Causal realism[1]

Michael Esfeld
University of Lausanne, Department of Philosophy
Michael-Andreas.Esfeld@unil.ch

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Abstract

According to causal realism, causation is a fundamental feature of the world, consisting in the fact that the properties that there are in the world, including notably the fundamental physical ones, are dispositions or powers to produce certain effects. The paper presents arguments for this view from the metaphysics of properties and the philosophy of physics, pointing out how this view leads to a coherent ontology for both physics as well as biology and the special sciences in general.

1. Introduction

Causal realism is the view that causation is a real and fundamental feature of the world. That is to say, causation cannot be reduced to other features of the world, such as, for instance, certain patterns of regularities in the distribution of the fundamental physical properties. Causation consists in one event bringing about or producing another event, causation being a relation of production or bringing something into being (see Hall 2004 for an analysis of the contrast between the production conception of causation and the regularity conception; the counterfactual analysis of causation is a sophisticated version of the regularity conception). I shall take events to be the relata of causal relations, without arguing for this claim in this paper, since this issue is not important for present purposes. More precisely, an event e_1, in virtue of instantiating a property *F*, brings about another event e_2, instantiating a property *G*. One can therefore characterize causal realism as the view that properties are powers. In short, *F*s are the power to produce *G*s. Saying that properties are powers means that it is essential for a property to exercise a certain causal role; that is what constitutes its identity. One can therefore characterize causal realism as the view that properties are causal in themselves. To abbreviate this view, I shall speak in terms of *causal properties*.

To make the claim of this paper audacious, I shall defend the view that all properties that there are in the world are causal properties. The limiting clause "that there are in the world" is intended to leave open whether or not abstract mathematical objects exist: abstract mathematical objects, if they exist, do not cause anything, so that their properties are not powers. However, to the extent that properties are instantiated in the real, concrete world (by contrast to a – hypothetical – realm of abstract mathematical objects), it is essential for them to exercise a certain causal role. This is a sparse view of properties: it is not the case that for any predicate, there is a corresponding property in the world.

Properties, being causal in themselves and thus powers, are dispositions – more precisely, dispositions that manifest themselves in bringing about certain effects. Dispositions, thus

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conceived, are not Aristotelian potentialities, but real, actual properties. Furthermore, there is no question of dispositions in this sense requiring non-dispositional properties as their bases. If all properties are causal in themselves, being powers, then all properties are dispositions. The view defended in this paper hence coincides with the position known as dispositional monism or dispositional essentialism (see notably Bird 2007). In claiming that all properties are dispositions, it is not intended to deny that properties are qualities. The view is rather this one: *in being certain qualities, properties are causal, namely powers to produce certain specific effects* (see Esfeld and Sachse 2011, chapter 2.1, for a detailed exposition of this claim). Thus, for instance, in being a certain qualitative, fundamental physical property, charge is the power to create an electromagnetic field, manifesting itself in the attraction of opposite-charged and the repulsion of like-charged objects; and mass is a qualitative, fundamental physical property that is distinct from charge in being the power to create gravitational attraction (this example is meant to be a rough and ready illustration of this view of properties; an adequate scientific discussion would require much more details, and, notably, certain commitments in the interpretation of the relevant scientific theories).

The view of *causal properties* is both a metaphysical and an empirical position: it is a stance in the metaphysics of properties, and it is a claim about what is the best interpretation of the ontological commitments of our scientific theories. It is opposed to the view of *categorical properties*, that is, the view according to which properties are pure qualities, exercising a causal role only contingently, depending on the whole distribution of the fundamental physical properties in a given world and / or the laws of nature holding in a given world. That latter view also is both a metaphysical and an empirical position. As a metaphysical position, it is usually traced back to Hume's stance on causation and is today known as *Humean metaphysics* (see notably Lewis 1986, introduction, and Lewis 2009). As an empirical position, it can be traced back to Russell's famous claim that causation is a notion that has no place in the interpretation of contemporary physics (Russell 1912). For the sake of simplicity, I shall confront the view of causal properties only with the Humean view of categorical properties, thereby leaving out in particular views that invoke a commitment to universals and certain relations among universals in order to account for causation and laws (see notably Armstrong 1983); the issue of a commitment to universals is not important for the arguments considered in this paper.

