A Defense of Scientific Phenomenalism from the Perspective of Contemporary Physics

JOHN LEE

Modern science, particularly physics, is currently making claims about the existence of all kinds of fascinating entities. These range from quarks, superstrings, and gravitinos to singularities, warped spacetime, and gravitational waves. While these entities inspire awe and amazement, it is possible that their positing is premature and perhaps entirely unfounded. In this essay, I will argue that this is indeed the case. Any ontological claims about the aforementioned entities rest on a form of realism that I believe is unwarranted. Rather, anti-realism, particularly scientific phenomenalism is the view that seems to be most reasonable. In this essay, I will first explain a version of scientific phenomenalism (SP) defended by W.T. Stace. After addressing some standard objections, I will propose some advantages that SP holds over scientific realism, particularly in the realm of physics.

Scientific phenomenalism belongs to the larger category of anti-realism. Anti-realism denies the main claims of realism, namely, that scientific theories have truth values, theoretical entities really exist, and the aim of science is to give a literally true account of the world.[i] SP denies these claims and holds that science tells us simply how things appear. All that can be known to exist, at least scientifically, are the sensations of the world that we experience and how they are ordered. Any claims about the existence of theoretical entities (like forces, curved spacetime, electrons, potential energy, and electromagnetic fields) that underlie these sensations are unfounded.

SP holds that no amount of sense data can justify belief in something outside of perception. For no matter how many observations you have, it is invalid to then logically infer the existence of something beyond those observations. Stace argues that all causal relationships that are observed are in the world of perception. He writes,

> If you admit that we never observe anything except sensed objects and their relations, regularities, and sequences, then it is obvious that we are completely shut in by our sensations and can never get outside them. Not only causal relations, but all other observed relations, upon which *any* kind of inferences might be founded, will lead only to further sensible objects and their relations. No inference, therefore, can pass from what is sensible to what is not sensible.[ii]

I believe Stace is right insofar as we are unable to infer the existence of theoretical entities based on sensible objects and relations. I do think that some inference from observables to unobservables is appropriate, just not in the practice of science.

Put another way, science, by its own standards, involves the study of the observable world. A theory that is produced can only mean something scientifically if there is some observation that can be done to confirm or falsify the theory. And so, if a scientific claim involves the existence of an object that *by definition* cannot be observed, this claim ceases to be scientific. This is what happens when theoretical entities are posited to exist. They themselves can never be observed, only their supposed effects. Thus, claims about the existence of these entities are not in the realm of science. That is not to say that such claims are meaningless. Rather, they are metaphysical claims which I believe happen to have significant problems (I will not go into those problems here). But for scientists to make claims about the existence of theoretical entities is for scientists to go beyond the bounds of their discipline. As Chalmers puts it, "a motivation underlying anti-realism seems to be the desire to restrict science to those claims that can be justified by scientific means, and so avoid unjustifiable speculation."[iii] It seems quite inappropriate to posit and defend, in the name of science, the existence of entities that can, in principle, never be measured by the very tools of science, or any other tools for that matter.

However, this is not at all to say that theoretical entities are worthless and completely untrue. They are untrue in the sense that they do not correspond to any real, mind-independent existence in the physical world. However, they can be true in the sense that they are able to predict certain sensations (both in the future, and past recorded ones).[iv] For forces, curved spacetime, electrons, potential energy, and electromagnetic fields have proved to be very effective in predicting certain phenomena. Stace writes,

> It is a matter of no importance to the scientific man whether the forces exist or not. That may be said to be a purely philosophical question. And I think the philosopher should pronounce them fictions. But that would not make the law useless or untrue. If it could still be used to predict phenomena, it would be just as true as it was.[v]

While exploring this issue it is important to address a point more fundamental to the discussion. This is whether science explains anything, or if it just describes and predicts phenomena. Stace holds that it does the latter, and that beliefs in the former are what cause confusions over theoretical entities. For if one believes that science explains things, then it is quite natural to look for underlying entities that are "causing" the observed phenomena. However, what really seems to be going on is the more detailed description of what is happening. For example, a table feels hard to the touch because of the repulsion of the electron shells of the atoms involved, which is attributed to the electromagnetic force, which is ultimately a manifestation of the combined electroweak force. While these "explanations" are couched in explanatory language, it is clear that they are just further descriptions, at some point, leaving the realm of perception and entering the realm of theoretical entities. Niels Bohr wrote, "It is wrong to think that the task of physics is to find out how nature *is*. Physics concerns only what we can *say* about nature."[vi]

