When the Concrete is Hard

Laura Ruetsche

November 18, 2019

1 Physics Avoidance

Reed and Simon's *Methods of Modern Mathematical Physics* epitomizes an ideal of physics "presented as an abstract, elegant corpus generally divorced from application" (1975 ix). Their introduction to volume II opens by lamenting this presentation as "a serious defect"—and not just because it leaves students "ignorant of the fact that almost all deep ideas in functional analysis have their *immediate* roots in 'applications'."

> More deleterious than historical ignorance is the fact that students are too often misled into believing that the most profitable directions for research are the abstract ones. In our opinion, exactly the opposite is true. . . . it is the study of specific applications and the consequent generalizations that have been the more important.

Reed and Simon express a moral lost on those suffering from the syndrome *Physics Avoidance* labels "Theory T Thinking." The totemization of abstraction comes at a cost. The cost to mathematics is progress, Reed and Simon suggest. The costs to philosophy, Mark Wilson reckons, include relevance and adequacy.

Reed and Simon continue:

> Typically, the history [of a piece of conceptual machinery] is in two stages: first a specific method (typically difficult, computational, and sometime nonrigorous) is developed to handle a small class of problems. Later the study of the method itself becomes important. The ideas are studied on the abstract level, and the techniques systematized. With the newly developed machinery, the original problem becomes an easy special case. (Reed and Simon 1975, ix-x)

Here again they echo a central theme of *Physics Avoidance*. Our conceptual machineries have natural histories whose meanderings we'll miss if we insist on viewing specific applications through the sanitizing lens of subsequent abstraction. Losing sight of the myriad strategies, often untidy and unregimented, conceptual machineries deploy to extend their natural histories, Wilson claims, we are tempted into impoverished and wrong-headed philosophies of language and of science. Reed, Simon, and Wilson agree: The concrete is hard *before* it is settled. And that is also when it has the most to teach us.

The lesson seems lost on Eugene Wigner (and friends).

> Our knowledge of the physical world has been divided into two categories. Initial conditions and laws of nature. The state of the world is described by initial conditions. These are complicated and no accurate regularity has been discovered in them. In a sense, the physicist is not interested in the initial conditions, but leaves their study to the astronomer, geologist, geographer, etc. (Houtappel, van Dam, and Wigner 1965, 596)

Wigner and friends present classic symptoms of Theory T thinking. These include: (i) Identifying physics with its "evolutionary" laws, conceived as governing how systems change over time. "The laws of nature, of course, are the parts we're supposed to idolize" (*PA* 357); (ii) Regarding these laws as "autonomous" (160): free from reliance on exogenous elements (e.g. "boundary conditions, interfaces, constraints, and allied auxiliary ingredients" (342)); (iii) Disdaining as "merely geographical" the "complicated" and "irregular" peculiarities characterizing concrete physical situations. For Theory T thinkers, what isn't law, is uninteresting brute contingency.

Although there are many additional symptoms of Theory T syndrome, this short list is enough to exhibit the syndrome's allegiance with an explanatory ideal: to explain is to identify the past conditions which, given T's laws, entail the explanandum. Related ideals include: to predict is to derive from T's laws an account of how present conditions will evolve; to design is to identify a situation from which a desired result will, as a consequence of T's laws, follow. It strikes Wilson that it hasn't struck the rest of us hard enough that physics almost never proceeds on the foregoing terms.

> The surest and happiest routes to predictive, explanatory, and design success do not always lie directly ahead, but employ clever stratagems for evading the computational hazards that render the direct path unpassable ...i.e. *physics avoidance*. Most physical treatments one encounters in real life are characterized by some form of deductive evasion. (52)

Exercises in physics encountered in the field break the Theory T mould. They're unsettled, incomplete. Marked by commitments in tension with one another, they can appear inconsistent. They paper over their lacunae with unrigorous mathematics, often disguised by crafty bookkeeping. They rely critically on non-evolutionary and/or exogenous considerations, such as static constraints, phenomenological inputs, helping hands extended from other scales, boundary conditions. *Physics Avoidance* catalogs many distinct species of its eponymous genus; one suspects that Wilson's private collection extends to many more.

2 Non-ideal Theory

Plato sought to understand justice by confabulating an ideal city fully realizing that elusive commodity. Many contemporary political philosophers advocate a different approach to matters of justice: "non-ideal theory," where rather than imagining a perfect state, we consider the state we find ourselves in and try to diagnose its ills with a view toward beginning to address them.

