Metaphysics Within Science: Against Radical Naturalism

Fredrik Andersen

Jonas R. Becker Arenhart

Abstract[1]

In *Every Thing Must Go* James Ladyman and Don Ross argue for a radical version of *naturalistic metaphysics* and propose that contemporary *analytic metaphysics* is detached from science and should be discontinued. In this paper we address the issues of whether i) science and metaphysics are separable, ii) intuitions and understanding should be excluded from scientific theory, and iii) Ontic Structural Realism satisfies the criteria of the radical version of naturalism advanced by Ladyman and Ross. Our point underlying those topics is that successful scientific research presupposes metaphysics, and that basic epistemic virtues common to metaphysics and science may allow us — as opposed to what Ladyman and Ross suggest — to increase our understanding of the world and to put constraints on allowable metaphysical theories.

Key-words: analytic metaphysics; naturalistic metaphysics; Ontic structural realism; science.

Introduction

The specialization of all academic branches has led to a presumably clear distinction between disciplines even when they are investigating the same subject matter. As modern physics has moved in on traditionally philosophical topics such as the nature of time and space, the reality of causal connections, the individuality and separability of physical objects and so on, philosophers have gradually lost popular authority on these issues. Backed by great experimental success and hugely surprising results, many physicists now regard philosophy

1

and its old ways as no more than a cultural relic. The debate over the utility of philosophy in general and metaphysics in particular has also seeped into the philosophical debate and forced the question: What, if any, is the purpose of pursuing metaphysics? One view is that metaphysicians either ignore or misunderstand the physical theories of the relevant issues. Even some *soi dissant* naturalistic philosophers have been targeted as either providing worthless contributions to the enterprise of human knowledge or working on philosophical projects completely orthogonal to actual science and its search for objective truth (see for instance Callender 2011; French and Mckenzie 2012). Ladyman and Ross have contributed to polarizing this debate with their book *Every Thing Must Go*. Here they claim that "…analytic metaphysics, a professional activity engaged in by some extremely intelligent and morally serious people, fails to qualify as part of the enlightened pursuit of objective truth, and should be discontinued" (2007, p.vii).

Ladyman and Ross seem to target the entire field of analytic metaphysics:

> Chapter 1, as indicated above, is partly destructive in its aim. It is intended to persuade the reader that standard analytic metaphysics (or 'neo-scholastic' metaphysics as we call it) contributes nothing to human knowledge and, where it has any impact at all, systematically misrepresents the relative significance of what we do know on the basis of science. (Ladyman and Ross 2007, p.vii)

Their claim that the entire field of contemporary analytic metaphysics is misrepresenting our best available knowledge and contributes nothing to the search for objective truth is argued in three steps. First, they list a series of what they consider futile metaphysical theories in the contemporary analytic field. Second, they propose that such metaphysics can show no fruitful output. Finally, they invoke a tenet of popularized evolutionary psychology to explain why we are in this situation. According to Ladyman and Ross we seem to have no reasons to trust our own reason when it comes to dealing with actual science, and without mathematization and systematic, institutionally backed,[i] [ii] representation we would be at a loss. In order to construct a unified world-view on these premises they suggest that the only route toward "objective truth" is a strongly naturalistic methodology that naturally concludes with Ontic Structural Realism.

In this paper we argue that there is an important role for metaphysics in science, also within a naturalistic project. We further argue that Ontic Structural Realism, although a relevant metaphysical contender, is neither the only nor even the more naturalistically motivated metaphysical alternative. We do however agree with Ladyman and Ross that it might be time to re-think and evaluate contemporary metaphysical methodology. Although we share the naturalistic starting-point, our view differs from that of Ladyman and Ross. While we accept that scientific data must be taken into consideration in a naturalistic metaphysics, we do not think that they play the role of "raw theories"[iii]. We treat theories as including experimental and observational data, the mathematical representation of those data, and the conceptual interpretations of these mathematical representations. In effect, the metaphysical framework within which conceptual interpretations are given is an intrinsic part of any theory.

We therefore do not share the generally pessimistic outlook of Ladyman and Ross concerning metaphysics. Science and Metaphysics are enterprises through which we increase human knowledge, provided that some minimal epistemic requirements are met. We think that metaphysics is useful, not only for unifying theories after they are given by the scientist, as Ladyman and Ross imply. Science is at least in part a metaphysical enterprise presupposing metaphysical conceptualization as well as providing metaphysicians with issues for analysis.

The paper has three main parts. First, we discuss the role of metaphysics in science and consider Ladyman and Ross' proposition that metaphysics should exclusively be about unifying scientific theories. Second, we argue that Ontic Structural Realism is not a naturalistic metaphysics in the strong sense proposed by Ladyman and Ross. Finally, we offer an alternative to what a productive relation between metaphysics and science should look like by proposing some basic methodological principles.

1. The role of metaphysical intuitions in science

1.1 An attack on anti-naturalistic metaphysics

Ladyman and Ross argue that analytic metaphysics fails to qualify as a contributor in the search for objective truth based on the idea that metaphysics is neither informed nor motivated by science. This lack of naturalism takes two main forms.

The first is that metaphysicians develop their theories aiming at a *domesticated* version of science which seeks to provide understanding and explanation. What is meant by domestication here is the interpretive simplifying work done in order to render physical theories less abstract and mathematical and thereby simpler and more accessible in terms of our common notions. However, these simplified versions of scientific theories are often misleading in that they do not properly reflect the actual theories. A domesticated theory, in Ladyman and Ross' terminology, is an exposition of modern physics that draws a picture of the world as a container of objects which are composed of smaller objects that are responsible for all behaviour through some version of Humean causation. In order to apply such a *Weltanschauung* to modern physical theories a lot of simplifying work must be done and in the process relevant intricacies are ignored. Treating this simplification as the actual theory and then arguing from or against it in metaphysical contexts creates a straw theory argumentation that is ultimately as ill-informed as a complete neglect toward the initial theory. An example of domestication in analytic philosophy is the idea that quantum physics, due to its probabilistic character somehow saves free will, and an external one is the standard physics textbook claim that special relativity removed the possibility of an ether and that we are left with empty space. Considering Einstein's (2004, p.6) rejection of this might help us see the subtleties of the topic: [iv]

> More careful reflection teaches us however, that the special theory of relativity does not compel us to deny ether. We may assume the existence of an ether; only we must give up ascribing a definite state of motion to it, i.e. we must by abstraction take from it the last mechanical characteristic which Lorentz had still left it.

