PHYSICS TODAY

Readers Elaborate on Fashion and Truth, Fact and Theory

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Physics Today **56** (12), 16 (2003);
https://doi.org/10.1063/1.4796940

SU(4) flavor symmetry should be considered. Of course, it eventually turned out that this is not the correct way to deal with the new facts.

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Highlighted in Michael Riordan's Opinion piece is the danger of relaxing the criteria for what constitutes scientific fact. He is, however, in danger of blunting a valuable new tool of science when he identifies computer experiments as part of the problem rather than part of the solution.

Fifty years ago, Enrico Fermi, John Pasta, and Stanislaw Ulam invented the computer experiment and predicted recurrence in nonlinear systems. They programmed the early MANIAC computer at Los Alamos Laboratory to simulate an array of 64 weakly coupled nonlinear oscillators. The researchers expected the array to relax into a random equipartition of energies. Instead, it periodically returned to the starting condition. Fermi affectionately referred to that phenomenon as a "little discovery."[1] Since then, Fermi-Pasta-Ulam recurrence has been experimentally confirmed and has become a key concept in understanding the behavior of complex nonlinear systems.

A few years ago, NSF Director Rita Colwell gave a talk in which she referred to simulation as "the third branch of science."[2] She based that statement on the use of computer simulation in fields such as astrophysics and Earth sciences, where system complexity prevents evaluation of theoretical predictions by any means other than computer simulation. In those fields, computer simulations bridge the gap between theory and experiment for complex nonlinear systems so that the theoretical predictions can be compared far more precisely to experimental results. Without simulations, approximations must be used, which limit accuracy and introduce unknown errors into predictions.

Thus, computer modeling and simulation are primarily theoretical tools. A powerful adjunct for the theorist, they provide additional predictions but never replace experiment. For example, the numerical predictions of gravity-wave emission from merging black holes are beyond analytical check and will only be confirmed with data from the Laser Interferometer Gravitational-Wave Observatory (LIGO) and other experiments. Modeling and simulation can point to new directions for both experimental and theoretical investigation, so they truly merit being called the third branch.

References

1. S. Strogatz, *New York Times*, 4 March 2003, p. A25.
2. R. R. Colwell, "Complexity and Connectivity: A New Cartography for Science and Engineering," remarks from the American Geophysical Union's fall meeting, San Francisco (1999). Available online at http://www.nsf.gov/od/lpa/forum/colwell/rc991213agu.htm.

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I greatly enjoyed Michael Riordan's Opinion piece criticizing the Platonic aspects of contemporary theoretical physics. He is right that several of today's research areas—superstrings, wormholes, and extra dimensions, for example—have cut loose almost completely from experimental reality.

Unfortunately, though, Riordan's arguments were undercut by his appeals to Charles Sanders Peirce and the pragmatist definition of truth. Although I believe Riordan is right to be proud of physicists' discovery of quarks, that feeling would not be justified if the reality of quarks meant merely that experienced practitioners agree that quarks are a "convenient rubric," as Riordan called it, for mocking up the observable consequences of certain experiments. That was also true of Ptolemy's epicycles, phlogiston, and Lamarckian evolution—not to mention young-Earth creationism. No, the discovery of quarks is impressive because they are more than a useful fiction; as proved by experiment, they really do exist outside our imaginations.

The pragmatist notion of truth is based on radical philosophical skepticism and leads logically to outright subjectivism—the claim that all scientific theories are mere "fanciful ideas and constructs." And like the Platonism that Riordan criticizes, that kind of error has done real damage to physics.

Consider, for example, Andreas Osiander's plea that Copernicus didn't really mean it, Ernst Mach's bizarre and influential refusal to believe that atoms represented more than a useful rubric for organizing experience, and the ongoing refusal to face and fix what John Bell called the "unprofessionally vague and ambiguous" foundations of quantum theory.[1] This refusal is usually based on the claim that the wavefunction is merely a mental construct, and does not refer to physical reality (see the Opinion piece by Christopher Fuchs and Asher Peres, PHYSICS TODAY, March 2000, page 70). Consider also the contemporary attacks on science from the social-construction crowd; as those attackers point out, the pragmatist conception of truth gives scientists the same claim to know reality as any other group: none.

Pitting science against Platonism tells only half the story. What makes the scientific method unique is that it rejects both Platonism and skeptical subjectivism. Unlike Platonism, science demands that its conclusions be based on hard, empirical evidence. But science also rejects the idea that we are cut off from true reality, forever confined to superficial appearances, subjective constructs, and useful fictions.

At its best, science neither rejects empirical evidence in favor of rationalist flights of fancy nor dismisses as impossible the task of uncovering deep truths about the external world. Instead, it demonstrates, in the face of both traditional philosophical approaches, that hidden realities can be reliably grasped by means of empirical evidence. And that is an achievement all physicists can be proud of.

Reference

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The Opinion column by Michael Riordan was thoroughly enjoyable. I agree with his overall view, with only one or two exceptions. He says that "good experimenters are irredeemable skeptics who thoroughly enjoy refuting the more speculative ideas of their theoretical colleagues." True, but the history of physics abounds with stories of bad experimenters who got self-duped while trying to confirm their own pet theories. Also, I have another model for the term "Platonic physics." Rather than Riordan's philosophical view, I go by the much more pedestrian idea of Platonic love. In both Platonic