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Semirealism, Concrete Structures and Theory Change

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Abstract After a presentation of some relevant aspects of Chakravartty's semirealism (A Metaphysics for scientific realism. Knowing the unobservable. Cambridge University Press, Cambridge, 2007), this paper addresses two difficulties that appear to be inherent to important components of his proposed metaphysics for scientific realism. First, if particulars *and* laws are concrete structures, namely actual groupings of causal properties as the semirealist contends, the relation between particulars and laws becomes also a relation between particulars with some annoying consequences. This worry—and some others—are resolved if laws are taken to be statements and particulars are construed not only as groupings of properties, but things that contain a non-conceptual ingredient which can be given in perceptual awareness. Second, on the semirealist's view of particulars it becomes difficult to defend an epistemological version of scientific realism according to which we have good reasons to believe that the same things are referred to despite the fact that successive theories may attribute different properties to them.

Anjan Chakravartty is a scientific realist. For him our best scientific theories do provide knowledge of some observable and unobservable entities. But his book is not—at least not directly—a plea in favour of scientific realism. Chakravartty's main objective is not to assess the cogency of the reasons *pro et contra* one could adduce for believing—or not—in the partial and approximate truth of some theories. These epistemological issues have occupied centre stage after the collapse of logical positivism. They gave rise to the vast—and still expanding—literature on the

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no-miracle argument (Putnam), the pessimistic meta-induction (Laudan), the status of novel predictions (Popper, Leplin) and so on.

Chakravartty addresses the more fundamental issue of the very meaning of scientific realism. What are the beliefs about existing things that a consistent scientific realist must be committed to? An answer to this question requires an investigation of the lightest possible metaphysical baggage a scientific realist cannot avoid to burden himself with. What—minimal—amount of metaphysics a consistent scientific realist must commit himself to when he claims that some entities "exist" or are "real"? What is the metaphysical import of the assertion that our best theories are—partially and approximately—"true"? These are the main questions tackled by Chakravartty in his highly original and path-breaking book. "To summarize the aims of the book very concisely, I investigate the core elements of promising versions of contemporary realism, and develop a metaphysics that makes sense of these commitments" (p. xiii).

This is an ambitious agenda indeed! But Chakravartty does not pretend to elaborate a full-fledged metaphysical basis for scientific realism. To Chakravartty's credit, such virtuous modesty accounts in no small measure for the fulfilment of the pledge made to the reader in the Preface. The *semirealism* he proposes is not presented as *the* metaphysics of scientific realism, but as an example of an economical and coherent response to the metaphysical queries that a scientific realist cannot fail to address.

For a scientific realist like myself with a keen interest in neo-Aristotelian metaphysics, Chakravartty's work proved to be enormously stimulating and useful. Chakravartty's style is limpid, his arguments are carefully and convincingly articulated and his familiarity with current debates is impressive. In fact, I had a hard time—for the purpose of this critical review—to identify points I could disagree with. I found some however and in what follows I will concentrate on two of them. As a preliminary to this task, a brief presentation of some of the main tenets of Chakravartty's semirealism is in order.

1 Semirealism

Semirealism is first and foremost realism about well-detected properties and relations, i.e. properties and relations "with which we have managed to forge significant causal contact" (p. 60). Realism about properties is required to give a "minimal" interpretation of mathematical equations such as Fresnel's law of the propagation of light. "Minimally, the variables simply represent amplitudes (intensities) and angles (directions of propagation). (…) these properties are to be understood simply in terms of dispositions to enter into the very relations of properties described (…) by these equations. To suppose that a direction of propagation is *furthermore* a direction in the ether is to go beyond what is minimally required to give an interpretation of this particular set of equations" (p.53). Such pronouncements seem to be in line with the structural realism advocated by Worrall, French and Ladyman. However, relying on the arguments put forward by entity realists such as Hawking and Cartwright, Chakravartty is keen to include objects in

his ontology. What are these? Objects are particulars, minimally construed as sets of cohering dispositional properties. "They are collections of property instances that cohere at specifiable space–time locations" (p. 80). Remaining faithful to his ascetic metaphysical stance, Chakravartty leaves aside deeper metaphysical issues on the nature of properties, the instantiation relation and the possible grounds of the unity of an object, be it the existence of a "bare substratum" or a relation of "compresence" between properties. "My aim is not to champion any one of these views, so let us refer to these aspects neutrally as 'primitives'" (p. 82).