As adherents of a form of naturalism, we agree with Ladyman and Ross that arguments from domesticated science, in the above sense, add little to the debate.

The second aspect of non-naturalism in analytic metaphysics according to Ladyman and Ross (2007, pp.15-17), is the use of *a priori* intuitions in metaphysical investigations. As the term intuition is a philosophically charged one, it is worth noting that what Ladyman and Ross refer to as intuition is more closely connected to common sense hunches, usually based on a feeble understanding of the subject matter. This is then contrasted with the "experienced practitioner's ability to see at a glance how their abstract structure probably — in advance of essential careful checking — maps onto a problem space" (Ladyman and Ross 2007, p.15). So the criticism is directed toward the use of "common sense notions" for metaphysical treatment of scientific theories, and does not relate to trained scientific intuitions or intuitions in the Kantian sense of prerequisites for human experience. Ladyman and Ross argue that our intuitions are shaped to deal exclusively with familiar objects and not with the infinitely large or small.[v] Since theories dealing with unobservable entities in the quantum realm diverge from our intuitions, it is implied that if our metaphysical doctrines are built upon and judged in accordance with these intuitions they will be irrelevant for actual science. Science and its high level abstractions are most of the time unintuitive and do not match our everyday inferential methods, or so the argument goes.

1.2 Metaphysics strikes back

While we sympathize with the idea of analysing and reconsidering metaphysical approaches and methods, we resist the complete rejection of the role of intuition in philosophy. One problem is the paralogistic[vi] use of the term 'intuition'. Ladyman and Ross loosely define intuitions as a part of the domesticating process of finding 'common sense pictures', then argue against intuitive approaches in analytic metaphysics where 'intuitive' has a wider meaning. Considering common sense guesswork about theoretical entities we assume there is little disagreement as to their utility or lack thereof. This is not the sense of intuition most metaphysicians deal with, however; intuitions have an important role in science, as we shall argue.

Quantum entities have escaped simple modelling since the outset and the quantum postulate itself — energy transfers are quantized — runs counter to the commonsensical idea that energy 'flows'. But pre-theoretical intuitions such as the arrow of time, the principle of contradiction, the principle of identity and so on are still very much applied in all fields of scientific thinking. These intuitions are not justifiable purely through empirical facts as they presumably have more to do with the way human beings experience the world than with necessary conclusions based on physical evidence.[vii] If we reject all the above intuitions on the ground that they are instances of *a priori* metaphysics therefore, we are left with no argumentative restrictions. This ultimately means that "anything goes". If so, the boundaries between sense and non-sense are impossible to draw and we are lead to a trivialization of the debate. This does not mean that we should cling to traditionally held beliefs simply because some new notion appears surprising and difficult. We use science to correct intuitions when such correction is possible to perform without losing intelligibility. For instance, if we are to work with certain interpretations of quantum mechanics, we seem obliged to reject the idea that things have properties on their own that exist independently of interactions (French and Krause 2006; Arenhart 2013). But although there are reasons to revise key concepts in metaphysics, removing them completely and all at once leaves us with no science. A rejection of metaphysical notions such as time, space, identity, causality, properties and so on is simply not an option since at least time and space are necessary for even the minimal content (structure) proposed in Ontic Structural Realism. So rather than rejecting assumptions because they are intuitive, we should regularly correct and revise them in light of empirical data.

Ladyman and Ross (2007, p.28) argue that science is the ultimate arbiter on objective facts about the world and that there are no epistemological rivals to it. If a question has no scientific answer, we better leave it behind instead of trying to answer it with metaphysics or religion. But since scientific theories involve metaphysical assumptions that are rarely made explicit (science does not wear its metaphysics on its sleeves) how are we to judge the interpretative work? Judging from the EPR debate in quantum mechanics, for instance, it seems some metaphysics is needed to understand the nature of data, the idea of "real world" requiring explanation and the categories we employ to derive metaphysics from physics as well as physics from mathematics. If the role of the philosopher should be, as Ladyman and Ross suggest, unifying scientific theories, are we to assume that scientists are somehow naturally predisposed toward sound metaphysics; that they work with raw data, or that Science as a higher entity guarantees the soundness of current scientific thinking? Following Hanson (1958), arguably there is no raw data to be found and the everyday use of prejudices toward objects and their nature is not pure negligence toward empirical data. It is a way in which we use the presumably known to address the unknown. Instead, reflections over what empirical data are and how we arrived at them, could inform us about which assumptions can reasonably be made. This allows us to posit plausible statements (pre-judgments) about the nature of our universe, or what we can call 'intuitive' or immediate beliefs about the general features of nature; they are seen as starting points for theorizing. Johannes Kepler (1984, p.155) presents a fitting example: "For where, walking through the fields, he encounters hedges and things near to his path, he would believe, on the testimony of the sense of sight, that distant mountains are really following him".

