How Theoretical Physics Makes Progress

Moti Mizrahi

Florida Institute of Technology

Nicholas Maxwell, *Understanding Scientific Progress: Aim-Oriented Empiricism*, St. Paul, MN: Paragon House, 2017, 232pp, $24.95.

In this ambitious book, Maxwell sets out "to solve eight fundamental philosophical problems about scientific progress" (ix), which he characterizes as follows in chapter 1:

1. "A weaker version of Hume's problem [of induction]: When theories are accepted in science on the basis of empirical success, what are (or what ought to be) the precise methods employed to determine this acceptance, and what is the rationale for holding that theories so accepted constitute genuine contributions to scientific knowledge?" (6)
2. The "problem of the underdetermination of theory by evidence [...]: How can there be scientific progress, at the level of theory at least, if available empirical data must always be predicted equally successfully by infinitely many different theories?" (2)
3. The "problem of verisimilitude [...]: If we could make sense of the idea that, given two false theories, one may nevertheless be closer to the truth than the other, then we could at least in turn make sense of the idea that physics makes progress in advancing from one false theory to another" (3).
4. The "problem of what it can mean to say of a theory that it is simple, unified or explanatory, when any theory can be formulated in a variety of ways, some simple or unified, others horrendously complex" (3).
5. The "problem of justifying, or providing a rationale for, this appeal to theory simplicity or unity" (3).
6. The problem of articulating "a definite, acceptable conception of scientific method" (4).
7. The problem of finding reasons "for holding that this conception of scientific method gives us, when put into scientific practice, our best hope of making scientific progress" (4).
8. The problem of finding "a method for the discovery of new theories in science" (7).

In chapter 2, Maxwell discusses the importance of problems 1-8. In chapter 3, he explains why previous attempts to solve problems 1-8 have failed. The fault lies with "Standard Empiricism (SE)," the view that "evidence alone decides what theories are accepted and rejected. [...] considerations of simplicity, unity, or explanatory power may legitimately influence choice of theory as well, but not in such a way that nature herself, or the phenomena, are presupposed to be simple, unified, or comprehensible" (16). According to Maxwell, "most philosophers of science have adopted some version of [SE]" (17). This assertion is not supported by data from the PhilPapers Survey, which show that most philosophers (75%) and most philosophers of science (60%) are scientific realists (Chalmers and Bourget 2014). For realists, theoretical virtues, such as simplicity and unity, are truth-conducive. Unlike constructive empiricists, who reject Inference to the Best Explanation (IBE) as a legitimate form of inference (van Fraassen 1989,

Ch. 6), realists embrace IBE. Both simplicity and unity count as criteria for selecting the best explanation from competing hypotheses (Mizrahi 2012).

In chapter 4, Maxwell sets the stage for his solution to problems 1-8. In addition to being empirically successful, theories must be "sufficiently simple, unified or explanatory" (20). In chapter 5, Maxwell explains what it means for a theory to be unified (problem 4). The upshot of his formal account of theoretical unity is that a fundamental physical theory "must constitute a sufficiently good step towards the ultimate goal of theoretical physics of discovering the true, unified theory of everything" (56).

In chapter 6, Maxwell presents his account of progress: "Aim-Oriented Empiricism (AOE)" (67). Instead of an explicit statement of AOE, readers will find a figure that is supposed to capture that physics accepts, "not just *one* thesis, but a *hierarchy* of theses concerning the comprehensibility and knowability of the universe" (66). For Maxwell, the gist of AOE is that metaphysical theses must be explicitly acknowledged. Maxwell argues that AOE solves problems 2, 3, 1, 6, and 8 in chapters 7, 8, and 9, 10, and 11, respectively. In chapter 12, he argues that AOE applies, not just to physics, but to all of natural science, "because physics is the fundamental discipline of natural science, presupposed by all the other branches of natural science" (155-6).

In chapter 13, Maxwell lists the "benefits for science [that] would come from discarding standard empiricism (SE) and embracing and implementing AOE instead" (161), which include an increase in scientific knowledge and understanding, a rational method of discovery, and an objective measure of theoretical unity. In chapter 14, Maxwell argues that AOE can be applied to solve not only scientific problems but also global problems.

Readers familiar with the literature on scientific progress will probably wonder about the following. First, Maxwell sets out to solve problems that "remained unsolved for so long despite the fact that some of the greatest minds ever have struggled to solve it" (ix). Yet, he doesn't discuss previous attempts to solve these problems, except to cite occasionally the usual suspects, such as Popper and Kuhn, despite claiming that they have failed (Ch. 3).

Second, Maxwell claims that philosophers "have all but given up on the attempt to make sense of [scientific progress]" (1). Clues as to why Maxwell would make this false claim can be found in the book's list of references. With the exception of Maxwell's own work, there are few works from 2000 onwards. The few works from 2000 onwards are mostly works by scientists rather than philosophers. This means that the book doesn't engage with recent work on scientific progress in philosophy of science, like Chang (2004), Bird (2008), Mizrahi (2013), Niiniluoto (2014), and Rowbottom (2015).

