical with certain configurations of elements of the primitive ontology). Hence, if one is committed to the existence of something without being able to locate it in the primitive ontology, one has to enlarge the primitive ontology so that it includes this element as a further primitive. In short, if the primitive ontology of basic physical objects is deemed to be insufficient, then further primitives have to be added to the ontology. The primitive

ontology then is amended beyond primitive physical objects; but there is no secondary ontology, as there are no secondary entities.

2. Leibnizian relationalism as primitive ontology

Consider David Lewis's famous thesis of Humean Supervenience:

> Humean supervenience is named in honor of the greater denier of necessary connections. It is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another. (…) We have geometry: a system of external relations of spatio-temporal distance between points. … And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated. For short: we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that. (Lewis 1986b, pp. IX-X)

This is supposed to be a parsimonious primitive ontology: there are only concrete entities, and these are all contingent; they do not implement any primitive modality. The primitive ontology consists only in distance relations between point objects – be it space-time points, be it material objects – and natural intrinsic properties instantiated at these points. Candidates for these properties are fundamental physical dynamical parameters such as mass and charge, etc. Everything else supervenes on the entire spatio-temporal configuration of point objects with intrinsic properties of the universe. The variation in the instantiations of these properties constitutes what is known as the Humean mosaic. On Lewis's realiser functionalism, supervenience comes down to identity: everything else is realised by – and thus located in – configurations of point objects and their intrinsic properties.[2]

However, the commitment to local qualities in the guise of intrinsic properties is problematic in the context of a parsimonious primitive ontology: the rationale of Lewis's Humeanism is to eschew necessary connections between distinct entities. This implies that the causal role that these properties play is contingent instead of being essential to them. This means that, for instance, the properties of mass and charge can swap their roles: there is another world possible in which the property that we pick out as charge in the actual world plays the role of the property that we pick out as mass in the actual world, and *vice versa*.

Hence, Lewis's Humeanism implies that properties are pure qualities, known as quiddities. Moreover, we do not have epistemic access to these qualities. Our access is limited to the causal roles that the properties play for the evolution of the configuration of matter in the actual world. The lack of epistemic access to properties construed as pure qualities is known as humility. Lewis (2009) endorses humility as well as quidditism. However, the rather baroque metaphysics of pure qualities with its implication of possible worlds differing only in the pure qualities that are instantiated in them is a heavy burden on Humeanism, notably if Humeanism is conceived as a parsimonious primitive ontology that is supposed to be close to science.[3]

It may seem that the obvious way out of this situation is to conceive the properties in such a manner that their essence consists in the causal roles that they play in a world so that they are dispositions or powers. But this implies that one abandons Humeanism altogether, since there then are primitive modal connections between a disposition or power and its manifestation.[4]

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2 See Lewis (1966, 1970, 1972).

3 See e.g. Black (2000).

4 See e.g. Bird (2007) and Vetter (2015, ch. 1.2).

Indeed, these modal connections amount to necessary connections among distinct entities. The dispositions or powers bring about or produce the evolution of the configuration of matter of the universe. Given their instantiations, a certain evolution is necessary through the manifestations of the instantiated dispositions or powers.

However, there is third option beyond countenancing either categorical intrinsic properties that are pure qualities or modal properties qua dispositions or powers that are tied to playing a certain causal role, thereby bringing about the evolution of the configuration of matter. The third way is to reject the commitment to properties altogether and to retain only point objects and distance relations among them. That means going structural, namely conceiving a parsimonious primitive ontology in terms of ontic structural realism.

Doing so, one does not have to jettison the commitment to objects, as in the radical version of ontic structural realism of Ladyman and Ross (2007, chs. 2 and 3) and French (2014, chs. 5-7). Abandoning objects raises issues of intelligibility and compatibility with standard first-order logic, if only relations and no relata are admitted. The moderate version of ontic structural realism treats objects and relations on a par as being mutually ontologically dependent: relations require relata in which they stand, but all there is to the relata is given by the relations that obtain among them.[5]