Kepler points to the rational corrections we make when observing the world. We simply do not believe that the mountain is following us although visually it appears to do so. We immediately or intuitively reject the observation in favour of a more plausible world-view. The pre-physical nature of this is seen in the fact that we do not perform empirical tests before we reject the visual data. We do it immediately. Immediate corrections and judgments are present in all observation and is perhaps more famously explicated in Hanson (1958) as the "seeing as" and "seeing that" of observation. In Kepler's example it is a simple case of rejecting rational impossibilities, and thereby maintaining intelligibility through an immediate modification of the sense data. Intelligibility is in this case a touchstone for our knowledge of the world. In the same way, one can argue for the validity of a scientific theory on the grounds of the increased intelligibility that follows from its acceptance. Dobzhansky's (2010) argument for the utility of evolutionary theory — "Nothing in biology makes sense except in the light of evolution" — is perhaps the most famous example. Modern physics and its use of model based thinking shows how far we can go beyond direct observation through cooperative thought and experimentation. By applying constructs and intuitions such as causal laws, laws of symmetry, forces fields etc., we increase intelligibility beyond what we can directly experience. And although scientific theories are often surprising, we can usually follow the trains of thought that led us to where we are. The basic justification for these theoretical constructs is that without them we are lost. So, even though science may be the ultimate arbiter on a lot of subjects, some conceptual workings are required even for us to make sense of such arbitrage.

We recognize that intuitions, in the sense we are employing the term, are not fixed categories immune to scientific knowledge. We may correct our intuitions at a pre-theoretical as well as a theoretical level. Instead of directly applying our intuitions in quantum physics for instance, we apply constructs. The search for intuitive understanding in this case does not imply that we can always explain what is going on in everyday language terms. But even when we are compelled to employ a specialized language and correct our assumptions about the world, some basic intuitions are maintained. We also see this in Ladyman and Ross' proposal that scientific theories should be unified, since unification is a way to render as many theories as possible coherent with each other and thereby increase the intelligibility of the field. Coherence is a principle that underlies all searches for truth and knowledge. It is a pre-theoretical intuition that science, as a subset of all projects searching for truth and knowledge, should ultimately be coherent and unifiable. The same holds for the unity of truth, a principle to which Ladyman and Ross' (2007, p.27) appeal in order to justify their unification enterprise.

The Seeing as and Seeing that to which Hanson (1958, Ch. 1) refers are facts of observation that might possibly be explained through some evolutionarily developed need for prejudice towards objects with which one wishes to interact, or it might be a primitive fact that observation is also necessarily qualitative. Nonetheless there seems to be no other option than to accept that due to the theoretical bias of observation and data construction, metaphysics enters science at the outset. The question is therefore who should do the metaphysical work. Ladyman and Ross (2007, p.28) see human beings as poorly prepared by evolution to perform any such work, and we assume that they do not consider scientists a higher class of beings with natural dispositions toward healthy metaphysics. Their suggestion is that science itself "…just is our set of institutional error filters for the job of discovering the objective character of the world – that and no more but also that and no less …" The implication being that "Science" as a sociological entity provides error filters and that "the epistemic supremacy of science rests on repeated iteration of institutional error filters"

(Ladyman and Ross 2007, p.29). To us, the demarcation between sensible and nonsensical projects purely by reference to institutional factors seems unnecessarily obscure. Arguably, the metaphysical work intrinsic to science should be done by actual scientists and metaphysicians, rather than accepting the notion of "Science" as a provider of sound principles and metaphysics for its practitioners. A textbook example of such collaborative work can be found in Reichenbach, Schlick and Einstein's discussions on the nature of space and time in light of relativity theory.

2. Ontic Structural Realism as the naturalistic alternative

2.1 The rise of OSR

Ladyman and Ross advance a version of Ontic Structural Realism (OSR) as a metaphysical proposal which they argue is authorized by science. But is this actually the case or does OSR need extra-scientific arguments in order to remain a plausible candidate, for instance, as an ontology for quantum mechanics? OSR is standardly motivated by two issues: the desire to be a realist in the face of the debate between modern versions of anti-realism and traditional realism, and from the metaphysical underdetermination in quantum mechanics. We briefly sketch the first and discuss the second.

According to the realist, our best current scientific theories should be seen as approximately true, and their terms (or most of them) refer, including the ones related to unobservable entities. The standard defence of this view is based on the so-called no-miracles argument, stating roughly that it would be a miracle if our best current scientific theories could enjoy such great empirical success and still not be approximately true, with theoretical terms successfully referring. Most versions of scientific anti-realism (constructive empiricism included) are based on the agnostic claim that we need not believe in the truth of our theories or in the existence of unobservables in order to account for their success. These claims rest on analyses of realist arguments, such as inference to the best explanation, and on the so-called pessimistic meta-induction. According to the latter, roughly put, the history of science presents us with many cases of empirically successful theories whose falsity is beyond doubt now; so, why should we think that our actual mature theories are better off? Worrall (1989) proposed that the opposition between these two main currents could be overcome by adopting structural realism: our theories do not determine the nature of the entities being dealt with, but science progresses by structural accumulation through scientific revolutions.

The second main motivation for OSR comes from the desire to determine the nature of structuralism. Worrall's structuralism advanced the epistemic thesis according to which we cannot know the nature of the entities dealt with, although the entities are there somehow. In this sense *structure is all we know*. Ladyman (1998) advanced the ontological thesis that *structure is all there is*, and placed the ontological weight on relations and structures, rather than objects. According to this view the particular entities should be re-conceptualized in structural terms, playing only a secondary ontological role. This implies that objects are at best epiphenomenal, while only the structures to which the objects can be reduced have ontological priority. The main motivation for such a shift in ontology came from quantum mechanics and its relation to the metaphysics of particular objects.