Accordingly, I shall mention the metaphysical argument for causal in contrast to Humean categorical properties in the next section, then move on to arguments from physics (sections 3 and 4) and finally consider the perspective for an account of the relationship between physics and the special sciences such as biology that this view offers (section 5). Covering all these issues in a short paper means that I can only sketch out the main features of the central arguments here, providing the reader with some sort of an overview of the case for causal realism (for a detailed study, see Esfeld and Sachse 2011).

2. *The metaphysical argument for causal properties*

The main metaphysical argument against the view of categorical properties is that this view is committed to quidditism. Accordingly, the main argument for the causal view of properties is that this view avoids any association with quidditism. If properties play a causal and nomological role only contingently, then their essence is independent of the causal relations in which they enter and the laws in which they figure. Their essence then is a pure quality, known as *quiddity* (see Black 2000). It is a primitive suchness, consisting in the simple fact of being such and such a quality, without that quality being tied to anything, notably not tied to certain causal or nomological relations. Consequently, it is not possible to have a cognitive access to the qualitative nature of the properties; that consequence is known as humility (see in particular Lewis 2009).

The commitment to quiddities is objectionable, since it obliges one to recognize worlds as being qualitatively different, although they are indiscernible. Quidditism about properties is analogous to haecceitism about individuals. A haecceitistic difference between possible worlds is a difference that consists only in the fact that there are different individuals in two worlds, without there being any qualitative difference between the worlds in question. In other words, a haecceitistic difference is a difference between individuals which has the consequence that worlds have to be recognized as different, although they are indiscernible. If one maintains that the essence of properties is a primitive suchness (a quiddity), a similar consequence ensues: one is in this case committed to recognizing worlds as different that are identical with respect to all causal and nomological relations, but that differ in the purely qualitative essence of the properties that exist in them.

Thus, for instance, the property that exercises the charge role in the actual world can exercise the mass role in another possible world, since the qualitative nature of that property is on this conception not tied to any role that tokens of the type in question exercise in a given world. We can therefore conceive a swap of the roles that properties play in two possible worlds, such as the property F playing the charge role and the property G playing the mass role in world w_1, and F playing the mass role and G playing the charge role in w_2. The worlds w_1 and w_2 are indiscernible. Nonetheless, the friend of categorical properties is committed to recognizing w_1 and w_2 as two qualitatively different worlds. To put it in a nutshell, there is a qualitative difference between these two worlds that does not make any difference. Thus inflating the commitment to worlds is uncomfortable for any metaphysical position, and notably for a position that sees itself as being close to empiricism, as does Humean metaphysics.

The causal theory of properties avoids any association with quidditism by tying the essence of a property to its causal and thereby to its nomological role: instead of the essence of a property being a primitive suchness, the essence of a property is the power to enter into certain causal relations. Consequently, what the properties are manifests itself in the causal relations in which they figure (more precisely, the causal relations in which events stand in virtue of the properties that they instantiate). It is thus not possible to separate the properties from the causal relations (see notably Shoemaker 1980, Hawthorne 2001, Bird 2007, Chakravartty 2007, chapter 3 to 5). The laws of nature supervene on the properties in revealing what properties can do in being certain powers (see e.g. Dorato 2005, chapter 4). Consequently, worlds that are indiscernible as regards the causal and nomological relations are one and the same world. Although being committed to objective modality by tying the essence of a property to a certain causal – and thereby a certain nomological – role, the causal view of properties thus is ontologically parsimonious.