The crucial point for present purposes is that on this view, relations take the place of Lewis's natural, purely qualitative, intrinsic properties – more precisely, one natural relation, namely the distance relation, takes the place of natural intrinsic properties. The primitive ontology thereby becomes even more parsimonious than in Lewis's framework. Parsimony as a criterion for ontological commitment has to be understood with respect to empirical adequacy: the question is which commitments are minimally sufficient to obtain an ontology of the natural world that is coherent and empirically adequate, given in particular our scientific theories.[6]

Empirical adequacy requires recognising a plurality of objects. Even if one defends the view known as priority monism, as does notably Schaffer (2010b) – that is, the ontological priority of the one entity that is the whole universe –, one has to include an internal differentiation of the one whole into a plurality of objects. This implies that there are fundamental relations that carry out that internal differentiation, as is admitted also by Schaffer (2010a). Hence, *pace* Heil (2012, ch. 7) and Lowe (2016), relations have to be recognised in a parsimonious ontology. There has to be a world-making relation, that is, a relation that binds all and only those objects together that make up a world. It is evident that the distance relation does this job: all and only those objects that are spatially related constitute a world. If there were objects that were not at a distance from each other, they would inhabit different worlds. If they are related by a distance, they are in one and the same world, as also stressed by Lewis (1986a, ch. 1.6). Hence, distance is the – only – natural relation, because it is the world-making relation.

If the distance relation is the world-making relation, one can at the same time employ it to individuate the objects that stand in this relation; that, then, is the point of ontic structural realism in this context: each object in a configuration of objects is distinguished from all the other objects by the position that it has relative to all the other objects. The numerical

5 See Esfeld (2004, section 3), Esfeld and Lam (2011) as well as McKenzie (2014).

6 See Barrett (2021) on empirical adequacy.

plurality of these objects then is not primitive, but derives from the relations that individuate them. In consequence, the following two propositions are equivalent: (a) There is one whole (i.e. the universe) exhibiting an internal differentiation in terms of relations that individuate a plurality of simple objects within the whole. (b) There are relations that individuate simple objects so that the relations and the objects make up a configuration that is the universe; this formulation relies on the relational holism conceptualised in Pettit (1993, ch. 4) and Esfeld (1998). The decisive issue, again, is that the objects are individuated by the relations in which they stand.

Descartes famously defined matter as *res extensa*.[7] Indeed, that is what matter is according to science. There is nothing more to matter beyond extension in the guise of distance relations between in the last resort simple and thus not extended point like objects (particles) and the change in these relations. There is no stuff-essence of matter; it would be mysterious what such a stuff-essence could be. The impenetrability of matter, often regarded as a criterion that characterises matter, is accounted for by the individuation of the material objects through the distance relations: for there to be two material objects, there has to be a distance between them – that is, a non-vanishing distance; consequently, if there are two objects, they cannot penetrate each other.

Furthermore, the definition of matter in terms of distance relations is meaningful: it distinguishes material from non-material objects. Descartes defined matter as *res extensa* and mind as *res cogitans*.[8] That is to say: standing in distance relations (extension) makes it that points are matter (point particles), whereas standing in thinking relations makes it that points are minds.[9]

We can thus formulate the primitive ontology in terms of the following two axioms or principles:

(1) *There are distance relations that individuate simple objects, namely point particles (matter points)*.

(2) *The point particles are permanent, with the distances between them changing*.

Esfeld and Deckert (2017, ch. 2) provide a detailed account of these axioms.

The distance relation is irreflexive: nothing can stand in a distance to itself. It is symmetric: if object *i* is at a certain distance to object *j*, then *j* is at the same distance to *i*. It is connex, meaning that any two objects in a configuration stand in a distance relation to each other. It fulfils the triangle inequality – that is, for any three objects *i, j, k*, the sum of the distances between *i* and *j* and *j* and *k* is greater than or equal to the distance between *i* and *k*. What is important are the ratios between the distances – that is, not how far is *i* from *j* in absolute terms, but how far is *i* from *j* in comparison to how far is *i* from *k*, and *k* from *j*.

For the distance relation to individuate the objects, it has to satisfy the following requirement: if object *i* is not identical with object *j*, then the two sets that list all the distance relations in which these objects stand with respect to all the other objects in a configuration must differ in at least one such relation. It is such differences in the way in which *i* and *j* relate with the other objects in the configuration that make it that *i* and *j* are different objects. This requirement entails that the objects (the matter points) are *absolutely* discernible. They satisfy

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7 See e.g. *Principles of Philosophy*, part II, §§ 4-5.