The main claim by friends of OSR is that quantum mechanics does not uniquely determine its ontology; that is, one cannot judge based only on quantum mechanical grounds whether quantum entities are individuals or non-individuals (French and Krause 2006, Ch. 4). In the first days of the "new" quantum mechanics, it was thought that quantum theory gave full support to the view that its entities were not individuals. Roughly put, the lack of individuality of quantum entities was argued for on the basis that permutations of particles did not count as giving rise to a distinct state in quantum statistics. In classical statistical mechanics, on the other hand, permutations did give rise to distinct states, so something should account for the difference between the classical and the quantum case. Since it was thought that it was the identity of classical particles that accounted for their behaviour, the first suggestion to explain the dissimilarities between the quantum and the classical case was that quantum particles had "lost their identity". Later it was shown that the theory is also compatible with the view that its entities are individuals, provided that their individuality is grounded on some non-qualitative principle. In other words, indiscernibility only undermines the individuality of quantum entities as long as individuality depends fully on whether one can find some particular quality to distinguish between entities. But there are individuality principles which may account for the individuality of indiscernible items, such as bare particulars and individual essences (Moreland 1998; Adams 1979). These principles allow for qualitatively indiscernible items while still granting numerical diversity. Naturalists in general find these principles disreputable due to their purely metaphysical nature. But quantum mechanics endowed with bare particulars or individual essences is nonetheless a theory of individual objects (for the whole discussion, see French and Krause 2006, Ch. 4). Furthermore, recent discoveries of weaker versions of the Principle of the Identity of Indiscernibles employing relations to discern (weakly discerning relations, that is, symmetric and irreflexive relations) seem to allow for so-called "thin" forms of individuality that do not require such substantial metaphysical posits as substrata (see Saunders 2006; Muller 2011 for instance). This may be seen as enforcing metaphysical underdetermination, even though some see weak discernibility as pushing towards a form of OSR (more on this soon).

The existence of one scientific theory compatible with two distinct metaphysical packages is known as *metaphysical underdetermination*. What should a realist do in such a situation? Ladyman (1998, p.420) suggested that metaphysical underdetermination points to the inadequacy of object oriented realism: "It is an ersatz form of realism that recommends belief in the existence of entities that have such an ambiguous metaphysical status". That is, what is the use of being realist when one cannot determine the metaphysical nature of the entities posited by the theories? According to OSR, it is better to leave objects behind entirely and keep only the structure common to both metaphysical packages.

2.2 Is OSR a scientific metaphysics?

Although the term underdetermination is a modern one, the problem is not new. Underdetermination or observationally equivalent hypotheses has motivated anti-realism at least since the beginning of the scientific revolution. When Kepler worked on celestial systems and the orbit of Mars, he showed that the Ptolemaic, Tychonic and Copernican systems could all be reduced to one structure (Itokazu 2009). From OSR's standpoint one should initially think that the natural solution would be to keep the structure and disregard the specific theories of planetary motion. A similar argument, although in a purely instrumentalist version, was proposed by Kepler's contemporary, Ursus (Jardine 1984, pp.41-57). However, when Kepler approached the problem from a classical realist position and sought to unify celestial and terrestrial laws, he found that the common structure was lacking in simplicity as well as explanatory and predictive power compared to elliptic orbits. Kepler's argument was made on optical, astronomical, geometrical and physical grounds. In this case the geometrical underdetermination of physical and metaphysical theory was resolved through strong realism as Kepler refused to accept a view in which the earth was moving and not moving (Jardine 1984, p.144).

The problem of underdetermination arises as an effect of the multitude of available options involved in scientific, mathematical, and metaphysical thinking. An example might help to clarify: if one investigates particle trajectories, the standard data is a set of various positions. Imagine a data set looking like fig. 1, where the particle starts out at the left and ends up somewhere to the right.

Fig. 1

The mathematical formulation that we choose to represent the relation between the points is a constructed model that does not directly follow from the data. In other words, formalisms are underdetermined by data. Simply put; we can represent the data in more than one way:

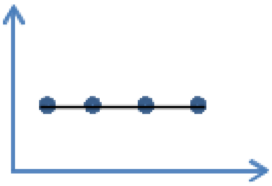

Fig. a

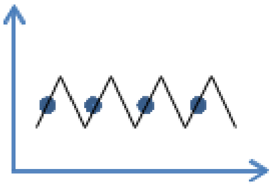

Fig. b

Since we have multiple ways in which to relate the data, the choice we make regarding formalisms in cases like this is not a choice based purely on empirical evidence. It contains intuitions about what the data represent and how they are most reasonably modelled. In the case at hand, therefore, there is physics seeping into the mathematics as soon as we choose formalism. This implies that the certainties of mathematical proof — as is often used to promote the mathematization of the natural sciences — is somewhat less absolute when mathematics is used to describe real events.

> As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality. Einstein (2007)

Einstein's point is that the choices we make between formalisms are physically and metaphysically loaded and thereby justified with a less than mathematical certainty. So it seems as if all data underdetermine formalisms, all formalisms underdetermine scientific theory and all scientific theory underdetermines metaphysics. Again this implies that if we are to fully avoid underdetermination, we are left with no more than uninterpreted data.

We have two main objections, both related to the strong naturalistic claim that science admits no epistemic rivals, one of the central tenets of the naturalism defended by Ladyman and Ross (Ladyman and Ross 2007, p.28). On Ladyman and Ross' view this implies that metaphysicians, as unifiers of scientific theories, should derive their theories from fundamental physics. Two issues emerge against the claim that OSR derives its plausibility from actual physics. The first one concerns the need to overcome metaphysical underdetermination in this particular situation. If quantum mechanics does not answer the question concerning the metaphysical nature of quantum entities, why should we bother? That is, provided that quantum mechanics does not solve the problem, shouldn't the naturalist embrace some form of quietism in ontology? If one refuses to adopt quietism there should be something within science allowing us to decide. Since there does not seem to be a clear scientific answer to the problem of individuality in quantum mechanics, the suggestion that we should shift to an ontology of structures seems to be an instance of *a priori* metaphysics. A strong naturalist, maintaining that science allows no epistemic boundaries or rivals should remain neutral. Otherwise non-scientific matters are deciding the issue in favour of structures. In this sense, OSR cannot be the view recommended by a strong naturalist position.

The question we wish to ask is; why should we shift to an ontology of structures when facing metaphysical underdetermination? There is an apparent conflict between Ladyman and Ross' approach to metaphysics, and the central tenet of their strong naturalism, according to which science has no epistemic rivals. Since science does not determine whether its entities are individuals or non-individuals, why tackle the issue from an ontic structural point of view? Isn't the problem of individuals versus non-individuals just an instance of neo-medieval metaphysics that the true naturalist should keep away from? It seems to us that, by judging from the requirements of Ladyman and Ross's naturalism, the problem OSR was designed to solve is a non-issue.