3. Structures and causal properties in fundamental physics

There is a so-called argument from science for the causal view of properties, drawing on the claim that the descriptions scientists give of the properties they acknowledge, including notably the properties they take to be fundamental, are causal descriptions, revealing what these properties can do in interactions. However, that argument is not cogent for two reasons. In the first place, without adding further premises, there is no valid inference from dispositional descriptions to an ontology of dispositional properties (that is, properties whose essence is a certain power or disposition). Such further premises are available; but they finally rely on the fact that the alternative view of properties, the categorical one, has to subscribe to metaphysical commitments such as the one to quiddities that do not serve any purpose for science, having notably no explanatory role, whereas the causal view of properties avoids any such free-floating commitments by identifying the essence of properties with their causal role (see Williams 2011). In brief, due to the additional premises needed, the so-called argument from science does not make the case for the causal view of properties stronger than it is already as based on the mentioned metaphysical argument only.

Furthermore – and more importantly as far as the relationship between science and the causal view of properties is concerned –, the claim according to which the descriptions scientists give of the properties they acknowledge are causal descriptions is in dispute. One can maintain that at least as far as fundamental physics is concerned, the basic descriptions are structural rather than dispositional ones, drawing on certain symmetries rather than certain causal powers. More precisely and more generally speaking, one can associate these two types of descriptions with two different forms of or approaches to scientific realism. Entity realism, laying stress on experiments rather than theories, seeks for causal explanations of experimental results and commits itself to theoretical entities – such as e.g. electrons, or elementary particles in general – only insofar as these have the power, disposition or capacity to produce phenomena such as the ones observed in the experiments in question. Structural realism, by contrast, starts from the structure of scientific theories and maintains in its epistemic form (epistemic structural realism – Worrall 1989) that there is a continuity of the structure of physical theories in the history of science; in its ontic form, going back to Ladyman (1998), structural realism maintains that structure is all there is in nature.

To strengthen the case for the causal view of properties, we should therefore, for the sake of the argument, base ourselves not on experiments and entity realism, but on theories and ontic structural realism (OSR). The first point that we can make in this context is to emphasize that nearly all the proponents of OSR conceive the structures to which they are committed in a non-Humean manner, namely as modal structures (see French and Ladyman 2003, Ladyman and Ross 2007, chapters 2 to 4, French 2010, section 3; but see Sparber 2009 and Lyre 2010 and 2011 for Humean versions of OSR). There is a clear reason for this commitment: it does not seem to make sense to conceive structures that are pure qualities. The identity of a structure obviously is constituted by its playing a certain nomological role. This is particularly evident when considering structures that are defined by certain symmetries (see notably the “group structural realism” advocated by Roberts 2011). Thus, it obviously does not make sense to conceive one and the same structure playing in one world, say, the role of the quantum structures of entanglement and in another world the role of the metrical-gravitational structures – as it does make sense in Humean metaphysics to conceive one and the same qualitative, intrinsic property to play the charge role in one world and the mass role in another world. The decisive question in this context therefore is this one: Is the nomological role that a structure plays also a causal role? Or is it a plausible move when it comes to structures to go for a separation between the nomological and the causal role – so that a structure necessarily plays a nomological role, the nomological role constituting its identity, but only contingently a causal role?

OSR is a realism with respect to the structure of a scientific theory (maintaining that there is a continuity in the structure of the mature scientific theories in the history of science, structure thus being immune to what is known as the argument from pessimistic induction). But this stance does not commit the ontic structural realist to Platonism about mathematical entities such as the mathematical structure of a fundamental physical theory. What the realist claims is that the mathematical structure of a fundamental physical theory *refers to* or *represents* something that there is in the world independently of our theories. In brief, the mathematical structure is a means of representation, and the point of OSR is the claim that what there is in the world, what the mathematical structure represents or refers to, is itself a structure, namely a physical structure.

