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Physics of Philosophy

On Unifying Physics

Eternal must that progress be
Which Nature through futurity
Decrees the human soul;
Capacious still, it still improves
As through the abyss of time it moves,
Or endless ages roll.

- "On the Powers of the Human Understanding" by Philip Freneau (1752-1832)

Unifying physics with a final theory presents itself as a formidable goal for theoretical physicists working with the most fundamental ideas of nature. Numerous attempts at unifying the current theories of today's physics are being made by courageous physicists. Our most fundamental theories provide quite an accurate account of nature, but so far, are not complete. This essay will explore the possibility that an ultimate theory of nature exists and that physicists may find it. If a completely unified theory of nature can be formulated, it seems likely that indeed physicists of the future will discover it.

The history of physics has shown that unification brings about more understanding of natural phenomena. Our physical theories unify nature, and bring together our ideas of physical reality. Thus, the likelihood of future physicists discovering a final theory hinges on theoretical advancement, which in turn relies on experimental advancement. It is interesting to note then, how experiment and theory play their roles in the partnership for unification. Where does the problem with unifying physics lie? Does the problem of unification lie in finding the theory, or testing it? Michio Kaku, believes that the problem is theoretical:

"I don't think that we have to wait a century until our accelerators, space probes, and cosmic-ray counters will be powerful enough to probe the tenth dimension indirectly."[1]

He feels his particular specialization of physics, string theory, contains enough structure and originality that it *will* be tested and he feels that there is no problem experimentally, when the issue comes to unifying physics. He truly sides with the optimists that our technology will certainly be powerful enough one

[1]Kaku, Michio. Hyperspace, Oxford University Press, (1994), pg 189.

day to test any beautiful theory. On, another side of the argument, the problem may be precisely experimental, as suggested by Feynman:

"The end of the line may happen when the experiments get harder and harder to make, more and more expensive, so you get 99.9 percent of the phenomena, but there is always some phenomenon which has just been discovered, which is very hard to measure, and which disagrees; and as soon as you have the explanation of that one there is always another one, and it gets slower and slower and more and more uninteresting."[2]

To clarify Feynman's point, take for instance, Joseph Lykken recent article in *Physics Today*, where he points out that gravitational physics consisted of a few cheap table-top experiments and now with the advent of the Laser Interferometer Gravitational-Wave Observatory, the gravity program is competing for the big dollars.[3] As experiments become more expensive, it is recognized that basic research in physics is a major undertaking of our civilization. The requirement of more and more money to fund better experiments can be alarming. And although exciting, it is disturbing that there may be a gap that will widen between theory and experiment, and one or the other may stall scientific progress. Obviously a final theory will only be found if both theory and experiment agree consistently with each other and the communication between practitioners of both, remain solid.

This speculation, that the final theory may be obstructed by either a theoretical or an experimental handicap, leads me to believe that the end is far from reach. Clearly, only close collaboration between the experimentalists and theorists will result in a final theory, if one does exist, and for the minds of theorists to create such a theory, experiment cannot be running miles behind. Experiments govern our view of reality.

If we hope to cross a finish line, the companionship of theory and experiment remains a central priority. I offer two views on whether the finish line is in sight. Kip Thorne, suggests the seeds for revolution have been laid, he insists there will be surprises that may radically alter our view of the universe, and we will probably learn the details of unification in the coming century. While he believes the point may very well come in his lifetime,[4] Michio Kaku suggests the 'great ideas' of science have already been found, and the finish line is no longer fundamental unification or unraveling the secrets of nature, but becoming masters of the universe, and applying our knowledge *to* the universe:

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[2]Feynman, Richard. The Character of Physical Law MIT Press, (1965), pg 172

[3]Lykken, Joseph. "Crisis in Physics?" *Physics Today*. Vol. 55, Number 11. Nov. 2002, pg 56-57.

[4]Thorne, Kip. Black Holes and Time Warps: Einstein's Outrageous Legacy W.W. Norton and Company, (1994), pg 525.