The second issue comes from underdetermination itself, one of the springboards to OSR. For real metaphysical underdetermination, we need to see that quantum mechanics is compatible with at least two types of ontologies: one of individuals and one of non-individuals. It is also required that both ontologies are legitimate candidates for quantum mechanics, having all the credentials of a potentially true ontology of the theory. However, all the proposed principles for saving individuality in the quantum realm are mysterious. A naturalistically minded metaphysician, in the strong sense, should not accept that the individuality of quantum objects is a real option. Hence, the problem of underdetermination is a purely speculative matter; it requires adoption of neo-medieval metaphysics to get off the ground. And with the option of individuality of quantum objects taken off the table, one is motivated to maintain the ontology of non-individuals for quantum objects (see Arenhart 2013).

Against this claim, however, one could recall that Saunders' (2006) weak discernibility not only saves a version of the PII in quantum mechanics but also provides a "proof" that quantum entities are individuals. However, if that were really the case, then, once again, there would be no metaphysical underdetermination. Quantum entities are individuals, period (this view has some difficulties that we shall not discuss here, see Arenhart (2013)). Then, again, the motivation for adopting OSR is gone. To escape this, one could consider Muller's (2011) claim that weakly discerning relations do not lead us only to discernible objects, but also to OSR: since it is relations that do the discerning, by employing this kind of discernibility we are committed with a metaphysics of relations. However, even if this were the case, one still has to provide reasons not to see this as a distinct metaphysical position and not a simple re-statement of the above claim that quantum mechanics deals with individual objects. That is, the adoption of weakly discerning relations to escape metaphysical underdetermination leads us directly to another form of metaphysical underdetermination: Does weak discernibility amount to a metaphysics of relations only (a radical version of OSR eliminating objects) or to a metaphysics of relations *and* individual objects? The choice among these does not seem to be based on quantum mechanical “facts”, but rather on metaphysical theory.

Since the epistemic problem is solvable only by the acceptance or refutation of a set of metaphysical principles, the undisputable epistemic primacy of science seems too strong a demand. Science cannot answer every metaphysical concern. Throughout the history of science metaphysics has been an intrinsic part of solving problems either as explicit parts of the theories themselves, as in the case of Kepler, or as justification for the superiority of one theory over the other, as in the case of special relativity[viii] and the formulation and defence of Bohmian quantum mechanics (where basic principles are guiding the search for a “metaphysically natural” (i.e. causal) version of quantum mechanics). Why then assume that a metaphysics free science can decide which questions are open for philosophical discussion and which are not? Such a decision can only be made on methodological, epistemological and ontological grounds.

3. Metaphysics in science

> When we say that we have succeeded in understanding a group of natural processes, we invariably mean that a constructive theory has been found which covers the processes in question. Einstein (1919)

The constructive theories that Einstein (1919) describes as the “most important class of theories” are the ones providing some understanding and explanation of the world. Ladyman and Ross here propose that providing understanding is, most of the time, a case of theory domestication that is contrary to science (Ladyman and Ross 2007, pp.1-7). On

Einstein's view a theory should explain some phenomenon. We propose that where multiple theories are presented, the theory that either explains a single phenomenon more thoroughly or explains more phenomena should be deemed superior. This means that theories with little explanatory power should be replaced when a theory with greater explanatory power emerges. Accepting explanation or intelligibility as an intrinsic part of science helps us toward common epistemic virtues for scientific and metaphysical theories.

The acceptance of an epistemic virtue common to science and metaphysics runs counter to Ladyman and Ross' general outlook as they seem to think that metaphysics and science are two fully separable and indeed separated fields where one should dictate the other. But if metaphysics and science are strictly separate fields, it seems that they should contain no common subject matter and will therefore be unable to inform, much less dictate, each other. However, that science and metaphysics are both attempting to understand key issues such as causation, time, space, and individuation, suggests that they are co-dependent fields that should trade information. In order for that exchange of information to be as smooth as possible, we need a common starting ground. Our suggestion is that we look at the basic goal first, and build from there.

The basic common goal of scientific and philosophical research is to understand the world. In a naïve sense we can say that knowledge involves relating facts in a way that leaves us with a sense of understanding. This sense of understanding is recognizable in the negative, meaning that knowledge involves a lack of disharmony where contradiction, argumentative gaps and unjustified assumptions are typical markers. Common for these markers is that they are avoidable through coherent argumentation. We therefore propose coherence as a basic epistemic virtue common to science and metaphysics. Nevertheless, we see that a strict coherence cannot be expected at any given time. Scientific and metaphysical theories are constantly under development and if we apply coherence as a strict criterion we might end up with chronic conservatism. Any novel idea will conflict with some established theory and would then be rejected solely on that ground. Instead we must allow some argumentative gaps and *apparent* contradictions in the theoretical body, provided they don't trivialize the theory.

A trivial theory is a theory that allows "everything" to follow from it (in more technical terminology: it has a trivial consequence relation, every sentence in the language of the theory is a logical consequence of the theory). However, apparently contradictory non-trivial theories appear both in science and in metaphysics. Consider, for instance, Bohr's model of the atom and the Newton-Leibniz version of the infinitesimal calculus in the case of science, as well as dialetheism for the case of metaphysics. Allowing a place for contradictions would be profitable as long as the theory provides an increase of intelligibility. In cases such as dialetheism which holds, to put it very roughly, that there are sentences 'A' such that both 'A' and its negation are true, some allowance for contradiction is required (see Priest and Berto 2013). The enlarged sense of coherence in dialetheism is based on a paraconsistent logic such that even though the underlying logic of most discussions in metaphysics and science is not really made explicit, we could take them to be paraconsistent in some cases. Coherence should then be taken as a basic principle and incoherent theories should be seen as temporary steps towards a more comprehensive theory free from contradiction. This means that where contradictions, gaps etc. are included, they must be justified by the increase of intelligibility gained from the theory. It also suggests that it is problematic if a theory sequesters a set of phenomena and thereby blocks future connections.