For example, when the question about why things fall was posed, the force of gravity was offered. And when this proved inadequate, curved spacetime was offered.[vii] However, in reality, these forces and spacetime curves are simply mathematical tools to predict sensations. As Stace points out, "And anyone who takes them for 'existences' gets asked awkward questions as to what 'curved space' is curved 'in.'"[viii]

I will now address some standard objections to SP. First, it is argued that scientific theories (like quantum mechanics) have been so amazingly successful in making predictions, how could they at least not in some way be true? SP acknowledges that theories can be very successful in predicting phenomena; that is why theoretical entities are not worthless. However, just because a theory makes successful predictions, it does not follow that it must be true or nearly true. On the contrary, the ability of a theory to make predictions with related theoretical entities not actually existing has allowed the continuation of some past theories (an example is Fresnel's theory of light as waves in an elastic ether)[ix]. Furthermore, because of the metaphysical nature of claims about theoretical entities, it is not necessary for the entities to exist for a prediction to be correct. In fact, theoretical entities by definition could never be observed, only their supposed effects.

Another objection involves the supposed vindication of atomic theory in the early twentieth century. Near the end of the nineteenth century, several anti-realists (including Duhem, Mach, and Ostwald) would not accept the atomic theory as true. The supposed atoms were not real, but rather "useful fictions." However, by 1910, the supposed vindication of this theory was thought to have put anti-realism to rest.[x] According to Chalmers, the anti-realists have a response:

> They demand that only that part of science that is subject to confirmation by observation and experiment should be treated as candidates for truth or falsity. However, they can acknowledge that as science progresses, and as more probing instruments and experimental techniques are devised, the range of claims that can be subject to experimental confirmation is extended.[xi]

Another reply is that, to use the objector's own language, it is still not clear that the atom has ever been observed. An atom can never be *seen*. The wavelength of visible light is not small enough to resolve the distances at the atomic scale. All that is "seen" are pictorial representations of some other probing technique. "Experiences" of atoms (or any other merely theoretical entities) are ultimately *sensations* which are quite compatible with scientific phenomenalism.

One may further object that scientific theories imply the existence of theoretical entities. However, this cannot be so. As Beebee puts it,

> A theory employing theoretical terms is really only 'about' the observable world: what makes the theory true is the *observable* facts being the way the theory says they are. Theoretical terms are introduced into a theory only to make it simpler or more elegant. Their presence does not indicate any ontological commitment to unobservable entities 'referred' to by the terms, since the terms don't, despite initial appearances, refer to such entities.[xii]

A good example of this is presented by Stace. He discusses the nature of potential energy. Classical physics includes the idea of potential energy in order to support the law of conservation of energy. In order to preserve conservation of energy, sometimes when energy seems to disappear, it really is being transferred into potential energy. "Now", as Stace writes, "what does this blessed world 'potential'—which is thus brought in to save the situation—mean as applied to energy?...What positive meaning has the term? Strictly speaking, none whatever. Either the energy exists or it does not exist. There is no realm of the 'potential' halfway between existence and non-existence."[xiii] Rather, the concept of potential energy is introduced to simplify the equations. However, it is a subtle and easy step to make the claim that this potential energy *actually* exists: "There will always be a temptation to hypostatize the potential energy as an 'existence,' and to believe that it is a 'cause' which 'explains' the phenomena."[xiv] It is natural for humans to try to create a mental picture of a physical process. However, it seems that this inclination is naïve, and cannot be the aim of scientific theories. Paul Dirac writes, "The main object of physical science is not the provision of pictures, but is the formulation of laws governing phenomena and the application of these laws to the discovery of new phenomena. If a picture exists, so much the better; but whether a picture exists or not is a matter of only secondary importance."[xv]

I will now present some of the advantages of adopting SP as opposed to scientific realism. One favorable result of scientific phenomenalism is that it accounts quite nicely for the rejection of theoretical entities in the past, but the retention of their corresponding observations. It is easy to forget that in the past, light corpuscles and the ether were believed in strongly, perhaps as strongly as electrons are believed in now. However, these entities were rejected because their corresponding theories were rejected. The observations, that initially supported and then disproved their existences, remained. Chalmers writes,

