Varieties of scientific realism: new work for principles, laws, and computation

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When should one believe in entities, processes, properties, etc., postulated by a theory? Why should we believe that theoretical posits (hypotheses, principles, laws of nature, causal connections, etc.) of our theories are true?

The interest for scientific realism (Stathis Psillos' selective realism and forms of structural realism, see Ladyman and French), and reactions from antirealism side (K. Stanford, and Van Fraassen) have been on the rise in the last two decades.

The mainstream scientific realism employs empirical success of theories as a measure of realism commitments such as the existence of entities of a theory, and to its hypotheses being approximately true. But what else can help the realist pick the theoretical posits to commit to, when empirical success is not manifest yet and theories are not mature? We discuss here two possible versions of realism: one in which principles and laws of nature play explanatory roles and the other in which the mathematical formalism has a computational power. The first case is a version of the inference to the best explanation used in scientific realism literature (Lipton, Doppelt). The second is rarely discussed in the literature, but it has been suggested elsewhere (Humphreys, Thagard)

Selective realism extracts those parts of the theories (more interestingly, the unobservable posits of a theory) which can explain their empirical success, especially their novel empirical predictions. But even novel empirical does *always* not entail realism: history of science teaches us of multiple cases in which this justification is now warranted (Vickers, Saatsi, Lyons). The general view is that the relation between realism and success is weaker than the realist would have it.

In its broadest aim, this presentation expands scientific realism in other directions than novel, empirical success. First, we are interested in appraising realist commitments of theories (and models) for which an immediate empirical adequacy is not available. Second, we discuss prospective realism, when models and theories are not fully matured and when the hindsight view is not available. Prospective realism nevertheless can interpret a current theory (or model) and predict which entities will be retained in its future iterations.

(i) Principles, laws, inter-field explanation, and realism. Principles and laws of nature are taken here as explanatory tools. The realist may want to know how principles belonging to one scientific domain interact with principles and laws belonging to other domains in the process of scientific inquiry. Some principles can clash, some principles explain laws of another domain, or constrain them, or are inconsistent with laws or principles in other domains. There is nevertheless another set of cases when principles act as enablers of other laws or facilitate hybrid approaches and unification of domains. We explore the inter-field explanatory power of principles. These inter-field relationships among principles and laws are important for the realists: as principles act as enablers of laws in other areas, the realist can commit more firmly to its theoretical posits.

We adopt a version of M. Lange's approach to symmetry principles *qua* meta-laws. (2007, 2009, 2011) In Lange, symmetry principles 'guide' conservation laws in a similar way in which laws determine sub-nomic facts. The emphasis is here less on the internal links between principles and laws of the same domain, but on how principles of a domain relate 'externally' to laws and principles of other domains. A clash of principles between well established theories (which the realist is committed to) and the new, non-mature theory can reduce the commitment of the realist, even if empirical success is not available.

Possible inter-field roles of principles discussed here include: clashes of principles, principles constraining laws of other domains, or, on the contrary, principles enabling the hybridization or even the unification of laws belonging to different domains. Several examples from contemporary physics are briefly discussed: the case of the correspondence principles, the clash of principles of quantum physics and relativity, and the case of coupling constants in contemporary physics. The argument here is that the realist can update her commitments to theoretical posits in one theory based on the inter-field relation among principles.

(ii) Integrability, mathematical explanation, and 'inference to the best computation'. The second version of realism briefly mentioned here is the case in which a theory or model is used to compute theoretical posits of another theory. The realist has reasons to increase her commitments to the posits of the theory that calculates rather than the theory that 'is calculated.' We discuss integrability as a case of computational success and a case of mathematical explanation. We argue that this is not a case of standard mathematical explanation (Baker, Pincock, Bangu). We discuss briefly cases from the particle physics and quantum gravity. A theory that help scientists compute the constants or coupling factors of another theory is considered here "computationally successful."

The presentation ends with some potential historical cases to back up both (i) and (ii). We also discussed major counterexamples to (i) and (ii) versions of realism. One possible rebuttal to (ii) based on 'alternative computations' is mentioned and assessed.