The principle of coherence also seems to play a role in Ladyman and Ross' demand that theories should be unified. Theory unification involves the external relations between theories and whether we can construct a "theory of everything" where each field of knowledge contributes to the total world view. Direct external coherence between theories, which is Ladyman and Ross' concern, is often difficult to produce since the theories we have to deal with are still under construction. But one can demand some basic coherence between theories in the sense that any acceptable theory must display certain characteristics as well as not blocking all possible future connection. The natural place to start seems to be that all theories must be internally coherent. We call this a Minimal Coherence Criterion (MCC).

- Minimal Coherence

In order to ensure that our theories make sense and that loose speculation is excluded, it must be possible to present the internal structure of the theory as a non-trivial whole. The first step toward this is to make sure the theory can be presented as one argument which includes an account of the data production process. This means that a coherent exposition of the theory including all assumptions taken from other theories must be possible. In the case of molecular biology for instance, one must accept the assumptions made about how microscopes work if one is to argue from data produced by using microscopes. Although it would be too strong a demand that every single biology paper should include optical theories, we should reasonably assume that the standard theory is accepted if nothing else is stated explicitly. The first point of coherence is then that when one is using apparatus that takes its justification from other fields, one is also assuming the field's theoretical framework. Kepler applied a similar kind of a coherence criterion in the field of astronomy and we take it that it can be generalized as a basic principle

> We thereby designate a certain totality of the views of some notable practitioner, from which totality he demonstrates the entire basis of the heavenly motions. All the premises, both physical and geometrical, that are adopted in the entire work undertaken by that astronomer, are included in that totality. Kepler (1984, p.139)

Building on Kepler, we take theories as argumentative wholes where the mathematical and logical apparatus are intrinsic parts of the broader theoretical framework. Therefore the flexibility of the coherence criterion presented above is important, since allowing contradictions and classical logic would entail a trivial theory.[ix] So the underlying logic infiltrates even the most abstract aspects of theory and carries with it some general assumptions. When performing revisionary metaphysics the acceptance of a particular logic is no trivial matter.

Classical logic seems to be the underlying logic of most current science. Since classical logic relies on a division between objects on the one hand and properties and relations on the other, it seems that a structural ontology would have to revise this aspect[x]. Otherwise Ontic Structural Realism violates the minimal coherence criterion by assigning truth value to a system that results from inferences made from a false system. However, advocating a change of logics means arguing against scientific standards from a non-scientific basis, which violates the strong naturalism Ladyman and Ross proposes. We see no plausible co-existence of Ontic Structural Realism and strong naturalism on this issue.

Accepting that science is not complete, we also accept that coherence cannot always be provided. So, in the case of quantum mechanical description of entities versus macro physical description of the measuring apparatus, we accept that a generally recognized coherent description is not available. This is the challenge of quantum mechanics. But instead of rejecting one or the other version, we must display some constraint when using quantum physics to make general metaphysical claims. The constraint proposed here is motivated by the minimal coherence criterion. If the general claim from an interpretation of the data makes the data production process impossible, we should reconsider. Consider the measurement problem in quantum mechanics.

The rough idea is that if quantum mechanical description of reality is to be universally applicable, it should include the description of the apparatus used to measure quantum systems. That is, there is no principled reason to avoid using quantum mechanics to describe the apparatus. However, the mathematical description of the initial state of (system at t0 +

apparatus at t0), when allowed to evolve according to the dynamics of quantum theory (i.e. the Schrödinger equation), does not lead to a definite measuring result at the time the measurement happens, but rather to a superposition of the allowed results and corresponding states of the system (see Albert 1992). Put simply, applying a quantum mechanical description of the measuring apparatus gives no definite outcome (Zinkernagel 2011, pp.218-219). In order to satisfy the minimal coherence criterion, we must somehow solve this problem. A number of suggestions have been made, the most common one being the introduction of an extra dynamical principle in the theory: the collapse postulate. When a measurement is made superposition breaks, according to the collapse postulate, and the state of (system + apparatus) collapses into a definite state. The main criticism to this solution is that it leaves the mystery untouched: when and why does the collapse occur? There are plenty of attempts to reconcile the quantum and classical realms. Some appeal to the existence of an extra-physical reality responsible for the collapse (Wiegner's friend, for instance), others to a plurality of worlds (the many worlds interpretation) and others still to some mathematical modification on the dynamics which accounts for the collapse (GRW approach). We shall briefly present two of these views in the following. There are others available, but these are representative of the kind of approaches advanced. What is common to them is the search to reconcile quantum description and macro description of reality. The following discussion is in no way complete, but it points to the central role of coherence and other more metaphysically loaded principles.

The rough idea of Wiegner's friend approach is that collapse only occurs when a conscious mind checks the result of a measurement. For that explanation to work, the mind in question must not be understood as a physical system, or the problem of its own physical description by quantum mechanics would reappear. The first objection to this approach concerns the lack of explanatory power: the role played by the mind in the collapse is not clear and neither is the precise time at which the collapse happens. Furthermore, the account seems to introduce an unacceptable form of dualism between physical systems and non-physical minds. This dualism sins not only against metaphysical parsimony, but also against coherence in the following sense: the idea of a supra-physical entity related to the physical engenders some difficulties on their precise connection, on the explanatory role of consciousness and on the very idea of a unified science.

Roughly the same argument is used against the many-worlds interpretation. In this case, whenever a superposition obtains, a measurement does not "actualize" one of the terms while destroying the others: every possible outcome gets actual in a distinct possible world. The actual world branches to take into account all of the possibilities. There are many intricacies involving the correct way to understand the original proposal, but we shall follow common wisdom on the many-worlds interpretation. This multiplication of worlds seems to provide an answer to the problem at much too high a cost. Parsimony is infringed, and since there are other options on the table most people prefer to look at more economic alternatives, even though there is no purely scientific objection.