To mention but one example, when one endorses a realist stance in the interpretation of quantum mechanics, one does not advocate Platonism with respect to mathematical entities such as the wavefunction (state vector) in a mathematical space; one maintains that these mathematical entities represent something that there is in the world by contrast to being mere tools in calculating probabilities for measurement outcomes (see e.g. Maudlin 2010 for a clear statement in that sense in contrast to claims to the contrary, such as Albert 1996). The realist in the interpretation of quantum mechanics therefore has the task to spell out what it is in the world that the quantum formalism refers to. Accordingly, the ontic structural realist has the charge to explain what a physical structure is in distinction to a mathematical structure that is employed as a means to represent what there is in the physical world, thereby replying to the widespread objection that OSR blurs the distinction between the mathematical and the physical (see e.g. Cao 2003 for that objection). Simply refusing to answer that question (as do Ladyman and Ross 2007, p. 158) is not acceptable.

In the context of a traditional metaphysics of universals and intrinsic properties, one can maintain that there are property types as universals, and that there are objects in the world that instantiate these property types. However, even if one is not an eliminativist about objects as is French (2010), but defends a moderate version of OSR that admits objects as that what stands in the relations in which the structures consist (Esfeld 2004, Esfeld and Lam 2008), such a move is not available to the ontic structural realist in order to answer the question what distinguishes physical from mathematical structures: it presupposes the existence of objects as something that is primitively there to instantiate the mathematical structures, being ontologically distinct from the structures. But insofar as OSR is in the position to admit objects, it can recognize only what French (2010) calls thin objects. More precisely, it can acknowledge objects only as that what stands in the relations that constitute the structures, the relations being the ways in which the objects are so that the objects do not have any existence or identity independently of the relations (Esfeld and Lam 2011).

Nonetheless, in order to answer the question how to distinguish physical from mathematical entities, the ontic structural realist can draw on another position that is widespread in traditional metaphysics, namely the causal criterion of existence, also known as Alexander's dictum: real physical structures distinguish themselves from their representations in terms of mathematical structures by being causally efficacious (Esfeld 2009). Concrete physical structures are first-order properties, too, namely first-order relations. They can be conceived as causal properties in the same manner as intrinsic properties: *in being certain qualitative* *physical structures, they are the power to bring about certain effects*. Structures can be causally efficacious in the same sense as intrinsic properties of events: as events can bring about effects in virtue of having certain intrinsic properties, they can bring about effects in virtue of standing in certain relations with each other so that it is the network of relations – that is, the structure as a whole – that is causally efficacious (see Esfeld and Sachse 2011, chapter 2, for details of such a metaphysics of causal structures). Furthermore, one thus accounts for the dynamics of physical systems: OSR is a proposal for an ontology of physical systems, but as such it is silent on their dynamical evolution.

This is not to say that the conception of causal structures is the only game in town to answer the question what distinguishes real physical structures from their representation in terms of mathematical structures, to spell out the modal nature of structures in OSR and to account for the dynamics of physical systems on the basis of OSR (see Psillos 2011 for a criticism of this position). The reflection on these issues in the framework of OSR has just begun. But an answer to these questions is needed so that one can then engage in the business of assessing the options.