'Modern science has no doubt uncovered the fundamental laws underlying most of the disciplines of science: the quantum theory of matter, Einstein's theory of space-time, the Big Bang theory of cosmology, the Darwinian theory of evolution and molecular basis of DNA and life. Despite some notable exceptions (e.g. determining the nature of consciousness and proving superstring theory is the fabled unified field theory) the 'great ideas' of science for the most part, have probably been found."[5]

Nature certainly has huge fundamental surprises up her sleeves, and I suggest that we stay humble and persistent in our questions as we learn about Nature. History has shown that we will be blown away when we feel most certain and solid about the character of physical laws and principles. Perhaps Kaku's notable exceptions will determine how much further we have to go, and how much more revolutionary fundamental ideas are still awaiting our discovery.

But merely because the end may be far from our reach, we cannot rule out the possibility of *an* end. Hopes for an end must therefore be tempered by experimental verification, and grounded in the history of our physical discovery. The empirical history must be shown to converge to a point, while the practice of unification must be shown to encompass far more predictive power than the unification before it. In this recipe, I also suggest the addition of the invaluable partnership of theory and experiment.

Proving empirical history converges to a point is somewhat of an impossible task, and can only be somewhat realized by looking at our past, seeing how theory and experiment have held hands, and realizing the graph of empirical history may not be as exponential as it has been in the last 200 years.

Though, the evidence has shown that revolutions in physics has given man great predictive power, with the advent of quantum mechanics numerous technologies have proven invaluable and shown the predictive capabilities new unifications yield.

Richard Feynman had something to say about final theories, and I offer a short dialogue that might have occurred if I had been able to converse with him about this philosophical conjecture.

Michael Good: I claim that because there are patterns in the universe, that because experiment can be done, and because theories become better at describing nature, that there exists a way to explain the entire 'pattern' of the universe. There exists a final theory, a theory of everything.

Richard Feynman: Why bother making such a claim? Physics needs no such goal, it is meaningless to discuss whether there exists such a final theory,

[5]Kaku, Michio. Visions, Anchor Books, (1997), pg 9.

why not explore and find out as much as is possible about nature, and let nature tell you whether such a theory exists.

MG: I make this claim in order to rally support for the grandiose task physicists are undertaking. I make this claim, not merely for philosophical purposes, but for motivation of the public for the physicists, motivation of the physicists for their work, and as a way of instilling hope and inspiration that mankind is capable of divining the ultimate secrets of nature. I also believe the universe at its core is understandable.

RF: There is no danger in making a guess. Whether or not nature has an ultimate, simple, unified, beautiful form is an open question, and I don't want to say either way.[6] I want to find out as much as I can about nature, and not to presume ahead of time. I believe you do not appreciate the number of things not understood today. The answer is not so close as it may seem[7], and claiming that indeed a final theory exists, is a claim that cannot be experimentally verified. It *may* exist, but until we have it, it seems unimportant to me to be bothered by philosophical conjectures.

MG: You do not see how it can help rally physics? How having a goal, and direction for physics can lead to more support, more grant money, more funding?

RF: I do see that, but it can be harmful if everyone believes the same thing. We need diversity, and open-minds in physics. Merely saying there is an ultimate unification does not specify what kind of unification.[8] There may be other possibilities, and in fact, I see the devotion to uncovering a final theory without strict regard to experimental evidence as the wrong motivation for doing physics. Physics is like sex, sure it produces practical results, but that's not why we do it.

MG: I do physics for the love of exploration, satisfaction of curiosity, fun and discovery. But I also do physics in the hope that all may be 'conquered'. I claim we will completely learn the rules of the universe. I see it as positive to have this goal in mind, to imagine that we may grasp the universe with our minds. As the famous chess analogy goes, I see the universe as a challenging game of chess, where we observe and experiment by moving the pieces, and discovering what can and can't be done. As time progresses we are learning more and more of the rules of chess. We may be horrible players now, but learning what is allowed comes much easier, and it is exciting to find out the rules and laws of this fascinating place we live in.

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[6] P.C.W. Davies and J. Brown. Superstrings A Theory of Everything? Cambridge University Press, 1988, pg 193.

[7] Ibid, pg 192.