> Anti-realists can point to the history of science to substantiate their claim that the theoretical part of science does not qualify as securely established. Not only have theories of the past been rejected as false, but many of the entities postulated by them are no longer believed to exist...However, the anti-realist will insist that, although these theories proved to be untrue, there is no denying the posi-

> tive role they played in helping to order, and indeed to discover, observable phenomena...In the light of this, it seems plausible to evaluate theories solely in terms of their ability to order and predict observable phenomena.[xvi]

I will now discuss a few cases in which SP presents a great advantage in interpreting some rather paradoxical scientific findings. Usually, it is inevitable that in the first year or two of university education, physics students will encounter the first of many paradoxes within the realm of modern physics. Here, the nature of everyday light comes under great scrutiny. Two famous experiments suggest two totally opposite natures of light. First, the photoelectric effect revealed that light seemed to come in tiny bundles, or quanta. These quanta were called photons and appeared to behave like particles. However, the two-slit diffraction experiment revealed that light had a very wave-like nature. For when light was shone through a slide with two narrow slits close to each other, the effect on the screen behind was that of interference. This could only result from the constructive and destructive interference between waves of light. However, if individual photons were fired at this slide at half hour intervals, the same interference pattern would gradually emerge on the screen (one dot at a time). Somehow, it seems that each individual photon would conspire with all the rest (temporally separated) to interfere with one another and make the corresponding interference pattern.[xvii] But that is a nonsensical interpretation. Even though each photon acts like a particle, it has a distinct wave nature. But it itself is not purely a wave or else it would interfere with itself. Thus, light seemed to have both wave-like and particle-like properties, depending on which nature was being investigated. The problem was complicated further when this effect was observed using electrons. Not only radiation, but matter, appeared to have a dual nature. This, however, presents a significant problem. How could an electron be both a particle and also a wave spread out over vast amounts of space?[xviii] Both could not be true at the same time. And so a serious paradox arises. However, the young physicist encountering this problem for the first time simply accepts this paradox and moves on to her next class assignment. Later, she will probably take a course or two in quantum mechanics and learn about the existence of probability waves (or wave functions) which represent the electron and predict the results of the two-slit diffraction experiment. However, this just substitutes one hard to understand concept for an even more difficult one. For how could a probability wave ever exist? What is its fundamental nature? Is it just a mere mathematical construct? Bruce Gregory writes "The wave function [probability wave] that forms the solution to Schroedinger's equation does not picture some*thing* in nature."[xix]

And so, the ontological statuses of light, electrons, and probability waves become very troublesome, and can exist as a "thorn in one's mind."[xx] However, I suggest that the mental quandary that can occur when trying to grasp these entities is entirely unnecessary. Its elimination not only provides some mental relief, but a deeper understanding of reality. According to scientific phenomenalism, these troublesome entities are only troublesome because they are complex mathematical entities that are trying to be squeezed into an existential box. They do not exist in the physical world; they are simply mathematical constructs used to describe and predict phenomena that do actually exist. Once this is realized, the tension is relieved because we no longer have to reconcile there actually existing an object that has apparently contradictory properties. Rather, we simply acknowledge what does exist and thus what should be used in scientific reasoning: the observed phenomena and their mathematical description. Bruce Gregory, on Warner Heisenberg's take on this issue, writes:

> The problem with trying to understand the behavior of electrons arises, Heisenberg said, because we persist in thinking of electrons as tiny marbles; we

> persist in talking as if there were subatomic "objects" that physical theories somehow describe. But electrons are not objects in this sense at all... Asking what the behavior of electrons is "really" like arises out of the marble fallacy. Such questioning is futile. At best any answer is simply a matter of taste. Discussions that do not lead to any new predictions have no impact on science; discussions that lead to new predictions are challenges to be met by experiments in the laboratory.[xxi]