Chakravartty recalls the traditional distinction between dispositional and categorical properties. "The difference is usually explicated in terms of the manner in which they are described: the former in terms of what happens to objects under certain conditions, and the latter without reference to any happenings or conditions" (p. 123). However, the question of the ontological reducibility of one class of properties to the other is deemed to be inessential (p. 124). According to semirealism causal properties—whether reducible or not to categorical properties—do exist and confer dispositions of behaviour to the objects that have them.

Semirealism endows causal properties with paramount importance: these are none other than the properties denoted by the variables in lawlike statements. "(…) laws generally, and causal laws in particular, are relations between causal properties" (p. 128). Causal properties even include properties such as "angles of propagation", "volume" (in Boyle–Mariotte's law) traditionally classified as "categorical" properties. These properties stand in the relations described by the equations and form what Chakarvartty calls "concrete structures". "Causal properties are the fulcrum of semirealism. Their relations compose the concrete structures that are the primary subject matters of a tenable scientific realism. They regularly cohere to form interesting units, and these groupings make up the particulars (…) described by scientific theories. The continuous manifestations of the dispositions they confer constitute the causal processes to which empirical investigations become connected, so as to produce knowledge of the things they study" (p. 119).

Concrete structures which are relations between first-order properties of things are set in contrast with abstract structures which are properties of relations (such as having the same cardinality), that is, higher-order, formal (logical or mathematical) properties (p. 37). The properties that occur in laws are first-order properties. "Theories generally describe relations between relata, first-order properties, in terms of mathematical equations in which the variables name kinds of properties" (p. 41). If laws are relations between first-order properties, then laws belong to the furniture of the world.

Semirealism then offers an explanation of the regularities we can observe, since the things that possess some causal properties will *necessarily* behave in a certain way provided the adequate surrounding circumstances (*ceteris paribus* conditions) obtain. "The property of a volume on the part of a gas confers, *inter alia*, the disposition to become more highly pressurized under applied heat" (p. 41). "Particulars with causal properties such as volumes, masses, charges, velocities and so on are thereby disposed to behave in certain ways in the presence or absence of other particulars and properties, and it is these properties and resulting causal processes that scientific theories describe" (p. 120). Chakravartty then proceeds to

defend what he calls the "dispositional identity thesis" (DIT) according to which, in the words of Shoemaker, "the identity of a [causal] property is completely determined by its potential for contributing to the causal powers of the things that have it" (p. 123).

What makes a causal property the property that it is, is the set of dispositions that it confers to the particulars that have it. As a consequence the knowledge of particulars implies the knowledge of the concrete structures in which they are involved and vice versa. "(…) where one has grounds for believing that certain detection properties cohere, a knowledge of these properties and the concrete structures associated with them implies a knowledge of particulars. But the entailment also goes in the other direction, for just as one cannot identify a causal property without having at least some knowledge of its characteristic relations, one cannot identify an object without having at least some knowledge of its detection properties and their relations. Thus, where there is evidence of coherence, a knowledge of structures implies a knowledge of particulars" (p. 66). Surely, if particulars are defined as sets of cohering causal—and thus relational—properties, the knowledge of the structural relations between these properties and the knowledge of the particulars entail each other. (…) "all the relations of which causal properties are capable are "encoded" in the dispositions they confer. Properties and laws are thus flipsides of the same coin" (p. 147). Laws as relations between causal properties are concrete structures and ontological components of the world. Instantiated laws then seem to be a special class of particulars, since the latter are groupings of causal properties at a space–time location.

Having recalled some of the major features of Chakravartty's semirealism, I'm in a position to focus on two issues that arose some puzzlement in me. The first has to do with Chakravartty's notions of concrete structure and law and the second with his views on theory change.

