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The physical world as a blob: is OSR really realism?[1]

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The main purpose of this first book-length survey of ontic structural realism (OSR) is to convince the reader that the ontology of the physical world is one of "structures" and not of "objects". Despite the impressive range of topics that are accurately and exhaustively presented – continuity across scientific change, the underdetermination of metaphysics by physical theories, an historical survey on 20th structuralism, the role of models and of group theory in the representation of structures, the relationship between structures and other key metaphysical notions (objects, causation, modality, dispositions, biological individuals) – my final impression is that the main objective has not been reached.

The reason has to do with the fact that the simple question: "what is *physical* (rather than mere *mathematical*) structure?" has received at best a very vague answer. Consequently, as we will see, French is forced to navigate between the Scilla of Tegmark's Pitagoreanism (2008) and the Caribdi of "blobobjectivism" (Horgan and Potrč 2008), namely the claim that the whole physical universe is a single concrete structurally complex but partless cosmos (a "blob"). The former alternative is discussed and then, understandably, rejected. While it is not clear whether French endorses the latter alternative as a plausible ontological rendering of "physical structure" (173-4, 183, 189) – he presents its pros and cons[2] – he does not seem too unsympathetic about it. In any case, I will argue that, insofar as I can understand OSR, blobobjectivism is its most coherent development but is a rather inadequate way to make sense of the ontology of contemporary physics.

Given the above dilemma, the challenge of clarifying the nature of "physical structure" has not been taken up yet. In part, this follows from the fact that French often does *not* take stock among the various responses that he discusses to defend OSR from foreseeable obections. His review of the literature is always accompanied by new arguments, but he plays *defensively*:

[1] Thanks to Angelo Cei and Elena Castellani for their critical comments on a previous draft of
[2] I think this follows despite the fact that French does not endorse Horgan and Potrč's contextualist semantics.

aware of the difficulties generated by his ambitious program, he seems just content to show that some of his responses are viable, without trying to explore them in depth and defend OSR more effectively. This is more evident when the going gets tough, in particular in chapters 7 and 8, which deal, respectively, with his attempt to eliminate an ontology of objects and with the problem of clarifying the difference between physical and mathematical structures. Here the arguments are more sketchy and promissory, and they probably only aim to open new paths for future research.

After having expressed my opinion, the fact that French's knowledge of physics, metaphysics and possible ways of relating them is encyclopaedic as well as precise is uncontroversial. Many readers will learn a lot (as I did) from a book that succeeds in illuminating many philosophical questions about the ontology of physics by using OSR as its only focus. But the best way to pay due homage to a thought-provocative book is to criticize it, and I hope that my objections will be useful for the future developments of OSR's research program.

1 The two arguments in favour of OSR

The difficulty of distinguishing *mathematical* from *physical* structure is related to another crucial question raised by French's version of OSR, namely that of offering a clear and precise account of "object". It is only after such an account that can we distinguish – within the old umbrella-term "entity" as it was used by Hacking (1983) – between object realism and ontic structural realism. Without such an account, we cannot make sense of French's version of OSR: given his eliminationism about objects, structures and object must be *sharply* separated.

Part of the problem of course lies in the unavoidable vagueness of the latter notion in ordinary language. French seems to take for granted that the unclear notion of object presupposes the clearer notion of "individual": *x* counts as an object if and only if *x* possesses an identity, and therefore is an *individual*. But of course, at this point, the trouble is only shifted to the new question: which among the available theories of individuality should we prefer in order to establish whether *x* is an object?[3] Should we opt for a reduction of individuality to properties or should we rather prefer a view that insists that identity is a primitive, irreducible, non-property-like feature of any entity?

[3] This problem had already been noted by Howard (2011).

However, if quantum physics underdetermines the choice between these two metaphysical theories, as French seems to claim in chapter 2, one should remain *agnostic* about the existence of objects (as in Epistemic Structural Realism). On the contrary, French surprisingly embraces an *atheistic* stance toward their non existence, in favour a *theistic* stance toward structures! In a nutshell, here is my reconstruction of his argument:

1. *Quantum physics* underdetermines a choice between an ontology of individuals or non-individuals (*first* motivation in favour of OSR).
2. In order to overcome this unwanted underdetermination we should embrace an ontology of structures that is common to the two metaphysical views.
3. *Contemporary physics* and in particular the group theoretic representations that underpin it, favours OSR: this *second* motivation for OSR is supposed to be independent of the first.
4. OSR favours the priority of structures over individuals.
5. Premises 3 and 4 imply that contemporary physics favours the priority of structures over individuals (reconceptualization or elimination of objects).
6. Given 5, contemporary physics does *not* underdetermine the metaphysics of individuality, a fortiori in view of French's eliminativism about objects!