Theory T Thinking posits an ideal theory. Wilson's approach to philosophy of science shares with non-ideal approaches to political philosophy a commitment to start from the practices we've got, rather than a confabulated ideal. However, *Physics Avoidance* appears to lack a conspicuous ameliorative agenda. (At least one where it's *physics* that's ameliorated. Wilson clearly thinks that *philosophy*'s failings are legion, and ameliorable by better attention to the strategies *Physics Avoidance* documents.) In what follows, casting Wilson's work (against its will) as a user's manual for non-ideal philosophy of physics, I'll ask: What might *Physics Avoidance* teach us about how to make *physics* better?

Implicit in an ideal is a taxonomy of failure modes, as well as a roadmap of possible ways to improve. Deficient roadmaps derived from constricted ideals can impede physics. (Philosophy is culpable if it insists on an ideal generating deficient roadmaps.) Criticizing ideals for their constriction can be a first step toward amelioration. And *Physics Avoidance* is a sustained criticism of the Theory T ideal. For one thing, it is too stringent: "The scientific enterprise won't have failed if we find ourselves confined to more variegated forms of mathematical architecture" (*PA* 174) than fit into the Theory T mould. It follows that it is too blunt. If physics comprehends "more variegated forms of mathematical architecture" than are dreamt of in Theory T thinking, each with its own success conditions, then physics also comprehends more variegated failure modes, ways to fall short of those success conditions. Approaches more ecumenical than Theory T thinking could inform more nuanced diagnoses of (f)ailing physics, as well as richer roadmaps of routes to recovery.

Directing the ameliorative project is an understanding of *physics avoidance* broader than the one we started with (according to which physics avoidance happens when physics departs from the Theory T mould). Ecumenically countenancing a heterogeneous collection of explanatory architectures and their attendant success conditions, we can say: physics avoidance happens when explanatory/predictive/design exercises adhere to ground rules of none of these architectures. With physics avoidance so understood, the ameliorative agenda is to identify its symptoms, assess the severity of the underlying condition, and attempt appropriate remedy.

3 Diagnosis

Sometimes, all it takes to avoid physics is a constant.

Consider Planck's, introduced by its namesake in 1900 in order to write down a phenomenological law describing blackbody radiation. A blackbody is one that absorbs all electromagnetic radiation incident upon it. A blackbody in thermal equilibrium with its environment had better *emit* radiation too! *Blackbody radiation* is the radiation it emits, in the form of electromagnetic waves. The phenomena Planck and others were trying to save consisted in the variation, at a fixed equilibrium temperature, of the strength of the radiation emitted as a function of its frequency. Blackbody radiation had eluded capture by classical electrodynamics, aka Maxwell theory. Maxwell theory supposed energy to vary continuously. But Planck's phenomenological law could be derived by assuming that blackbody radiation came in *discrete chunks*, multiples of his constant. In 1920, Planck received a Nobel Prize for his work. His acceptance speech, recounting his struggles with the constant, reads like a meditation on the topic of physics avoidance.

Planck reports that his 1900 self regarded the constant as "a new and strange element" (Planck 1920). The constant is a rough mathematical edge, indicating unsettled concrete—a symptoms of physics avoidance. Presented with such a symptom, the adept diagnostician asks whether it reflects an underlying condition meriting remedy. Planck takes this question up.

His first answer evokes his 1900 self.

> I was filled ... with what would be thought today naively charming and agreeable expectations, that the laws of classical electrodynamics would, if approached in a sufficiently general manner with the avoidance of special hypotheses, be sufficient to enable us to grasp the most significant part of the process to be explained, and thus to achieve the desired aim.

Although the strange and novel constant shakes this Theory T expectation, it does not immediately dislodge it. Planck hopes that "with more or less gentle pressure," the constant might be fit into the "fixed frame" of Maxwell Theory. Under this guise, the constant represents a symptom of what I'll call *mild physics avoidance*—a departure from salient explanatory ideals that signals the incompleteness (only in the sense of details!) of the physics we're using. Once we've patched things up, naive 1900 Planck hopes, we'll see that energy isn't *really* discretized. Rather, there's a bothersomely complicated underlying story, *a story told within the framework, and obedient to the ground rules, of classical physics*, that treating energy as discretized enables us to approximate. Naive 1900 Planck can hope that physics avoidance is a transient frailty. In cases of mild physics avoidance, the physics avoided is just the physics we're using, only less expurgated. We're not missing much by avoiding it.

However, like "an intruder who, after appropriating an assured place, has gone over to the offensive," the constant "proved elusive and resistant to all efforts to fit it into the framework of classical theory." The constant emerges as a symptom of a strain of physics avoidance distinct from, and more noteworthy than, mild physics avoidance. I'll call it *severe physics avoidance*, because the underlying condition is dire— "the old framework must somehow or other be burst asunder." Planck offers two models of the bursting. On the first model,

> the derivation of the radiation law was based on a sound physical conception. In this case the quantum of action must play a fundamental role in physics, and here was something entirely new . . .