2 Laws and Concrete Structures

In order to tell what a scientific law is, we have to look at scientific theories. Typically, a scientific theory is couched in a mathematical language and contains two main ingredients: statements and models. On this I fully agree with Chakravartty who distances himself from both the syntactical and semantic views of theories and claims that the scientific realist must construe theories as made up of linguistic elements—i.e. statements—and non-linguistic ingredients—i.e. models (p. 194). Scientific statements most often present themselves as mathematical formulae or equations such as $pV = K$, $\Delta l = k\Delta T$, $F = ma$... We are also told that "p" stands for pressure, "V" for volume, "l" for length, "T" for temperature etc. and we are given instructions on how to measure those variables, that is, on the procedures by means of which numbers in some units are associated to those variables. An equation is considered to be (non-vacuously) true if there exist things in the world—*e.g.* (almost) perfect gases—for which the measurement results (approximately) satisfy or verify the equation.

Lawlike statements are supposed to be universal. The—often disregarded—problem here is to specify what we quantify upon. In Boyle–Mariotte's law, for *all*

measured values of p and V, their product (at constant temperature) is equal to a constant:

$$(p)(V)\,(p\,V\,=\,K) \qquad \text{(BM)}$$

But this is not enough. We must also specify the set of things in the world for which this formula holds true, namely (perfect) gases, which form a delimited class of entities. In the formulation just given, Boyle–Mariotte's equation (BM) does not explicitly state that quantification runs over the class of perfect gases. BM must be completed in order to obtain the following *bona fide* lawlike statement:

$$(x)(p)(V)(Gx \wedge px \wedge Vx \rightarrow (px.Vx = K)) \qquad \text{(BML)}$$

Which reads: for all x's, if x is a gas, then all values of its pressure and volume satisfy BM. In BML, a double quantification is present: one which ranges over entities—in this case, the class of things that we call "gases"—and one which ranges over properties, namely numerical values of pressure and volume. This statement is non-vacuously true if there are gases in the first place, that is things which do possess a pressure, a volume, are (almost) perfect (that is, are remote from their point of liquefaction etc.), and if the measurement values for p and V approximately satisfy BM.

I have insisted on this because I have the impression that not a few philosophers have been misled by the standard formulation of law statements in most scientific textbooks which, at face value, seem to express relations between kinds[1] of properties denoted by *"V"*, "*p"* etc. However, what a lawlike statement literally describes is a regular behaviour of things in the word. Contrary to Chakravartty, I tend on this point to side with empiricists such as Stathis Psillos who defend a regularist view of laws. In my opinion, a lawlike statement does *not* literally express a relation between properties and, as a consequence, does *not* describe a concrete structure.

Lawlike statements describe the behaviour of things in the world. But things are particulars and "A particular is a *unity* in space–time; it is something that coheres, and has a location" (p. 80). I certainly agree with this. But I think that a particular is more than a coherent grouping of causal properties at some location as Chakravartty contends. It is also something that we identify as a "this" or a "that" in actual perception—the "x's" that we quantify upon in BML—before we attribute properties to it. Otherwise particulars would lack the concreteness Chakravartty is willing to attribute to them. We are thus led back to a traditional metaphysical issue which echoes ancient debates between Plato and Aristotle, and their countless followers. The nature of what makes up an existing particular on top of its properties is a thorny metaphysical question which, I think, cannot be resolved by defining the nature of a "substratum", or "haecceitas" or a relation of "compresence" or what have you. Such moves would be tantamount to pile up properties on properties with no end in sight. As far as I'm concerned, I'm inclined to accept that a real particular

[1] The kinds referred to here are the sets of numerical values for pressure, volume etc. At a given time a gas has a pressure of some specific value, and also has the possibility of acquiring some other values of pressure.

contains an ingredient which is not a property and—as a consequence—cannot be conceptualized. Spatio-temporal location won't do the trick since it is again a property. (Besides, we may mention that spatio-temporal location cannot be attributed to some theoretical entities in physics). Existence is not a property. Aristotle famously attempted to capture the unintelligible non-conceptual surplus in particular substances through the metaphor of (prime) matter. Chakravartty's sympathy however seems to lean towards Plato when he writes: "If one accepts that dispositions are occurrent properties whether or not they are manifested, it may be tempting to say that laws are in a sense actual, whether or not they are actualized. This would amount to the idea, offered here merely as food for thought, that uninstantiated but possible relations "exist" in potential form, standing by to be realized in appropriate circumstances" (p. 147).