8 See e.g. *Principles of Philosophy*, part I, § 53.

9 See Esfeld and Köstner (2022, sections 3-4).

Leibniz's principle of the identity of indiscernibles. What is known as *weak* discernibility in the literature since Saunders (2006) is not sufficient for individuation. Weak discernibility requires only that objects stand in an irreflexive relation, without there being anything that distinguishes any one object from all the other ones.

Individuation through relations and thus absolute discernibility implies that any model of this ontology has to include at least three matter points that are individuated by the distance relations. Consequently, symmetrical configurations are ruled out, but also, for instance, the configuration of an isosceles triangle. This is a considerable restriction. However, having empirical adequacy in mind, there is no need to admit worlds with only one or two objects or *entirely* symmetrical worlds. Excluding symmetrical configurations is the ontological price to pay for a structural individuation of objects: they are individuated by the relations in which they stand instead of qualitative intrinsic properties, or a primitive thisness (haecceity).

Hence, through axiom (1), this primitive ontology endorses not only Leibniz's principle of the identity of indiscernibles, but also Leibnizian relationalism about space. According to Leibniz, distances make up the order of what coexists.[10] In other words, distance is the world-making relation. However, axiom (1) is not sufficient for empirical adequacy: there is not only variation within the configuration of matter of the universe as given by the relative distances that distinguish simple objects from one another, but also change of that configuration. The business of science is to identify and capture salient regularities in the evolution of the configuration of matter in terms of laws of motion. As conceiving a world does not require endorsing space as primitive, but only a world-making relation in the guise of the distance relation, so conceiving a world that evolves does not require endorsing time as primitive. Through axiom (2), this primitive ontology implements also Leibniz's view of time: time derives from change. According to Leibniz, time is the order of succession.[11] Change, construed as change in the distances among matter points that are permanent, does not presuppose any temporal notion.

Nonetheless, change, thus conceived, is directed in the following sense: it goes from one particular state of the configuration of matter consisting in certain distances among the matter points to another particular state of that configuration consisting in other distances among some matter points.[12] Any such change may be reversible. Nevertheless, the actual change in the configuration is directed in virtue of the fact that it goes from one specific state of the configuration of the universe to another specific state of that configuration. By contrast, there is no direction in the distance relations individuating matter points as given by axiom 1, since there is no spatial direction as long as there are only distance relations, but no space into which these relations are embedded. In sum, by drawing on Leibnizian relationalism, we obtain a primitive ontology that is even more parsimonious than Lewis's Humean mosaic and that avoids the drawbacks of the latter.

3. Functionalism as solution to the problem of location

According to Lewis's thesis of Humean supervenience, everything else supervenes on the primitive ontology. However, talking in terms of supervenience does as such not answer the question of how exactly, given a parsimonious primitive ontology, everything else that exists

10 See third letter to Newton-Clarke, § 4, in Leibniz (1890, p. 363); English translation Leibniz (2000).

11 See third letter to Newton-Clarke, § 4, and fourth letter, § 41 in Leibniz (1890, pp. 363, 376).

12 See Lopez and Esfeld (2025).

in the natural world is thereby included. Consider how Frank Jackson describes the task of ontology or metaphysics:

> Metaphysicians seek a comprehensive account of some subject matter – the mind, the semantic, or, most ambitiously, everything – in terms of a limited number of more or less basic notions. … The methodology is not that of letting a thousand flowers bloom but rather that of making do with as meagre a diet as possible. … But if metaphysics seeks comprehension in terms of limited ingredients, it is continually going to be faced with the problem of location. Because the ingredients *are* limited, some putative features of the world are not going to appear explicitly in the story. The question then will be whether they, nevertheless, figure implicitly in the story. Serious metaphysics is simultaneously discriminatory and putatively complete, and the combination of these two facts means that there is bound to be a whole range of putative features of our world up for either elimination or location.[13]

As Jackson makes clear, the problem of location, which is also known as the placement problem following Price (2004), arises in any case if one formulates a scientific or philosophical theory of the world. The task is to come up with a general strategy how to locate or place everything that does not figure explicitly in the basic notions that define the ontology. If one has obtained a solution to this problem, it will apply to whatever candidate for location.