(Here, in fact, was the germ of modern quantum theory!) So understood, Planck's constant functions as a *surrogate for missing physics*, a summary, for the purposes of describing blackbody radiation, of what deeper physics, then unknown, implies about those phenomena. Under this guise, Planck's constant is a symptom of severe physics avoidance. The underlying condition is severe because the physics we're avoiding is not merely a less expurgated version of the physics we're using. The physics we've avoiding genuinely and deeply revises the physics we're using. So we're missing a lot by avoiding it. On Planck's first model of the bursting asunder of existing frameworks, confronting the avoided physics is the way forward. Contemporary effective field theory approaches illustrate this hope: there "running the couplings" is a form of attention to physics avoidance that promises to illuminate the physics avoided.

Planck describes his second model of how the framework of classical physics might be "burst asunder" as follows:

> [If] the quantum of action was a fictional quantity, then the whole deduction of the radiation law was in the main illusory and represented nothing more than an empty non-significant play on formulae.

There is a spooky reconstruction of this model. The constant is neither a placeholder for a more detailed account framed by current physics, nor a surrogate for future physics. The spooky reconstruction is that neither theories at hand nor missing theories can explain why positing the constant enables us to describe blackbody radiation. In this case, there's no physics, present or future or conceivable, that we skirt by positing the constant. We're not avoiding physics, and either something other than the physics we're avoiding explains why the technologies we're using succeed, or *nothing* explains why the technologies we're avoiding succeed. Both disjuncts are spooky. If there's no physical reason (transparent to us or not) why the technologies we're using succeed, there's no (non-mystical) reason for them to continue to succeed. And yet they do.

Fortunately, there is a less spooky way to hear Planck's talk of his constant as a fictional quantity. On this reconstruction, there is deeper physics that explains why positing the constant works as well as it does. However these deeper explanations share so little conceptual machinery with current explanations that current explanations are inept guides to the features of the physical world that enable their own success. This is a strain of severe physics avoidance in which the physics we're avoiding lies so far beyond our grasp that careful attention to our avoidance behavior won't help us find it.

Presented with a piece of working physics, the Theory T thinker asks: Why does this theory work as well as it does? The question bristles with self congratulation. Presented with a piece of working physics, a student of *Physics Avoidance* asks a different question: Why does *physics avoidance* work as well as it does? Mild forms of physics avoidance are innocent shortcuts, where the long way round discloses nothing of interest. Severe forms of physics avoidance cloak revolutionarily new ways of coming to grips with the phenomena. Wilson observes that

> As students of scientific methodology, we should strive to diagnose correctly the *true empirical support* of the explanatory architectures scientists employ. (*PA* 87; italics mine)

"Why does *physics avoidance* work as well as it does?" is a question that could drive an ameliorative agenda. But just how far?

4 Cure?

With Reed and Simon, Wilson appreciates that in many cases, the rough edges that signal physics avoidance are subsequently smoothed by advances in technologies of applied mathematics.

> only much later, pressured by the necessities of greater applicational rigor, do clever applied mathematicians figure out the true structural underpinnings behind these strange appeals. (*PA* 134)

He even has a name for this ameliorative process: restoring "descriptive harmony."

> As this improved understanding of our descriptive practices is obtained, out-of-territory reasoning ingredients formerly tolerated as "useful idealizations" emerge as integral parts of a smoothly functioning portion of descriptive machinery. (332)

With descriptive harmony restored, the concrete looks settled. But has the patient been set on the road to recovery?

It is instructive to approach this question by way of Wilson's notion of "explanatory mimicry."

> We often encounter situations in which some physics avoidance pattern X has been presumed to piggyback upon a fuller evolutionary model of type Y, but where it later emerges that the proper justification for X traces to underlying factors Z of an entirely different character . . .Y has served as an *explanatory mimic* with respect to Z. (78)

Explanatory mimicry guppies us into to overestimating the reach and potency of Theory T explanatory architecture. But being guppied is a generic phenomenon, not one keyed to a particular explanatory strategy.[1] Suppose that we are enjoying descriptive harmony and/or explanatory (ecumenically construed) success. Couldn't the rigorous, empirically adequate, intruder-free, settled frameworks we employ be *covertly* maladapted in a way that impedes our well-intentioned efforts to understand their "true empirical support"? What I'll call *covert physics avoidance* happens when some piece of settled physics works, and we think we understand why it works, but we're wrong. Having had the notion of physics avoidance afflicted upon them, humble

[1]Wilson may be claiming, not that is so keyed, but that due to a selection effect —treating Theory T thinking as a default, it's mimics of Theory T architecture that we'll fall for — Theory T mimicry has had an overbearing influence on received philosophies of science.

physicists might worry that even their most confrontational theories are committing covert physics avoidance right and left.