Despite Chakravartty's oratory prudence, this quotation reveals where semirealism naturally leads to: a—mitigated for sure—form of Platonism. It seems to me that Chakravartty did not push his rejection of ontic structuralism far enough. Certainly, the existence of structures is parasitic on the existence of their relata. For semi-realism however, the relata are first-order instantiated causal properties. This is not sufficient to get concreteness unless one provides some—minimal—indication on what instantiation is, namely the possession of the property by an existing "this" given in effective perceptive awareness. Properties cannot be real by themselves. Granted, if causal properties are properties of real things in the world, they are occurrent and actual—such as the possibility for a (real) gas to acquire a certain volume—even in the absence of some corresponding manifestations. However, for causal properties to exist they must be instantiated in real things which cannot be only groupings of properties—otherwise we would be confronted with an unwanted regress. These things are the concrete entities that are first given to us as "this" in actual perceptual awareness.

If particulars are groupings of causal properties—as semirealism contends—further difficulties loom. I'm quite sympathetic with the view that particulars have real causal properties which explain why they are able to enter into specific relations and processes. Yet, according to the semirealist's construal of particulars, one is led to accept the existence of properties of properties i.e. second-order properties. Take a particular gas, which according to semirealism is a certain set of properties. Then this particular has a volume and since a particular is a set of properties, volume becomes a second-order property. Semirealism certainly—and quite rightly—wants to avoid such a consequence. An obvious escape would be to include volume in the set of properties that characterize the particular gas. But then it becomes mysterious how a property which belongs to a set of properties can *confer* (in any sense of the word "confer") to this very same set a property which is already contained in it. On the other hand, if a particular is in the first place something that is identified in perception, one understands why a particular having a causal property has the disposition to behave in a certain definite way (in appropriate circumstances).

A similar difficulty arises with Chakravartty's conception of a law of nature which—let us recall—seems to be a special case of concrete structure. Then the relation $pV = K$ (for specific values of p and V) is a particular, but which is distinct—supposedly—from the particular gas which instantiates the law and which

has specific values for pressure and volume that satisfy BM. As a consequence, the connection between a particular, such as a gas, and Boyle–Mariotte's law is to be understood as a relation between particulars, that is a second-order relation between sets of properties. This is not only counterintuitive but also contains the seeds of an annoying regress. Presumably, this second-order relation will also count as a law and so on…

If—as I propose—laws are *not* considered to be realities on their own, but statements that describe the way some things regularly behave, these difficulties vanish. A particular gas has a volume, pressure, temperature that satisfies the equation BM, and this is true for all gases. There is no need to postulate the existence of a necessary relation between those properties. The necessary truth of lawlike statements springs from the existence in things of causal powers—which are real even if they are not "manifested". When a thing possesses such causal powers, it will necessarily behave in some specific ways, not in virtue of a necessary relation between some properties, but in virtue of the nature of these instantiated causal powers themselves. Causal powers may perhaps be described as related to other—not instantiated, and therefore not real—properties (as e.g. in the causal analysis of dispositions), but they are intrinsic properties of the things that have them. According to such a conception, the truth-makers of lawlike statements are regularities, but such regularities do have a metaphysical foundation in the intrinsic causal powers of particulars (see Ghins 2007).

3 Scientific Realism and Theory Change

Since we are capable of distinguishing gases from rocks and rivers, all these must have distinctive properties which, on pains of circularity, cannot be the same as the ones referred to in mathematical formulae such as BM. For entities accessible to unaided perception, these are properties such as colour, softness, smell etc. Our perceptual access to things may well be described by (some unknown) causal laws, but those are different from the ones that have been investigated by Boyle, Mariotte, Charles, van der Waals and others.

For gases that are perceptually identified, it makes—common—sense to contend that better knowledge of their properties (pressure, volume…) and the relations among them is achieved by means of scientific investigation. This also holds true for our earth, which in the course of history was thought to be a flat disc, a sphere, an ellipsoid…and also for the gas artificially produced by Stahl, Priestley, Lavoisier and others and which can be perceptually identified in the laboratory. This very same gas was (erroneously) attributed the property of lacking phlogiston by Stahl and Priestley and (correctly) attributed the property of being rich in oxygen by Lavoisier. I quite agree with Chakravartty when he claims that "one is dealing here with very different sets of putative detection properties" (p. 56), but I cannot follow him when he contends that "the realist should not accept the claim that 'dephlogisticated air' and 'oxygen' refer to the same thing" (p. 56). Chakravartty's view is a logical consequence of his identification of particulars with sets of properties; if the properties change, so do the particulars that have them. Yet, in

order to be able to attribute properties to a thing, the latter must have been previously identified by means of some *other distinct*—perceptual—properties. This fact guarantees that when a change of theory occurs, there is a sense in which theories continue to speak about the same objects.[2]