Functionalism provides an obvious solution to this problem. Starting from configurations of point particles as described by the basic notions that make up the primitive ontology, one defines everything else in terms of its role for the evolution of point particle configurations; this then enables the location of the thus defined entities in configurations of point particles, namely in those ones that realise the role in question, as is clear since notably Lewis (1966, 1970, 1972) has set out realiser functionalism.

Consider water. As we know from scientific investigation, there is no fundamental water stuff in the world. Science superseded the ancient view of the four elements earth, water, air and fire. But, of course, there is water in the world: there are things that fulfil the functional role of appearing odourless, colourless, being thirst-quenching through the change in the motion of the parts of our bodies that they cause. These are configurations of H_2O molecules. Thus, by defining water in terms of its thirst-quenching role – that is, its role for certain motions in our bodies –, we locate water in the primitive ontology. Some particle configurations, moving in certain characteristic ways, *are* water.

By the same token, there is no *élan vital*, a *sui generis* life stuff or causal power; but there are organisms in the world. The functional role that defines what it is to be alive in terms of characteristic motions such as reproduction and adaptation to the environment is realised by certain configurations of molecules, as we know since the rise of molecular biology in the second half of the 20th century. Again, this means that certain particle configurations, moving in certain particular ways, *are* organisms. Life thus is located in certain particle configurations.

Functionalism does not only apply to the objects of the special sciences. If the primitive ontology is given just by the two axioms that were stated in the previous section, then all there is to the point particles are the distance relations in which they stand and their change. Hence, already all the dynamical parameters that figure in a physical theory over and above

13 Jackson (1994, p. 25). See also Jackson (1998, ch. 1).

the parameters that define the primitive ontology do not count among the basic notions. Instead, they are introduced in a functionalist manner in terms of the causal role that they play for the evolution of the elements of the primitive ontology.

Consider gravitation: the motion of the objects in the world manifests some salient patterns or regularities. Arguably the most striking of these patterns is mutual attraction. This stable pattern enables us to introduce the notion of gravitational mass in order to represent this regular motion: gravitational mass is defined in terms of its role for particle motion, namely the role of mutual attraction. Already Ernst Mach brings this functional introduction of the notion of mass out in his comment on Newton's *Principles* when saying "The true definition of mass can be deduced only from the dynamical relations of bodies" (Mach 1919, p. 241).

All the evidence that we have are the dynamical relations of bodies – that is, their motions; these relations manifest certain stable patterns, such as attractive motion. To represent this pattern in a theory, physicists introduce the parameter of mass as defined by its function in the sense of its causal role for particle motion. Having such a parameter at one's disposal then enables the formulation of a law that captures the pattern at issue, such as Newton's law of gravitation.

There are more stable patterns in the motion of bodies than gravitational attraction. There is a further characteristic pattern of repulsive and attractive motion that also applies at all scales, namely the pattern of electricity and magnetism. To represent this pattern in a theory, one introduces a further parameter that is defined by its function for the particle motion, namely the parameter of charge. By means of this parameter, one can then formulate the laws that make it possible to describe, calculate and predict this characteristic repulsive and attractive motion of bodies, as the Lorentz force law and the Maxwell equations in classical electrodynamics.

By means of this procedure of a functional definition of parameters such as mass and charge, one locates mass and charge in what is accepted as primitive, namely particle motion, through the fact that this motion manifests certain stable patterns or regularities. Given the fact of such salient patterns or regularities, there is no need to include parameters such as mass and charge among the ontological primitives and to consider mass and charge as intrinsic properties of the objects – that is, as something that the objects possess in and of themselves. They enter a physical theory through their role for the motion of the primitive objects.