Of course contemporary physics is a "superset" of quantum statistical physics, but 1 and 6 are still contradictory: contemporary physics and quantum statistical physics either underdetermine together the metaphysics of individuality or together they do not. French, on the contrary, defends both 1 and 3, but it is not wholly clear whether he is justified in doing so. First, quantum statistics is incorporated as an essential and unquestioned component of contemporary physics. So why is it the case that whatever underdetermines quantum statistical physics does not also underdetermine contemporary physics at large? If it is the group theoretical approach to physics that breaks the underdetermination, this very approach should also eliminate the underdetermination argued by 1, given that *both* quantum statistical physics and contemporary physics at large, as French correctly notes (p. 43), are essentially underpinned by group-theoretical structures.

On the other hand, and for the same reasons, if French is correct in claiming that *differences solo numero* are compatible with quantum statistical physics (for arguments in favour of this claim see Dorato and Morganti 2013), he should provide strong arguments in favour of the fact that such differences are implausible within a *more general* group-theoretic approach to the ontology of fundamental physics, even though group theory underpins also quantum statistics. If I am not wrong, these arguments have *not* been provided. It follows that the evidence in favour of OSR is substantially weakened, because one of the two motivations in its favour must go (not everything…). In view of the relevance of group theoretic structures to describe and explain the physical world, I think that if asked and really had to choose, French would jettison the argument expressed in 1. And in fact, the book argues that an investigation into the problem of how mathematical models represent the world shows that group structural realism (GSR) is the best articulation of OSR.

On the other hand, it is clear why French cannot drop 1 altogether. The reason has to do with the already mentioned, undeniable vagueness of, the meaning of "individual" or "object". An answer to the question "why should two electrons be regarded as non-individuals (non-object like) simply in virtue of their indistinguishability?" presupposes *either* an arbitrary stipulation *or* some sort of essentialism about the meaning of "individual" or "object". For obvious reasons, neither strategy can be accepted by French. The former would trivialize OSR; the latter is incompatible with the fact that concepts, scientific ones included, change and that science invents new concepts (fields, for instance) that don't fit into the ordinary language categories. Consequently, the underdetermination thesis in 1 ought to be generalized to other physical theories (say relativity *vis à vis* the presentism/eternalism, or the perdurantism/endurantism debates), at least to the extent that metaphysical theories are based on ambiguous ordinary language notions (individual, parts, substance property, etc.) that are simply unfit to interpret the new language of contemporary physics. This is exactly what I think should be admitted, an acknowledgment that would jeopardise a good portion of contemporary metaphysics of science; but this is the topic for another paper.

2 The problem of the representation of the structure of physical phenomena

According to French physical theories are classes of models and their way of representing the world is one of the strongest arguments in favour of OSR. To clarify the nature of the model-world relation is to solve the question I want to focus on, namely how to characterize the difference between mathematical and physical structure in OSR in a precise way, without having to concede that it is vague (Ladyman and Ross 2007), which is way to blur his ontological stance.

In trying to solve this problem, French relies on Brading and Landry's distinction between the presentation of a model and its representation (2006) but gives it a different twist, whose implications are not always clear. According to Brading and Landry, *presenting* a certain structure is tantamount to specifying the relationship holding among theoretical models and data models of physical phenomena. However, in their view the theory-world connection requires something more, namely a notion of *representation*, which ought to specify the relationship holding between the *kinds* of objects presented by models and the individual phenomena that they are meant to represent (2006, pp. 576-577).

In French's interpretation, Brading and Landy's distinction is meant to defend a two-layered notion of representations. So he distinguishes between "the *presentation* of putative objects thanks to the shared structure that our theories make available and the representation of such objects (as features of the world) by those theories. The obvious question is then, how is this shared structure represented"? (p.101). The answer is that the semantic conception of theories suggests that, at the meta-level, a partial-set theoretic approach is the best instrument to represent the classes of models determined by physical theories, and therefore the group theoretic structure shared by theoretical models, data models and, as the passage above suggests, physical structure. On the other hand, it is this very same group-theoretic structure that is practically used by physicists for a lower-level representation of physical phenomena. By defending these two different levels of "representations" and by later construing a detailed account of how group theoretical structure represents physical phenomena, French aims to fend off the charge that OSR reifies mathematical structure by confusing the physical structure of phenomena as represented (in Brading and Landry's sense) by group theoretical structure with the meta-level representation of the latter structure allowed by partial set theory.