The soil of science is sensory perception without which the relations between properties expressed in mathematical formulae would have no sufficient empirical roots and float in the air, so to speak. Chakravartty is quite aware of the role of perception when he writes that "when it comes to property attribution, the epistemic buck stops with perception" (p. 137). Agreed! But when we attribute a property to a thing, we do so not on the basis of significant causal contact with that property but with a thing which has some properties. What is given to us in perception are objects with properties and not properties or sets of properties *simpliciter*.

One might quickly object at this stage that the identification of an object in perception is possible for gases, but not for molecules, electrons, genes etc. However, the phenomena described as "cathode rays" occurring in Thomson's tube as well as the variations in morphology and behaviour of living beings are certainly accessible to observation. The electron example is similar to the phlogiston/oxygen case. Surely, various properties have been attributed to the things, dubbed "electrons", causally responsible for cathode rays. But the identification of electrons through theory change is achieved by the observable phenomena and their causal role in producing specific phenomena. I thus disagree with Chakravartty when he writes: "It is reasonable to give the benefit of the doubt [as far as identity of reference is concerned] not just when general causal roles are retained, but where quite specific dispositions for relations conferred by particular detection properties are preserved. On this view, it would be unreasonable to apply the principle in such a way as to identify (with one another) the putative referents of significantly different systems of properties" (p. 55).

If one considers only the changing groupings of causal properties attributed to electrons, it certainly is reasonable to question the identity of their referent. But the causal properties of the electron are sufficiently minimally identified as the ones which are responsible for the occurrence of the perfectly identified luminous *phenomena* in precise laboratory conditions. It does then make sense to claim that the various theories about electrons deal with the same things. This holds also true for the genes, which are the entities causally responsible for the specific phenomena observed by Mendel, De Vries, Johannsen etc. Later on, it was discovered that the genes are configurations of DNA.

Certainly, scientific realism does not rest satisfied with the assertion that theories continue to deal with the same observable entities as science progresses. If we have reasons to believe that some lawlike statements are true, it is because in the words of Chakravartty we have managed to "forge significant causal contact" with entities such as electrons which have properties such as charge, spin, mass etc. which have been measured by means of different independent methods giving concordant

[2] The same kind of consideration permits to interpret the famous statement by Kuhn that «Though the world doesn't change with a change of paradigm, the scientist afterwards works in a different world» (see Ghins 2003).

numerical results. And those numerical results do satisfy lawlike statements. However, existence and truth claims about unobservables are not semantically different from existence and truth claims about observable entities. The latter are the starting point of any philosophical disquisition (see Ghins 2005) on realism. For having reasons to believe that the various methods of measurement are about the *same* entities, we have to eventually rely on effective perception and actual access to specific phenomena, just in the same way that we can progressively gain more knowledge about the observable properties of a distant tree when we walk in its direction and get closer to it.

4 Conclusion

To the extent that mathematical structures may be said to be preserved through theory change, those structures must exist in concrete entities called particulars. A relation between pressure and volume is present in a concrete entity such as a particular gas given in perception. A mathematical structure of numbers—such as measurement results—organized by a mathematical relation such as $pV = K$, has no existence by itself. Only gases with specific values of pressure and volume, and causal powers to behave in certain ways, do exist. Only entities such as electrons, with specific values of mass, spin, charge etc. exist. Unless I'm missing something, it seems to me that by stressing the reality of structures of properties, Chakravartty's semirealism becomes vulnerable to the same objections that have been directed to ontic structuralism, namely that structures are to thin to be real and lack sufficient ontological thickness. The same sort of difficulty apparently arises for semirealism at the level of properties. Surely, according to semirealism, only properties which are detected and detectable exist. Yet, their existence is parasitic on the existence of causal interactions with us or our measuring devices. These causal interactions are themselves specific kinds of relations. Thus, for properties to exist they must be possessed by existing particulars which cannot be characterized only by groupings of properties at a space–time location, but are entities which possess a non-conceptual ingredient, namely existence and which is originally apprehended in perceptual awareness.

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