Effective Theories and Infinite Idealizations: A Challenge for Scientific Realism

Effective field theories (EFTs) have received increased attention since the 1970s. Many physicists now believe that the Standard Model of particle physics and general relativity should be understood and formulated as EFTs. And the extension of EFT techniques to many other areas in physics, including non-field theories, suggests that it actually makes sense to speak more generally of "effective theories". The problem, however, is that it is not entirely clear how to characterize and interpret effective theories in this general sense. The effective approaches to string theory, many-body physics, classical gravitation and fluid dynamics—to name only a few—have little in common at first sight. And philosophers are of limited help here, as they have essentially focused on the restricted sense of EFT in high energy physics (e.g., Cao and Schweber, 1993; Huggett and Weingard, 1995; Hartmann, 2001; Castellani, 2002; Bain, 2013; Williams, 2017).

This problem is crucial for two reasons. Hartmann (2001) rightly argues, I believe, that effective field theories do not reduce to either phenomenological models or proviso-free theories, which suggests that effective theories give us a new framework for philosophical analysis. More crucially, effective theories also appear to offer the best of both worlds. They are universal enough to cover wide ranges of phenomena without running afoul of the highly unrealistic and often mutually incompatible assumptions of phenomenological models. And they are contextualized enough not to outrun their domain of empirical validity in contrast to proviso-free theories. In a word, effective theories appear to offer the best balance of a coherent, trustworthy, efficient, economical and empirically exhaustive set of physical descriptions of the world. Moreover, this suggestion doesn't hinge on any strong metaphysical claim about the existence of a true, final and complete theory in physics. All we need is that it is unlikely that there will ever be enough evidence that we have successfully formulated a final theory even if there is such a theory and that we have actually succeeded in formulating it. That is, all we need is the epistemic claim that all the theories we will ever have good reasons to trust are effective theories and so we might perfectly remain agnostic about the existence of a final theory. I shall call this working assumption the effective approach to theories.

The aim of this talk is to examine one key implication of this working assumption for the representational practice in physics. First, after presenting a simple toy-model of effective Newtonian gravity, I argue that effective theories are best characterized as theories with empirical restrictions directly built into their structure, i.e., as the sort of theories that wear their fallibility on their sleeves. Second, I present what I take to be the prevailing interpretation of effective theories by looking at common claims made in the literature on EFTs: essentially, philosophers take effective theories to offer accurate and stable representations of a limited region of the world beyond which new physics is to be expected. Third, I argue that the effective approach provides principled reasons for understanding infinite representations in physics as infinite idealizations where, by infinite representation, I mean any type of syntactic construct or model that explicitly refers to or stands for a physically infinite system. In a sense, this last claim directly follows from the intrinsic limitations of effective theories. But it needs to be carefully unpacked. I argue more specifically that the effective approach entails that infinite representations are not just false, to speak crudely, but that they are not even approximately true. The key idea here is that infinite representations systematically and significantly distort their target system on typical standards of accuracy compared to the most closely related class of finite representations of the same target system. I shall explain how the argument goes for the standards of accuracy underlying the model-theoretic (e.g., Da Costa and French, 2003) and the similarity account (e.g., Weisberg, 2013) of scientific representation.

If time allows, I will conclude with two further implications. First, the distinction often drawn in the literature between faithful or less patent infinite idealizations and unfaithful or more patent ones has no objective basis under the effective approach (see Ruetsche, 2011). Second, and more importantly, the effective approach entails that, for any theory and core theoretical terms within that theory, we cannot reliably commit to the existence of the corresponding physical objects if the characterization of their intrinsic properties extends well beyond the domain of empirical validity of the theory. As one should expect, this is especially problematic if we are to take physical fields to be real things for instance.

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