Another example might serve to illuminate this point further. In the field of particle physics, there exists the Standard Model (SM), a theory that has proved spectacular in making accurate predictions. However, there was a possible problem with the SM, one that at first glance could appear fatal. In order for the theory to work, all particles must be massless. This is obviously not the case, but a clever trick has been developed to circumvent this problem. This trick is the Higgs mechanism. The Higgs mechanism involves a field which gives mass to all the particles (that have mass) and as a result produces another particle, the Higgs boson. (Incidentally, this boson has not been "discovered" yet and is crucial to the survival of the SM.) This Higgs field is interesting because it supposedly couples to all massive particles. I have heard several analogies to try to explain how this happens. One explanation is that somehow, wherever a massive particle is present, it is present with the Higgs field which gives it its mass. Another more crude analogy refers to particles, when they move through space, as moving through a sort of molasses which is the Higgs field. The more they are slowed down by the molasses, the more mass they obtain. While these analogies have some intuitive appeal, they are really attempting to solve an unnecessary problem, namely, the problem of understanding what this Higgs field really *is* and how it behaves in the physical world. It seems to be more accurate to say that we observe that particles have mass, and the mathematical expression of this mass is the Higgs mechanism. But we do not have to say that the Higgs field really *exists*.

One last example from physics. According to Maxwell's equations, electromagnetic (EM) interactions occur via electromagnetic waves. These waves were initially thought to propagate through an ether. However, this ether was found not to exist, but the EM waves were still measured.[xxii] So, the natural question arises: What do these EM waves travel in? What do the waves wave in? The answer is *nothing*. It gets even more conceptually difficult when trying to understand how an EM wave moves. One way to think about it would be that at any given location, the electric (E)-field and magnetic (B)-field oscillate up and down at perpendicular directions as the EM wave passes through. But this only passes the problem off to E-fields and B-fields. What are they? Well, they can be measured by placing a test charge in the region and seeing how it moves. Now we are in the realm of observation. But until we move into this realm, the concepts of EM waves, E-fields, and B-fields are extremely difficult to grasp. Richard Feynman echoes this frustration: "I have no picture of the electromagnetic field that is in any sense accurate…It requires a much higher degree of imagination to understand the electromagnetic field than to understand invisible angels…"[xxiii] Perhaps these fields are just useful mathematical tools that help to predict where a test charge will move, or whether you will hear grunge rock or NPR coming from your radio.

Not only does scientific phenomenalism provide a more concise and mentally peaceful understanding of the physical world, it also can provide a better context for theory development. One of the supposed advantages of Popperian falsificationism is that it encourages the development of bold, risky hypotheses that are easy to falsify. By the invention of bold theories, science can move along because as each new theory is falsified, something new is learned which can be incorporated into the next theory.[xxiv] Thus, it is argued that falsificationism provides a cleaner, quicker, and more accurate development of science.

Whether or not this is the case, I believe that scientific phenomenalism can provide this same benefit. On the other hand, I believe that scientific realism can bog down scientific processes with unnecessary metaphysical problems. The following is, I think, a good example. In particle physics, there is a several decade old theory called supersymmetry (SUSY). According to this theory, every particle currently known to "exist" has a supersymmetric partner, which is usually much more massive. SUSY is theoretically attractive because it avoids the undesirable problem of large canceling infinities in the Standard Model. However, one alleged drawback to this theory is that in one simple act, the number of elementary particles currently thought to exist *doubles*. Some physicists find this troublesome, not only because it provides many more particles that have to be looked for and found, but because, to begin with, there were already too many elementary particles in the SM. However, this kind of theory, whether or not it is successful, is exactly the kind of theory that needs to be presented and rigorously explored just *because* of the fact that it is bold. The belief in scientific realism can produce a kind of reluctance to seriously explore more unconventional theories. This is because, according to this view, these more extravagant theories may contain many more theoretical entities that must be discovered and incorporated into an already burgeoning metaphysical schema. However, the scientific phenomenalist can welcome these theories as bold ways to advance the course of science. There is no need to try to make metaphysical sense of the new mathematical entities.

In the end, it seems that the more philosophically appropriate and practically useful philosophy of science is scientific phenomenalism. Not only does it check metaphysical claims that are cloaked in scientific terms, but it provides a more natural way of understanding some supposed paradoxes in physics. Some may say that SP eliminates the awe and wonder that have been inspired by these alleged theoretical entities. However, the awe and wonder remain; perhaps they have just been misdirected.

Notes

[i] Lecture notes from Dr. Jim Spiegel

[ii] Stace, W.T. "Science and the Physical World: A Defense of Phenomenalism," from The Theory of Knowledge: Classical and Contemporary Readings, ed. Louis Pojman. Stamford, CT: Wadsworth/ Thomson Learning, 2003, Pg 97.

[iii] Chalmers, A.F. What is this thing called Science? 3rd Ed., Indianapolis: Hackett Publishing, 1999, Pg 232.