Whether or not these are conclusive objections, they show how principled considerations come into play when trying to establish a proper understanding of data in physics. Their relationship is not, as the hard-nosed naturalist would have it, a one-way street; it is a relation of mutual influence where deep metaphysical ideas are not simply derived from science, but guide its proper interpretation and development.

- No gorilla brains!

At times science provides us with theories that are counterintuitive in some or all meanings of the word. In these cases we ask for explanations. What is meant by explanation in this sense is often a connection between the new theory and theories that we are already familiar with. In cases where no explanation is provided we must choose between accepting the new theory as a brute fact, or try to reinterpret the data in such a way that explanation is possible. One way to argue for the acceptance of unexplained theories is by reference to our common inability to understand the world. We have named this the "gorilla brain argument". Ladyman and Ross (2007, p.2) argue this point clearly: "…there is no reason to imagine that our habitual intuitions and referential responses are well designed for science or for metaphysics". Motivated by evolutionary psychology they argue that when a theory is shown to produce correct predictions but cannot be properly explained, we should accept that science simply went beyond human understanding.

If a theory is to be considered properly physical, as opposed to purely mathematical or logical, it must do more than just "save the phenomena". If all the theory has to offer is a mathematical formulation that gives correct predictions, why not just accept the formula and remain agnostic as to what it implies? Why should we introduce an interpretation of the data that none of us are able to understand? It seems to us that the introduction of an interpretation, whose only explanatory value is defining people as carriers of poorly working brains, is one we can do without. Ladyman and Ross apparently recognize this and propose that we reduce scientific knowledge to a set of formulas with successful predictions. These formulas will then be the structures of ontic structural realism.

Rather than following this route, we propose that there are more possible reinterpretations of quantum physics and that we should apply agnosticism as a temporary position. If we were to follow Ladyman and Ross in the abolition of relata, we would have to apply the minimal coherence criterion and ask by what procedure the data motivating the formulas were produced. In addition we would ask how the success of predictions can be evaluated if the objects involved in the measurements have an epiphenomenal status. So where general relativity describes the structure of space-time as a function of mass distribution, what happens to this structure if the massive objects are nothing but mathematical structures? A possible response from Ladyman and Ross could be that the structures give the mass rather than the other way around, but this still leaves us with no answer as to how mathematical structures are related to qualitative notions such as mass. If the structures under question are of some non-mathematical quality though, they are subject to all the problems OSR intends to resolve.[xi]

Sometimes we may even offer an explanation of why some results are unintuitive and difficult to grasp. This would provide some means for our common or habitual notions to be "corrected" along the way, in some sense allowing for a kind of reflexive equilibrium between common notions and abstract scientific knowledge. Research concerning human psychology may enlighten our most basic cognitive tendencies, like the ones to consider Newtonian space as the right one, our praise for Euclidean geometry and our difficulties to deal with probabilities (see Shieber 2012). Knowing that, however, does not prevent us from making corrections and adjustments to our "world-view", as it is enlarged from time to time by our most successful theories.

We have mainly dealt with coherence as the absence of contradictions. But coherence of argument also implies that the assumptions made and the conclusions drawn are not taken from thin air. Ad-hoc hypotheses, inserted in order to save the phenomena carry less epistemological weight than hypotheses that follow from the main argument, or from the basic assumptions made. However, Explanatory Power trumps concerns of Economy and Simplicity. By this we mean that principles of economy and simplicity should not, as a general rule, be applied at the cost of explanatory power.

Concluding remarks

The main aim of this paper has been to challenge the extreme naturalist view as proposed by Ladyman and Ross in "Everything must go" (2007). Although our own position allows for, and indeed demands metaphysics within the sciences, it takes little away from the general structural realist view. What we wanted to show is that even though one tries hard to exclude metaphysics from science and motivate all solutions from empirical evidence, metaphysics still forces its way to the fore. We have argued that one of the most deplorable features of analytic metaphysics, according to Ladyman and Ross, *viz.* the appeal to intuitions, is indeed required for us to make sense of the scientific enterprise. We do not regard intuition as a monolithic institution given from above, but use of its tools is essential even if we are to revise our intuitions by employing the achievements of natural science.

In the case of Ontic Structural Realism we saw that this position does not find any purely scientific motivation, but is motivated by and argued for on the basis of at least some *a priori* metaphysics. On our view the plausibility of Ontic Structural Realism as 'The Scientific Metaphysics' should not be decided on the grounds of whether or not it is purely scientifically motivated. We proposed that the inference from Metaphysical Underdetermination in quantum mechanics to OSR is not well-motivated; indeed, this inference is not compatible with the strong form of naturalism advanced by Ladyman and Ross: if science alone is to decide the legitimate questions of metaphysics, then, in cases of metaphysical underdetermination we should all be quietists. On the other hand, if some metaphysics is to be allowed to begin with, then there is no compelling reason for it to be a *structuralist* metaphysics.

Furthermore, if one accepts — as we have advanced — a basic criterion of coherence it seems that cases like the space-time structure of General Relativity and the general structure construction in relating singular data, demands a minimal realism toward the objects that either motivates or makes up the structure if realism toward the structure itself is to be justified. Some things must stay (!). Whether these assumed objects are best described as traditional particles, point particles, wave packets, energy wells, fields, or some further suggestion, remains to be seen. In the meantime we suggest to keep looking at all ends of the

Spectrum of human knowledge. Modern science is, after all, full of solutions to historically "unsolvable" problems.

Mailing Address

Fredrik Andersen:

Causation in Science, School of Economics and business

Norwegian University of Life Sciences (NMBU)

Postboks 5003, 1432 Aas, Norway

Contact: fredrik.andersen@nmbu.no

Jonas R. Becker Arenhart:

Department of Philosophy

Federal University of Santa Catarina (UFSC)

Florianópolis, Santa Catarina, Brazil

CEP: 88040-900

Contact: jonas.becker2@gmail.com

References

Adams, Robert. 1979. Primitive Thisness and Primitive Identity. *Journal of Philosophy* 76: 5-26.