4. Causal realism at work in the interpretation of fundamental physics

The arguments in the two preceding sections are rather abstract and general. In order to make a case for causal realism, one has to show in concrete terms how this interpretation applies to the current fundamental physical theories and what benefits one gets from doing so. A commitment to dispositions in the interpretation of quantum mechanics is usually linked with versions of quantum mechanics that recognize state reductions, leading from entanglement to something that comes at least close to classical physical properties (see Suárez 2007). The theory of Ghirardi, Rimini and Weber (1986) (GRW) is the most elaborate physical proposal in that respect. Indeed, in the GRW framework, one can maintain that the structures of quantum entanglement are the disposition or the power to bring about classical properties through state reductions in the form of spontaneous localizations. Doing so answers a number of crucial questions in the interpretation of quantum mechanics: (a) it tells us what the properties of quantum systems are if there are no properties with definite numerical values, namely dispositions to bring about such properties, and these dispositions are real and actual properties (by contrast to mere potentialities); (b) it provides for a solution to the so-called measurement problem, without smuggling the notions of measurement interactions, measurement devices, or observers into the interpretation of a fundamental physical theory; (c) it yields the probabilities that we need to account for the quantum probabilities, namely objective, single case probabilities, by conceiving the dispositions for state reductions in the form of spontaneous localizations as propensities; (d) it provides for an account of the direction of time: processes of state reductions are irreversible, thus singling out a direction of time; if these processes go back to entangled states as dispositions for state reductions, their irreversibility is explained by the relationship of dispositions and their manifestations being irreversible (see Dorato and Esfeld 2010 for spelling out these points in detail, and see Dorato 2007 for dispositions in the interpretation of quantum mechanics in general).

Nonetheless, causal realism in the interpretation of quantum mechanics is not tied to realism with respect to state reductions. Regarding the quantum structures of entanglement as dispositions or powers also has certain benefits in the framework of the version of quantum mechanics that goes back to Everett (1957), recognizing no state reductions and taking the dynamics given by the Schrödinger equation to be the complete dynamics of quantum systems (and, by way of consequence, all physical systems). The claim then is that the structures of quantum entanglement are the disposition or the power to bring about a splitting of the universe into infinitely many branches through decoherence, the branches existing in parallel without interfering with each other; each of them appears like a domain of classical properties to an internal observer.

Notably the above mentioned points (a) and (d) apply also in this framework: decoherence and the splitting of the world into infinitely many branches is a fundamental, irreversible process, whereas the Schrödinger dynamics is time-reversal invariant. Conceiving entangled states as dispositions that manifest themselves spontaneously through decoherence and the splitting of the universe into infinitely many branches grounds that principled irreversibility. Furthermore, one has to provide an answer to the question of what entangled states are prior to the splitting of the universe into infinitely many branches. Simply drawing on the quantum formalism and proposing a realist attitude towards the wavefunction or state vector in configuration space does not answer that question, as pointed out in the preceding section. Conceiving entangled states as dispositions in the mentioned sense, by contrast, answers that question in setting out a clear ontology of what entangled states are objectively in the world, grounding the subsequent appearance of classical properties (see Dorato and Esfeld in preparation for details).

Again, conceiving entangled states as dispositions or powers may not be the only game in town. But work in the philosophy of physics has to be done in order to answer the mentioned ontological questions, instead of hiding oneself behind a mathematical formalism and passing what is de facto a realism with respect to mathematical entities for a realism with respect to the physical world.

Dispositions in the sense of causal powers also figure prominently in the ontology of Bohmian mechanics, the third serious option in the philosophy of quantum mechanics. The quantum potential of Bohmian mechanics obviously is a physical structure whose essence consists not only in exercising a certain nomological role, but that nomological role also is a causal role: it is essential for the quantum potential to guide or pilot the movement of the quantum particles. However, in contrast to GRW and Everettian quantum mechanics, where entangled states and their development in time to classical properties or the appearance of classical properties is all there is, Bohmian mechanics cannot be construed as falling within dispositional monism or dispositional essentialism: over and above the quantum potential, there are the quantum particles, whose essential quantum property is their position, the hidden variable. The quantum potential acts on the quantum particles in determining their trajectory, but the quantum particles are causally inert: they do not in turn act on the quantum potential. But this fact constitutes a serious objection to the ontology of Bohmian mechanics. One can with good reason follow Bell (1987, in particular chapter 7) in acknowledging the need for local beables. It is, however, questionable whether one respects the spirit of Bell's demand in posing local beables that are hidden variables and that are causally inert, not manifesting themselves in any way.