However, there are at least three perplexities raised by this view and French's use of the notion of presentation.

1. Presenting a structure, in Brading and Landry's terminology, does not involve the model-world relationship as French has it in the quotation above ("sharing the structure"), but, more appropriately, only a relation between abstract mathematical models. It is only in this literal sense that the notion of *sharing* is applicable, since isomorphisms or morphisms of any kind can only hold between mathematical, causally inert structures and not between such structures and the physical world, as the passage above seems to indicate. The fact that according to French there is there only *one* type of sharing while there are *two* notions of representation creates the risk of reifying mathematical structures, and therefore a collapse of the two kinds of structures, at least until a precise notion of physical structure is provided.

2 French explicitly claims that it is the lower level, group theoretical representation of phenomena as it is practically used by physicists that can provide decisive evidence in favor of the priority of *physical relations* over *individual objects* (p.102). To the extent that it

enables us to draw such metaphysical conclusions, French ought to regard group theoretical structure as *philosophically* more important than set theoretical structure, as the Group Structural Realism (GSR) defended in chapter 6 also seems to imply. Given this priority, however, it is not clear why he insists on the necessity of a meta-theoretical representation of models in terms of partial set theory.

3. physical phenomena do not determine the kind of theoretical models that are used to represent them. Not only are such models not deducible from physical phenomena, but furthermore they simplify them drastically, by abstracting away many of their details: the *partial*-isomorphism approach, that is meant to capture this incompleteness of our representational devices, makes this problem only more evident. French is aware of this difficulty (p. 138), but it is not clear whether he can solve it. One cannot exclude the existence of "left-over entities that might not be captured, or captured only "partially", by the kind of mathematical representation of physical phenomena that is forced upon us by our *cognitive* structure – a sort of Kantian condition of "knowability" of phenomena that Eddington and Cassirer in different ways insisted upon but that French does not discuss at all.

Furthermore, since physical phenomenal constrain mathematical structure only to a certain extent, without a precise account of what it means to claim that the former share their structure with the latter, it is not clear why the model-world relation afforded by these structures should suggest a "reconceptualisation" of physical objects in structural terms. OSR's urgent problem is therefore not "how to best represent the shared structure of physical models" (chapter 5), but rather "what is the nature of the physical stuff that does the sharing?"

3 OSR as Group Structural Realism (GSR)

In order to answer this question (chapter 6), French understandably relies on the representational power offered by group theory. Symmetry and invariance, key group-theoretic notions of contemporary physics, are our main guide to determine what is physically objective. As such, they are essential to ground the invariance of physical laws across scientific change and therefore to give a precise meaning to the fact that previous theories become particular cases of their more general successors.

The central role of group theory in contemporary physics leads French to jump from a cautious epistemic structural realism to group structural realism (GSR), via an implicit appeal to an *inference to the best explanation*. In this perspective, group structure would not only enjoy just epistemic and heuristic priority in our search for fundamental features and entities of the physical world, but would also have an ontic priority of some sort. The most plausible hypothesis to explain the success of physical theories using group theoretical structure is that these theories are approximately *true*. But the truth of these theories implies the claim that that *the objective features of the physical world (however they are conceptualized) are accurately and effectively described by the group theoretical structure of our mathematized models*.

Apart from the philosophically controversial recourse to the inference to the best explanation, there is no excess metaphysical bag in this italicized statement, and I think that any physicist could endorse it. Troubles arise to the extent that GSR is supererogatively after something more: what do we gain when to the *uncontroversial* effectiveness of group theory we add the supererogatory claim that "group structure *is real*"? Unless a clear answer is provided to the question: "what instantiates the group structure?", we should conclude that GSR is either false or trivial. It is false because the physical world *is* not a group nor can it literally share structure with mathematical models for the reasons given above. It is trivial because an answer to the question "what is the group theoretical structure of physical models *about*?" cannot be "the structure of the physical world": this viciously circular reply would not be very illuminating if we don't know how to understand "physical structure".

In a word, I submit that the *only* meaning of the expression "the physical world has the structure of a group and group structures are exist" is "the physical world *instantiates* such structure"[4]: U(1) x SU(2) x SU(3) *represent* the fundamental ontology of the physical world, in the sense that the latter *instantiates* the former. But this claim can also be accepted in an empiricist approach, since lacking further arguments that French here does not provide, the "physical world" may well coincide with the "physical phenomena saved by our models". In this case, GSR collapses into group structural phenomenalism or epistemic structural realism, since group theory becomes "just" an epistemically powerful means to describe physical phenomena.