Albert, David Z. 1992. *Quantum mechanics and experience*. Cambridge: Harvard Un. Press.

Arenhart, Jonas. R. Becker. 2013. Wither away individuals. *Synthese* 190: 3475-3494.

Bain, Jonathan. 2013. Category-theoretic structure and radical ontic structural realism. *Synthese* 190: 1621–1635.

Callender, Craig. 2011. Philosophy of Science and Metaphysics. In *The Continuum Companion to the Philosophy of Science*, Steven French and Juha Saatsi (eds.), pp.33-54. London: Continuum.

Dobzhansky, Theodozius. 2010. Nothing in Biology Makes Sense Except in the Light of Evolution. *National Association of Biology Teachers*.

Einstein, A. 1919. What is the Theory of Relativity? *London Times*.

Einstein, A., *Geometry and experience*. JOC/EFR April 2007.

URL= http://www-history.mcs.st-andrews.ac.uk/Extras/Einstein_geometry.html

Einstein, A. 2004. Ether and Relativity. In *Sidelights on relativity*, Albert Einstein. Kessinger Publishing, Jun 1.

French, Steven, and Décio Krause. 2006. *Identity in Physics. A historical, philosophical and formal analysis*. Oxford: Oxford University Press.

French, Steven and Kerry Mckenzie. 2012. Thinking outside the (tool)box: towards a more productive engagement between metaphysics and philosophy of physics. *European Journal of Analytic Philosophy* 8(2): 42-59.

Hanson, Norwood R. 1958. *Patterns of discovery*. Cambridge: Cambridge University Press.

Itokazu, Anastasia Guidi. 2009. On the Equivalence of Hypotheses in Part 1 of Johannes Kepler's New Astronomy. *Journal for the History of Astronomy* Vol. 40, No. 2: 173-190.

Jardine, Nicholas. 1984. *The birth of history and philosophy of science*. Cambridge: Cambridge University Press.

Kepler, Johannes. 1984. Apologia pro Tychone contra Ursum. In *The birth of history and philosophy of science*, Nicholas Jardine. Cambridge: Cambridge University Press.

Ladyman, James. 1998. What is structural realism? *Studies in History and Philosophy of Science* 29(3): 409-424.

Ladyman, James, and Don Ross. 2007. *Everything Must Go: Metaphysics Naturalized.* Oxford: Oxford Un. Press.

Lam, Vincent, and Christian Wüthrich. 2015. No categorical support for radical ontic structural realism. *The British Journal for the Philosophy of Science*, 66(3): 605-634.

Moreland, James P. 1998. Theories of Individuation: A Reconsideration of Bare Particulars. *Pacific Philosophical Quarterly* 79: 51-63.

Muller, F. A. 2011. Withering away, weakly. *Synthese* 180(2): 223-233.

Norton, John D. 2012. *What can we Learn about the Ontology of Space and Time from the Theory of Relativity*. [Preprint] URL: http://philsci-archive.pitt.edu/id/eprint/9113 (accessed 2013-06-21).

Priest, Graham and Francesco Berto. 2013. Dialetheism. In *The Stanford Encyclopedia of Philosophy (Spring 2013 Edition)*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2013/entries/dialetheism/>.

Reichenbach, Hans. 1948. *The Philosophy of Space and Time*. Translated by M. Reichenbach & J. Freund. Dover publications.

Saunders, Simon. 2006. Are Quantum Particles Objects? *Analysis* 66: 52-63.

Shieber, J. 2012. A partial defense of intuitions on naturalist grounds. *Synthese* 187(2): 321-341.

Worrall, John. 1989. Structural Realism: the best of both worlds? *Dialectica* 43(1-2): 99-124.

Zinkernagel, Henrik. 2011. Some Trends in the Philosophy of Physics. *Theoria* 26(2): 215-241.

---

[i] "We demarcate good science – around lines which are inevitably fuzzy near the boundary – by reference to institutional factors, not to directly epistemological ones" (p.33).

[ii] "Science is, according to us, demarcated from non-science solely by institutional norms..." (p.28)

[iii] There seems to be a clear demand from Ladyman and Ross' version of naturalism that the sphere of "data" on which unifying naturalist metaphysicians are to build their 'world-view' is limited to the scientists interpretations of experimental data, and does not include the experimental data themselves.

[iv] Another contemporary example concerns the denial of the existence of macro objects (the latter is Ladyman and Ross' (2007, p.5) example).

[v] "Hence, there is no reason to imagine that our habitual intuitions and inferential responses are well designed for science or for metaphysics." (Ladyman and Ross 2007, p.2)

[vi] The term 'intuition' is used in a multitude of ways in the metaphysics literature, but in a singular and specific way in Ladyman and Ross' argument. In the latter it means 'common sense notions and world-views'.

[vii] See for instance the relational nature of space and time in relativity theory and its relation to the Machian metaphysical claim that "…the real lies in relations between events; spacetime is an abstraction from them" (Norton 2012)

[viii] In the case of special relativity the nature of time and space (traditionally metaphysical issues) is decided on the basis of methodological principles, not on empirical strength or explanatory value. Reichenbach (1948, pp.201-202) comments on this: "we can speak of an explanation by Einstein's theory as little as we can speak of an explanation by Lorentz's theory". The superiority of Einstein's theory is based on "... the recognition of the epistemological legitimacy of his procedure" (Reichenbach, pp.201-202).

[ix] As would maintaining the principle of contradiction and denying the demand for coherence (A→(AVB)), A&¬A,: B (trivially follows).

[x] Bain (2013) attempts such a revision in the mathematical realm. And even if Lam and Wüthrich's (2015) claim that Bain is unsuccessful should prove unjustified, the rewriting itself will be a breach of the naturalistic principles set up by Ladyman and Ross.

[xi] Thanks to Stephen Mumford and Mark Bickhart for brief discussions on this topic.