Nevertheless, they are thereby admitted to the ontology, albeit not as primitive, but as derived notions. The particles have mass and charge not as primitive features, but because they move in certain manners. In virtue of their motion particles have mass and charge, in the same way as some particle configurations are water or organisms, etc. All these features of the world are literally located in the particle motion. The propositions describing these features are thereby made true. Consequently, the different particle species distinguished in the standard model of elementary particles do not indicate intrinsic features of the particles. They depend on the way in which the particles move under given, stable environmental conditions that typically obtain in the universe. In brief, some particles are electrons, because they move "electronwise" so to speak under standard conditions.

The same procedure of location through a functional definition for the motion of matter applies to fields as in classical electrodynamics and to the wave function in quantum mechanics. The latter position is known as quantum Humeanism; it requires a formulation of

quantum mechanics with an explicit primitive ontology such as Bohmian mechanics.[14] Furthermore, this procedure also applies to geometry: Huggett (2006) has shown how geometry and inertial frames in classical mechanics can be introduced to capture the salient features of the change in the spatial relations among point particles.

In sum, thus, everything that figures in a scientific theory apart from the basic, primitive ontology of matter in motion enters through the functional role that it plays for the motion of the matter. One can say that the geometry, the dynamical parameters and the laws come in as a package in terms of their functional role for the evolution of the configuration of the elements of the primitive ontology.[15]

This stance has become known as *Super-Humeanism*, following its introduction and elaboration in Esfeld and Deckert (2017, ch. 2.3). The qualification "Super-" expresses the attitude to ban everything from the primitive ontology that can be introduced in terms of a functional role and thereby be located in what really has to be endorsed as primitive. Super-Humeanism thus is the combination of a primitive ontology that is minimally sufficient to account for our scientific as well as common sense knowledge with functionalism about the dynamical parameters of a physical theory.[16]

4. Nomological structure in the primitive ontology

The outlined primitive ontology approach is committed to reductionism about laws of nature in the sense of Hall (2009). The laws are not anything in addition to the primitive ontology, but are located in it via the salient patterns of particle motion. Hence, the law statements figuring in a scientific theory are made true by the evolution of the particle configuration of the universe (if they are true), as are the statements attributing dynamical parameters such as mass and charge to the particles.

However, *by going structural, the shift from Humeanism to Super-Humeanism introduces what can be called "nomological structure" into the primitive ontology, namely global constraints on particle motion*. It thereby deviates from Humeanism in being committed to a sort of primitive modality, albeit a mild one that does not amount to necessary connections among distinct entities. In the recent literature, notably Adlam (2022, sections 3.5 and 4) and Chen and Goldstein (2022, section 3) also construe laws of nature on the basis of admitting global constraints on the motion of matter without these constraints amounting to bringing about or producing the actual evolution of the configuration of matter. However, their focus is on introducing global constraints in a timeless ontology. By contrast, the focus of the present paper is on the implications of the shift from natural intrinsic properties to one type of a natural relation. Moreover, the present approach retains a principled distinction between variation within a configuration and change of that configuration (see axiom (2) in section 2), thereby bringing in time; this stance can also be defended with respect to contemporary physics, as argued in Esfeld and Deckert (2017).

In Lewis's metaphysics of Humean supervenience, a background space-time with a metric is taken for granted. This space-time grid is "coloured" so to speak by instantiations of qualitative, intrinsic properties at – some – of its points. The laws supervene on the colouring.

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14 See Miller (2014), Esfeld (2014), Callender (2015) and Bhogal and Perry (2017).

15 See also Hall (2009, § 5.2) and Loewer (2024, ch. 7).

16 For critical discussions of Super-Humeanism, see Wilson (2018), Marmodoro (2018), Darby (2018), Lazarovici (2018), Matarese (2020, 2021), Simpson (2021) and Loewer (2024, ch. 6).

The colours can be recombined without restrictions. That, then, is the Humean mosaic. On Leibnizian relationalism, by contrast, there is no background space-time. The geometry comes in together with the kinematics and the dynamics, being determined by the salient patterns in the actual particle motion. Huggett (2006) has shown how such an account can be worked out for classical mechanics.