[iv] Stace, W.T. "Science and the Physical World: A Defense of Phenomenalism," from The Theory of Knowledge: Classical and Contemporary Readings, ed. Louis Pojman. Stamford, CT: Wadsworth/ Thomson Learning, 2003, Pg 98.

[v] *Ibid.*

[vi] Niels Bohr, quoted in Aage Peterson, "The Philosophy of Niels Bohr," in *Niels Bohr: A Centenary Volume*, eds. A. French and P. Kennedy. Cambridge: Harvard University Press, 1985, 305.

[vii] Stace, W.T. "Science and the Physical World: A Defense of Phenomenalism," from The Theory of Knowledge: Classical and Contemporary Readings, ed. Louis Pojman. Stamford, CT: Wadsworth/ Thomson Learning, 2003, Pg 98.

[viii] *Ibid.*

[ix] Chalmers, A.F. What is this thing called Science? 3rd Ed., Indianapolis: Hackett Publishing, 1999, Pg 235.

[x] *Ibid*, Pg 237.

[xi] *Ibid.*

[xii] Beebee, H. *Scientific Realism & Anti-Realism*, http://www.anu.edu.au/physics/courses/A07/notes/Beebee3.pdf

[xiii] Stace, W.T. "Science and the Physical World: A Defense of Phenomenalism," from The Theory of Knowledge: Classical and Contemporary Readings, ed. Louis Pojman. Stamford, CT: Wadsworth/ Thomson Learning, 2003, Pg 99.

[xiv] *Ibid.*

[xv] P.A.M. Dirac, *The Principles of Quantum Mechanics*, 2d ed., Oxford: Clarendon Press, 1935, 10.

[xvi] Chalmers, A.F. What is this thing called Science? 3rd Ed., Indianapolis: Hackett Publishing, 1999, Pgs 232-33.

[xvii] Greene, Brian. The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory, New York: Norton, 1999, Pgs 101-102.

[xviii] Smith, Wolfgang. The Quantum Enigma: Finding the Hidden Key, Peru, Illinois: Sherwood, Sugden, & Company, 1995, Pg 117.

[xix] Gregory, Bruce. Inventing Reality: Physics as Language, New York: John Wiley & Sons, 1990, Pg 95.
[xx] Spoken by Morpheus in the film, *The Matrix*
[xxi] Gregory, Bruce. Inventing Reality: Physics as Language, New York: John Wiley & Sons, 1990, Pg 93.
[xxii] Chalmers, A.F. What is this thing called Science? 3rd Ed., Indianapolis: Hackett Publishing, 1999, Pgs 233.
[xxiii] Richard Feynman, Robert Leighton, and Matthew Sands, *The Feynman Lectures on Physics*, vol. 2 Reading, Mass.: Addison Wesley, 1963, 20-29.
[xxiv] Chalmers, A.F. What is this thing called Science? 3rd Ed., Indianapolis: Hackett Publishing, 1999.

Bibliography

Beebee, H. *Scientific Realism & Anti-Realism*, http://www.anu.edu.au/physics/courses/A07/notes/Beebee3.pdf

Chalmers, A.F. *What is this thing called Science? 3rd Ed.*, Indianapolis: Hackett Publishing, 1999.

Dirac, P.A.M. *The Principles of Quantum Mechanics, 2d ed.*, Oxford: Clarendon Press, 1935.

Feynman, Richard, Robert Leighton, and Matthew Sands, *The Feynman Lectures on Physics*, vol. 2 Reading, Mass.: Addison Wesley, 1963.

Greene, Brian. *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*, New York: Norton, 1999.

Gregory, Bruce. *Inventing Reality: Physics as Language*, New York: John Wiley & Sons, 1990.

Peterson, Aage. "The Philosophy of Niels Bohr," in *Niels Bohr: A Centenary Volume*, eds. A. French and P. Kennedy. Cambridge: Harvard University Press, 1985.

Smith, Wolfgang. *The Quantum Enigma: Finding the Hidden Key*, Peru, Illinois: Sherwood, Sugden, & Company, 1995.

Stace, W.T. "Science and the Physical World: A Defense of Phenomenalism," from *The Theory of Knowledge: Classical and Contemporary Readings*, ed. Louis Pojman. Stamford, CT: Wadsworth/Thomson Learning, 2003.