4 Eliminating objects without giving up causation?

In less radical versions of OSR, elementary particles do exist but are "thin objects" in the sense that their identity depend on the relational structure in which they are embedded. French's more radical, eliminationist version of OSR instead claims that particles literally do

[4] For the similar claim about "spacetime exists" see my (2000).

not exist as individuals or objects, and must be reconceptualized in group structural terms. Arguments in favor of this view are yielded by the structural conception of laws *à la* Cassirer, and by the fact that (i) quantum particles and their measurable properties "*are*" irreducible representations of the relevant symmetry groups and (ii) even their apparent intrinsic properties (spin mass and charge) are "structurally derived" (Lyre 2011). How is this "*are*" to be interpreted, epistemically or ontically?

A representation of a group is a homomorphism from the group to the automorphism group of another causally inert entity. However, single elementary particles leave tracks on a fluorescent screen: qua causally active, they *cannot* be just representations of groups and can be abstract only qua *kinds*. So French's fundamental physical structure must be endowed with causal efficacy not only to make sense of its effects in the labs around the world, but also to explain away the apparent causal efficacy of macro-objects, which, given French's reductionism, must be completely dependent on the fundamental relational structure of the world. In fact, if macro-objects could be regarded as causally active independently of the fundamental relational microstructure to which they allegedly reduce, we would have a good reason to believe in their autonomous existence: causal efficacy is usually treated as a *sufficient* criterion for existence. As a consequence, macro-objects would *not* be eliminable.

French deals with Psillos' (2006) objection that causation needs an ontology of objects in two steps. The first consists in the elimination of everyday objects – qua potential carriers of causal relations – from the ontology of the world: it follows that *if* there is causation in physics, it must reside in the fundamental group theoretic structure of the world. The second step consists in an attempt to introduce causation at the fundamental level, in the hypothesis that causation is not folk science. I will now discuss these two steps in turn.

1) According to French's revisionary metaphysics, the talk about the macroscopic objects of the manifest image is a practical expedient that will not be abandoned (as talk of quantum particles as *objects* in the laboratory), even though such objects can be eliminated from the catalogue of things that exists via their reconceptualization in terms of the fundamental relational structure of the universe. Of course, we need to know why macro-object talk is so useful without invoking any correspondence with reality. But even supposing that a solution to this problem can be provided, and that particles are not individuals, arguments by analogy between micro and macro-stuff fail. First, two identical tables, unlike quantum particles, have an uncontroversial identity in virtue of their different spatiotemporal location. Secondly, physics may describe the microcomponents of the wood of which my table is made of, and can explain why its macroscopic properties are what they seem to be to us, but its object

language does not contain "tables" (as Stebbing already noted in 1937 *a propos* of Eddington famous riddle). Thirdly, x is a table or a chair iff a human being attributes x the *function* that it usually has. The intentional and functional component of man-made macroobjects, currently at least, cannot be reproduced by physics. The conclusion is that strategies for the elimination of macroobjects and microobjects cannot be regarded as similar at all, and that tables cannot easily be eliminated in terms of physicalistic language, despite the fact that they are physical objects.

Other forms of eliminative reduction of macroobjects suffer from other difficulties. The first, widely discussed by French, involves *mereological* reductionism: can we regard my table as a collection of atoms, in such a way that we do not have two entities, the table and the collection of atoms, but one entity, the table regarded as identical to the sum of its *simple* components? This is one of the views that French considers to be more plausible: "What makes the sentence table exists true are whatever we take the fundament constituent to be" (p 175). However, it has been convincingly argued that mereological reductionism does not apply to quantum mechanics (Healey 2013, Caulton 2015). Surprisingly, French does not give the necessary attention to problem of quantum compositionality and in order to eliminate macro-objects seems to rely on the part/whole relation of *classical* mereology!

Secondly, eliminative reductions of macroobjects to microstructure cannot succeed until we have a more precise idea of the ontology of the reducing theory, i.e., until we know with some more precision what a "physical structure" is. And as we will see below, French did not succeed in clarifying this problem

Thirdly, the more plausible strategies for his eliminationism, the reductive ones, are either too weak or too strong. A mere ontological reduction will not do, since tables are physical objects even if functionally defined: the ontological reduction in this case is not as interesting as that invoked in the mind-body problem. An explanatory view of reduction is also too weak, since it does not necessarily eliminate macroobjects and their macroproperties: I can explain solidity in terms of atomic structure and chemical bonds, without eliminating the emergent, collective property: single atoms and their bonds are not solid, only the table is.

