Falsifiability in Particle Physics

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Particle physics, also known as high energy physics, contains many examples of the problems with the so-called doctrine of falsifiability, usually attributed to philosopher of science Karl Popper.

Introduction

In *The Road to Reality* mathematical physicist Roger Penrose writes:

One might have thought that there is no real danger here, because if the direction is wrong then the experiment would disprove it, so that some new direction would be forced upon us. This is the traditional picture of how science progresses. Indeed, the well-known philosopher of science Karl Popper provided a reasonable-looking criterion for the scientific admissibility of a proposed theory, namely that it be observationally refutable*. But I fear that this is too stringent a criterion, and definitely too idealistic a view of science in this modern world of "big science"*[1]*.*

Penrose cites the example of supersymmetry. The theory of supersymmetry predicts the existence of supersymmetric partners, so-called "superpartners", to known particles such as the electron, the muon, and so forth. These are predicted to have a higher mass than the known particles, determined by the supersymmetry breaking energy scale, essentially a free parameter of the theory. What this means is that if the superpartners are found at a new higher energy particle accelerator such as the Large Hadron Collider (LHC) at CERN or the Tevatron at Fermilab, this confirms the theory. If the superpartners are not found, this simply means the super symmetry breaking energy scale must be higher and the mass of the superpartners must be higher. The theory cannot be observationally refuted or falsified. Indeed, this property of the theory of supersymmetry means that it can provide a never-ending justification for building bigger accelerators to reach ever higher energy scales (Penrose does not mention this).

Penrose goes on to say:

We see that it is not so easy to dislodge a popular theoretical idea through the traditional scientific method of crucial experimentation, even if that idea happened to actually be wrong. The huge expense of high-energy experiments, also, makes it considerably harder to test a theory than it might have been otherwise. There are many other theoretical proposals, in particle physics, where predicted particles have mass-energies that are far too high for any serious possibility of refutation. Various specific versions of GUT ***[Grand Unified Theory]*** *or string theory make many such "predictions" that are quite safe from refutation for this kind of reason.*

Penrose goes on to discuss similar problems in cosmology for several pages. Cosmology has close ties to particle physics. Cosmology has become increasing littered with mysterious hypothetical entities such as "dark matter" and "dark energy" in recent years.

Popper's doctrine, often known as "falsifiability", is a common element of popular science. It occurs most frequently in discussions of the theory of evolution and alternative, often religious, theories of the origin and evolution of life such as creationism, creation science, and intelligent design. Typically, it is argued that creationism is "not science" because it is not "falsifiable". In contrast, the theory of evolution is implied to be "falsifiable", although pro-evolution popular science writers usually avoid stating specific experiments or observations that could falsify evolution. Curiously, this argument coexists with claims that evolution is a "fact" analogous to the sphericity of the Earth and thus beyond any doubt. Falsifiability pops up in other scientific controversies as well. It is actually quite rare to see the doctrine of falsifiability discussed or used in any substantive way in actual research papers in journals or conference proceedings.

In fact, it is almost always possible to devise a technically sophisticated and plausible explanation for even grossly contradictory evidence or, in some cases, the absence of evidence that one might logically expect. As Penrose indicates, particle physics contains several examples of this, not just supersymmetry. When particle physicists were unable to find free quarks, the putative building blocks of protons and neutrons, in experiments in the 1970s and 1980s, they discovered that Quantum Chromodynamics (QCD), the leading candidate for the theory of the force between quarks, predicted that the force between quarks rose with distance, making free quarks impossible. A Nobel Prize was recently awarded for this theory, a theory arguably confirmed by a lack of evidence! The neutrino was postulated to explain otherwise grossly contradictory evidence in radioactive decays; there is strong positive evidence that the neutrino exists.

It is not *always* possible to devise a technically sophisticated and plausible explanation for contradictory evidence. In recent centuries, we have accumulated truly overwhelming evidence that the Earth is not flat and is roughly a sphere about 8000 miles in diameter. Many people have now circumnavigated the Earth in many directions in planes and ships. It is probably fair to say that the ancient theory that the Earth is a sphere – found in Aristotle's *On the Heavens*, Plato's *Timaeus*, Claudius Ptolemy's *Almagest*, and other ancient sources – has become a proven fact. This level of certainty, however, is very unusual in science.

Mainstream scientific fields have frequently devised technically sophisticated and plausible explanations for even grossly contradictory evidence or, in some cases, the absence of expected evidence. This is not unusual. Modern mainstream scientific fields are often very heavily funded. The US Department of Energy spends several hundred million dollars per year on particle physics. Mainstream fields have the resources and manpower to develop extremely sophisticated polished explanations for contradictory evidence and to promote these explanations heavily. In this respect, mainstream science usually has a great advantage over alternative or fringe science which usually has very limited funds either to critique the established view or to develop its own arguments to a high technical level.

A skilled attorney can argue any side of an issue or court case convincingly. The same can be said of opportunistic politicians and public relations experts. Science is closer to law, politics, and public relations than generally recognized.

Most probably, technically sophisticated and plausible explanations for otherwise grossly contradictory evidence or, in some cases, the absence of evidence should be viewed as a warning sign, a yellow flag, whether they are encountered in mainstream or alternative science.

Such arguments can be correct. There is good evidence for the neutrino, for example. These explanations can also be very wrong and this has often been the case in history. By this criterion, particle physics and many other mainstream scientific fields today contain many warning signs of problems.

About the Author

John F. McGowan, Ph.D. is a software developer, research scientist, and consultant. He works primarily in the area of complex algorithms that embody advanced mathematical and logical concepts, including speech recognition and video compression technologies. He has many years of experience developing software in Visual Basic, C++, and many other programming languages and environments. He has a Ph.D. in Physics from the University of Illinois at Urbana- Champaign and a B.S. in Physics from the California Institute of Technology (Caltech). He can be reached at jmcgowan11@earthlink.net.

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[1] Roger Penrose, *The Road to Reality: A Complete Guide to the Laws of the Universe*, *Chapter 34.4 Can a wrong theory be experimentally refuted?*, Alfred Knopf, New York, 2006, p. 1020