Leibnizian relationalism has to endorse distances among the particles as primitive. Elaborating on Leibnizian relationalism in terms of (moderate) ontic structural realism, the distance relations individuate the particles. Consequently, their numerical plurality is not primitive, but derives from the relations in which they stand. Replacing Lewis's natural, qualitative, intrinsic properties with a natural relation – the distance relation – therefore entails that there are some constraints put on the possible particle motions. For instance, as mentioned in section 2, the particle configuration of the universe cannot evolve in such a way that there is an entirely symmetrical particle configuration of the whole universe. In other words, the particle motion has to be such that it always satisfies Leibniz's principle of the identity of indiscernibles. This constraint excludes certain particle configurations from the models of the ontology.

It is important to note that this constraint applies in virtue of the structural individuation of the basic physical objects. This constraint hence is independent of what the actual particle motion is like and thus what the precise laws of motion are that a physical theory formulates. It is therefore appropriate to use the term "nomological structure". Endorsing structure in the guise of relations that individuate the basic objects implies that structure in this sense is nomological because it puts constraints on the possible particle configurations that are satisfied by necessity through the structural individuation. It is thereby committed to a sort of primitive modality.

However, there are no necessary connections among distinct entities here. It would be entirely misplaced to translate this view back into Lewis's Humean mosaic by saying that certain combinations of colourings of the space-time grid are excluded. There are no colourings at all here, since the primitive ontology is not one in terms of a spatio-temporal distribution of properties. There are no intrinsic properties on this view, and there is no background space-time. There are only relations that individuate basic objects. In doing so, they have to satisfy certain constraints in terms of admissible configurations of the basic objects. That makes the structure nomological without entailing necessary connections among distinct entities.

These considerations bring out again that the rationale of Super-Humeanism is not a principle of free recombination, but a primitive ontology that replaces natural, intrinsic properties with exactly one type of a relation that serves as the world-making relation and that individuates basic objects. What appears as intrinsic properties of the basic objects (e.g. dynamical parameters such as mass and charge) then is accounted for by applying functionalism to them: they come in through the role that they exert for the evolution of the configuration of the basic objects. Consequently, they are located in the particle motion in a quite literal sense – e.g. certain particles are electrons, having a negative charge, because they move "electronwise" so to speak.

In conclusion, going for ontic structural realism opens up a third way in the metaphysics of laws and properties. Going this way turns the metaphysics of dispositional properties grounding the laws upside down: the salient patterns of motion such as attractive motion as in

gravitation are not manifestations of dispositions or powers that are intrinsic properties of the objects. On the contrary, these salient patterns of motion make it that objects have properties such as mass and charge, which are hence not primitive. In that sense, the account agrees with Humeanism, amounting to an even more parsimonious ontology than Humeanism in removing intrinsic properties altogether from what is admitted as primitive; that is why this stance is known as Super-Humeanism.

However, going for structures in the guise of a world-making relation that at the same time individuates the basic objects entails that these structures are nomological in the sense that they impose some constraints on the possible particle motion. In that sense, the proposed account deviates from Humeanism. That notwithstanding, the actual laws of motion come in as a package together with the geometry and the dynamical parameters in the usual Humean way as supervening on the actual particle motion throughout the whole of space-time (more precisely, as being located in that motion).

By imposing constraints on the possible particle motion, the nomological structure can only constrain the types of possible laws of motion. But the primitive ontology that implements that nomological structure cannot fix or even produce or bring about the actual evolution of the particle configuration. The initial particle configuration is given only by relative distances individuating point-particles and the nomological structure that these relations implement in doing so. Dynamical parameters such as mass, charge, energy, the wave-function of the universe, etc. and their initial values come out of the evolution of the actual particle motion throughout the whole of space-time instead of fixing or producing that motion. To put it in a nutshell, thus, even if one takes the mentioned nomological constraints to implement the backbone of laws of motion in the initial particle configuration of the universe, the initial conditions that enter into the dynamical equations expressing the actual laws of motion to calculate the evolution of the particle configuration are not thus implemented; apart from the primitive parameter of (relative) positions, the initial values of the dynamical parameters supervene on the actual particle motion throughout the entire space-time. That is why the actual laws of motion come in as a package together with the geometry and the dynamical parameters instead of governing or even producing that motion.

In sum, there is a genuine, substantial third way to account for the laws of nature on the basis of relations instead of properties, be they purely qualitative properties, be they dispositions or powers.

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