It then follows that in order to pursue an eliminative reduction of macroobjects to quantum structure one needs a stronger, identity theory: if I reduce *x* to *y* by showing that *x is y*, then I can treat *x* as non existent. However, this form of eliminative reduction is not justifiable even in the only clearly defined, strongest theory of reduction, namely Nagel's. Even supposing that one could get around the fact that there are no laws of tables and chairs as such, x is not eliminated in favour of y, given that the "is" in the sentence is an identity. Analogously, the macroscopic property "temperature of a gas" is not eliminated by statistical mechanics, in virtue the fact that temperature *is* mean molecular motion! Temperature is a real (though emergent) property of a gas: otherwise there would be nothing to reduce. If there are no clear examples of eliminative reductions in physics how can a reduction of everyday objects to fundamental physical structure be successful?

This may explain why the eliminative view of macroobjects as presented in chapter 7 is merely promissory, as he himself acknowledges (p. 189). In this chapter in particular, French begins by supposing a paradoxical thesis T, and then presents an extremely well-informed review of the existing literature in order to show how T could be defended but does not take stock, even if the wealth of new and original arguments pro and cons the various positions that are presented is really remarkable.

4.2 The second step: can we introduce causation in the fundamental relational structure?

In fairness to French, the problem of drawing a border between abstract, mathematical structure and physical structure is there for anyone, since it depends in part on the difficulty of finding a distinction between abstract and concrete. For instance, entities may be abstract in the spatiotemporal sense and yet be physical, as 3N configuration space might be required by the reality of the wave function. The criterion involving causation seems less controversial, and seems to be shared both by traditional objects-realists and structural realists like French. If mathematical entities are defined as causally inert, in order to avoid the collapse of physical onto mathematical structure, French must embody causation in his structuralist ontology, while avoiding at the same an ontology of objects as carriers of causal activity.

In order to achieve this aim, he endorses the process view of causation, in which the persistence of events in time – regarded as worldliness – is dependent upon their structure. This means that, say, the interaction of two particles regarded as objects is to be thought of in terms of "a system of relations some of which might be described as causal, where that notion is appropriately characterized in this context" (p.213). In a word, events are not instantiations of properties by objects; rather, the interactions of particles *qua* events must be reconceptualised in structuralistic terms: as advocated by Esfeld (2009), relations (or bundles thereof) can be causally powerful.

Admittedly, the picture is rather vague and promissory to say the least; plus, the threat of the blob-universe sticks it ugly head again. Suppose that properties are causal powers. If causal powers of properties were themselves structural, then "iteration" would lead to the view that the only causally empowered stuff is the universe/blob discussed above. In order to avoid this consequence, French notes that it is not incoherent to be structuralist about objects and their properties but *not* about their causal power (p. 218). How reasonable is this move?

Take two masses in Newtonian dynamics: m_1 and m_2. According to his proposal, the particles and their property "mass" dissolve in a network of relations but the power to attract other masses is non-structural and therefore non-relational. In this case, however, this attractive power, shared by the two masses, would be *intrinsic* to them. The problem in this case is that, presumably, in OSR a causal power should itself be relational, lest there exists a bundle of intrinsic powers that is be regarded as object-like. However, if one cannot stop to analyse these causal powers in structural terms, we are led eventually to the blob-cosmos, the partless One, or the night in which all the cows are black.

The argument is quickly presented. Suppose that the particles having mass entails that they have a power to attract other particles and therefore a power to generate a gravitational force $Grav(m_1,m_2)$, that is a causal relation between them to be regarded as the manifestation of their shared power. But the two masses taken together can be regarded as a unique bundle B_{12} (mass is additive) constituted by the relation $Grav(m_1, m_2)$, that in its turn must be related to other masses, m_3, m_4, and their bundles and so on until we end with the one, or the blob

In conclusion, I think that French's book has the merit to take OSR to its logical conclusions: the options for ontic structural realists are either an endorsement of Tegmark's Pitagoreanism or of blob-objectivism. Given this dilemma, dropping OSR seems unavoidable, at least until its main formulation can be – somewhat unfairly – summarized by the following passage: "perhaps the most intuitive plausible form of structuralism is precisely one according to which objects and their properties are metaphysically dissolved into a 'multilayered' network of relations, where certain of these relation are causally empowered and where this empowerment for want of a better word is inherent to the relations". (p. 218)

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