There are armchair and empirical reasons to take the worry seriously. An armchair reason is that ameliorative trajectories—routes to the restoration of descriptive harmony—are underdetermined. The ghostly infinitesimal haunting the original calculus could be exorcised by a rigorous theory of limits or by a rigorous theory of non-standard analysis. *Physics Avoidance* teems with case studies suggesting that we'll follow the trajectory easiest to reach by way of our present repertoire of conceptual machineries. Conceptual machineries vary markedly in their capacity to reveal the "true empirical support" of their successful applications, and there's no reason to expect the most-attainable extensions of our present machineries to also be the most empirically revealing. Although the trajectory we take settles the concrete—that's just what it is for it to be ameliorative—there's no reason to expect it to illuminate the "true empirical support" of the harmony we've achieved.

The history of physics abounds with examples provoking the worry that covert physics avoidance is rampant. Consider Ptolemaic epicycles, an advance in applied mathematics that brought circular motion into descriptive harmony with celestial data. The concrete looked settled. Yet there was physics being avoided: the physics aptly described by Copernican models. Or consider Clairault laws, higher order corrections to Newton's inverse-square law of gravity (see Wells 2015). The coefficients of cubic, quartic, etc., corrections can be tuned so that Clairault laws accurately describe anomalous perihelion advance. In a counterfactual history where these coefficients look so "natural" that we declare them "fundamental constants," the concrete looks settled. Yet there is physics being avoided: the physics aptly described by General Relativity.

Both illustrations of covert physics avoidance represent missed opportunities to significantly improve physics. The covert physics avoidance is also severe physics avoidance. In the Clairault Laws example, the physics avoided shares so little conceptual machinery with the physics in use that Planck might well regard elements of the physics in use — forces acting instantaneously at a distance across Euclidean three space – to be "fictional quantities." Noticing that physic avoidance can be both covert, and so severe that studying it won't guide us toward improved physics, should influence the odds we're willing accept on bets about the Theory T rapture.

5 The Theory T Rapture

Could the judicious pursuit of descriptive harmony deliver physics to a state of Theory T grace, a rapturous land of glory, where, released from the concrete, physics is unmarred by avoidance? Wilson doubts it, but not out of a deep metaphysical aversion to an unRapturous universe. He "cheerfully acknowledge[s] that such a futuristic eventuality might come to pass" (*PA* 280). But, he insists, Theory T thinkers aren't prophets of the Rapture.

> Philosophers should refrain from syntactic rhabdomancy of a Theory T character. We lack any privileged insight into what the mathematical contours of future science will look like, and we should cultivate the exemplars that suggest alternatives. As George Eliot writes, "Among all forms of mistake, prophesy is the most gratuitous." (137-138)

Wilson is betting against the Rapture. A naturalism about our cognitive abilities informs his bet, which is also a bet on a chronic mismatch between what we're given to work with and what it would take to spell theory T seamlessly out.

> With a limited stock of words and smallish brains, we must forever seek roundabout strategies that allow us to handle the extremely large range of challenges we confront within science and everyday practice. (4)
>
> I am a scientific realist at heart and have no doubt that all of these varied patterns "fit together" somehow. But, at the present moment in scientific time, we don't really know how this "fitting together" formally operates, and nature offers many surprises on this score. (78-79)

I'm betting against the Rapture too. But my grounds may be more minimal, and don't leave me feeling like a scientific realist at heart. My bet rests on evolutionary considerations informed by the very features of the natural histories of concepts *Physcis Avoidance* elaborates. Without supposing that a Rapture is, as a matter of metaphysics or cognitive psychology, beyond our reach, we can argue that, as a matter of methodology/conceptual natural history, we're unlikely to suffer the Rapture. Selection pressures in science, as well as the conceptual terrain in which those pressures operate, favor approaches that juryrig rather than optimize, and that settle for covert physics avoidance when covert physics avoidance is what's available. For these reasons, I suspect that covert physics avoidance is and will remain widespread. And so I wager that our successful and harmonious descriptive machineries fail (and will continue to fail) to serve as accurate guides to their "true empirical support." I part ways with Wilson either in harboring these suspicions or in not having a heart commodious enough to contain them and scientific realism both!

Works Cited

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