Third, Maxwell uses examples from theoretical physics as support for AOE. He claims that "solving the problems for this particular context solves the problem for natural science quite generally, and for other contexts as well" (7). But why think that what is the case in physics is also the case in other sciences as well? The answer to this question is eventually revealed in chapter 12, where Maxwell endorses a version of scientific reductionism according to which "all branches of natural science other than physics presuppose parts or aspects of some more fundamental science" (156). However, one would be hard pressed to find philosophers endorsing

scientific reductionism nowadays. As van Riel and van Gulick (2016) observe, the "hope that the actual progress of science can be successfully described in terms of reduction has vanished." In fact, Maxwell seems to acknowledge this when he writes, "physics is concerned to describe only a highly selected *aspect* of all that which exists" (168). For this implies that there are other aspects of existence that could be described by sciences other than physics. But if there are sciences that can describe what physics cannot, then those sciences cannot be reduced to physics.

There appears to be another inconsistency in Maxwell's account. On the one hand, he claims that "the scientific community at present takes [SE] for granted, and tries to ensure that scientific practice conforms to its edicts" (159). His solution to problems 1-8 is to discard SE and implement AOE (161). On the other hand, he also claims that "physics, in accepting the unified theories that it does accept, thereby allows considerations of unity or simplicity to over-ride empirical considerations" (29), so "AOE [has] in fact been put into practice" (114). So which one is it? Is AOE already put into practice or do we have to replace SE with AOE? If "physics [already] puts something like AOE into practice" (142), why insist that "We need to adopt and implement the new scientific paradigm of [AOE]" (161)?

Maxwell seems to be aware of this inconsistency (74), but it is not clear that he manages to resolve it. On the one hand, he needs it to be the case that considerations of simplicity and unity actually play a role in theory choice, since his argument for AOE is that it "does justice to what actually goes on in theoretical physics" (74). In that case, however, AOE would already be a matter of scientific practice. On the other hand, he needs it to be the case that SE, *not* AOE, is a matter of scientific practice, since his solution to problems 1-8 is to replace SE with AOE (141). In that case, however, Maxwell could not argue that AOE "does justice to what goes in physics" (77).

Likewise, readers are likely to be confused by apparently inconsistent statements about the status of SE. Maxwell claims that SE "has long been taken for granted--and is still taken for granted--by scientists and philosophers of science alike" (16). But he also says "that in practice physicists pay only lip service to standard empiricism," and that SE "has not been taken seriously" (153). So which one is it? Is SE taken seriously or not? If what is being paid to SE is merely "lip service" (142), why insist that science "move from SE to AOE" (162)?

Maxwell claims that AOE solves problems 1-8 by making metaphysical theses, such as physicalism (i.e., the thesis that the universe is physically comprehensible), explicit. For him, "the purpose of making explicit the metaphysical theses of AOE is to stimulate attempts to develop improved versions of these theses" (146). But it is not clear how making assumptions explicit is supposed to solve problems 1-8. The "whole point of [AOE] is to facilitate the critical assessment of theses low down in the hierarchy [i.e., "physicalism," "blueprint," which is the best current specific version of physicalism, and the currently accepted fundamental physical theories] in the light of the empirical success and failure of science" (104). But critical assessment does not guarantee progress. One might think that philosophers critically assess philosophical theories regularly, and yet there are serious questions about whether philosophy makes progress (Chalmers 2015).

Maxwell insists that, "even though AOE provides no arguments for the *truth* of theses in the hierarchy [e.g., physicalism], it does provide arguments for *accepting* these theses, granted that the aim of science is to acquire knowledge of the truth, insofar as this is possible" (106). We must accept these metaphysical theses because "their truth is required for science, or the pursuit of knowledge, to be possible at all" (106). Since he uses the term 'accept' and he cites van Fraassen, it is curious that Maxwell does not engage with van Fraassen's Constructive Empiricism, which seems to be the closest view to Maxwell's target of criticism, i.e., SE. For constructive empiricists, theoretical virtues, such as simplicity and unity, can play a pragmatic role in theory choice, but they are not truth-conducive, which is why they distinguish between accepting and believing theories. Constructive empiricists would deny that "the aim of science is to acquire knowledge of the truth" (106) and insist that it's empirical adequacy.

Accordingly, constructive empiricists would not be impressed by Maxwell's argument that theoretical knowledge is possible only if metaphysical theses, such as physicalism, are true. Where Maxwell *ponens*, constructive empiricists would *tollens*, since they find it "absurd to think that the world is more likely to be simple than complicated" (van Fraassen 1980, 90), and conclude that theoretical knowledge is impossible. Indeed, I suspect that antirealists would find Maxwell's AOE unpersuasive, since he simply asserts that "Anti-realism does not work. It does not solve [problems 1-8]" (59).

In chapter 14, Maxwell writes that his "hope is that this book will prompt the occasional reader to consult some of [his] earlier work" (182). I would recommend this book to readers interested in an overview of Maxwell's ideas about scientific progress in theoretical physics.

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