Turning briefly to the other fundamental physical theory, general relativity, it seems at first glance that this theory suits well causal realism, since it abandons the view of space-time as a passive background structure, regarding instead the metrical field as a dynamical entity that accounts for the gravitational effects. It seems therefore that one can conceive the metrical properties of space-time points as dispositions or causal powers to bring about the gravitational effects (see Bird 2009 and Bartels 1996, pp. 37-38, and 2011 – Bartels, however, voices also reservations about dispositional essentialism in this context). But the case is not so clear: the gravitational effects are due to the movement of bodies along geodesics. One can therefore also argue that what seems to be gravitational effects are not effects that need a causal explanation, but is simply due to the geometry of curved space-time, not requiring a causal explanation in the same way as the inertial motion of a particle in Newtonian mechanics does not call for a causal explanation (see Livanios 2008, in particular pp. 389-390). The case for causal realism in the philosophy of general relativity hangs on the ontology of the metrical field that one adopts, in other words, the stance that one takes in the traditional debate between substantivalism and relationalism cast in the framework of general relativity. Ultimately, the issue has to be settled in an ontology of quantum gravity.

In sum, causal realism can do a good ontological work in the framework of standard quantum mechanics with or without state reductions, less so in Bohmian mechanics, and the case of general relativity theory depends on further parameters, such as the ontological stance that one adopts towards space-time (substantivalism or relationalism).

5. *Causal realism from fundamental physics to the special sciences*

Assume that there are structures of quantum entanglement at the ontological ground floor that develop into classical properties that are correlated with each other in certain ways, or into the appearance of classical properties through the splitting of the universe into many branches. Assume furthermore that some of these classical properties build up local physical structures that distinguish themselves from their environment in bringing about certain effects as a whole – such as, for instance, a DNA sequence that produces a certain protein, or a brain that produces a certain behaviour of an organism. In conceiving the entangled states and, accordingly, such local physical structures as causal powers, causal realism provides for a unified ontology for fundamental physics as well as biology and the special sciences in general (see Esfeld and Sachse 2011 for details).

On a Humean metaphysics of categorical properties, properties that are pure qualities and configurations of such properties can have a certain function in a given world and thus make true descriptions in dispositional, or functional terms; but there can be no functional properties, that is properties for which it is essential to exercise a certain causal role. However, on a widespread account of functions, namely the causal-dispositional one, the properties to which biology and the special sciences are committed are functional properties, consisting in exercising a certain causal role (Cummins 1975). Notably the entire discussion of functionalism as the mainstream position in the philosophy of psychology and the social sciences is couched in terms of functional properties.

The advantage of causal realism is to be in the position to take the talk of functional properties literally: there really are functional properties in which biology and the special sciences in general trade out there in the world, for all the properties that there are in the world, down to the fundamental physical ones, are causal properties, being the disposition or the power to produce certain effects in being certain qualities. The commitment to causal properties in physics allows us to be realist about causal properties in the special sciences, and that commitment is a necessary condition for the latter realism: if there were no causal properties in physics, there would be no causal properties in the special sciences either (unless one were to maintain a dualism of free-floating properties of the special sciences). Taking for granted that the properties with which the special sciences deal supervene on the fundamental physical properties, if there is to be causation in the production sense in the domain of the special sciences, properties bringing about certain effects in virtue of their causal nature, there is causation in that sense in the fundamental physical domain, the supervenience base, as well. In other words, under the assumption of supervenience, if there is objective modality in the domain of the special sciences, there is objective modality also in the domain of fundamental physics.

Again, causal realism may not be the only game in town for a coherent ontology reaching from physics to biology and the special sciences in general. But, again, the task is to spell out such an ontology, and causal realism is one way to achieve that task. As any metaphysical position, causal realism has to be assessed on the basis of overall considerations, taking into account the metaphysics of properties, the philosophy of physics, and the philosophy of the special sciences.

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