[8] Ibid, pg 196.

RF: I agree with you except for the need to 'conquer'. I do physics for fun and fun alone. I do not want to subscribe to any final theory hypothesis. I am not afraid of this ignorance. I see it as negative to have a final goal in mind, when it locks you in a mind set. In order to do physics better, in order to be flexible and open to new ideas, I will not subscribe to your final theory hypothesis. I believe it is foolish to presume there exists a final theory, and to adhere to an idea without experimental predictions or verification.

MG: I see your point, but it leaves me dissatisfied, I want a goal in mind, I want to feel optimistic that our civilization may one day understand all there is, I want hope, and comfort in the idea that all may be unified!

RF: Fine! I'm not saying to not believe, I'm just saying that I don't believe it, and physicists don't need it to do physics!

A basic outline of this debate is simple:

Michael Good: Nature allows a complete unification of the fundamentals. Having this goal is a positive influence on physics.
Richard Feynman: Nature might or might not allow complete unification. Having this goal could be negative to physics.

MG: Taking a philosophic stance.
RF: Refusing to commit to stance.

MG: Doing physics for enjoyment, pleasure, and excitement, but also with a final purpose and goal in sight.
RF: Doing physics purely for the love of exploration, satisfaction of curiosity, fun and discovery.

Though the ideas are simple, they are subtle. John D. Barrow notes that because such a unification is even sought tells us something important about our expectations regarding the Universe, namely,

"These expectations we must have derived from an amalgam of our previous experience of the world and our inherited religious beliefs about its ultimate Nature and significance. Our monotheistic traditions reinforce the assumption that the Universe is at root a unity, that it is not governed by different legislation in different places..."[9]

Perhaps when I told Feynman, " I want hope, and comfort", that I am telling him I want God. And my beliefs are influenced by tradition and the Western culture, and that this is in turn affecting the way I do physics, 'searching for

[9] John D. Barrow. Theories of Everything: The Quest for the Ultimate Explanation Ballantine Books, New York, 1991. pg 22.

unity, searching for God.' This mode of thinking is interesting, but I foresee my mistakes. It seems we can slip down this philosophical path and fall into a great hole if we don't try to stay as close as possible to the physics. Therefore it seems to me that Feynman's non-philosophical stance is a very open-minded, and free flowing way of thinking. Understanding that physics typically doesn't need philosophic preconceptions to progress, and that the guidance of philosophers generally doesn't influence the way a physicist works. I enjoyed reading this analogy by Weinberg and I believe it clarifies the situation:

"In our hunt for the final theory, physicists are more like hounds than hawks; we have become good at sniffing around on the ground for traces of the beauty we expect in the laws of nature, but we do not seem to be able to see the path to truth from the heights of philosophy."[10]

Claiming a final unification is possible is making a philosophic claim, and this is not practicing physics. This claim cannot be verified until all experiments agree soundly with an all-encompassing theory of physics. It makes sense to me that it doesn't hurt to guess all of physics will be unified, but making the claim is not advised as Feynman recommends. Doing physics is important, with whatever motivation you like. But it's the action that counts, the science that matters. It would be safe to claim, with empirical history as evidence, that more unification is possible, more understanding of physical laws and principles will occur, and that the search for unification is justified, with plenty of diversity in motivation.

References

[1] Barrow, John D. Theories of Everything: The Quest for Ultimate Explanation Ballantine Books, New York, (1991).

[2] Davies, P.C.W. and J. Brown. Superstrings: A Theory of Everything? Cambridge University Press, (1988).

[3] Feynman, Richard. The Character of Physical Law MIT Press, (1965).

[4] Kaku, Michio. Hyperspace: Oxford University Press, (1994).

[5] Kaku, Michio. Visions: How Science Will Revolutionize the 21^{st} Century Anchor Books, (1997).

[6] Lykken, Joseph. "Crisis in Physics?" *Physics Today.* Vol. 55, Number 11. Nov. 2002, p 56-57.

[7] Thorne, Kip. Black Holes and Time Warps: Einstein's Outrageous Legacy W.W. Norton and Company, (1994).

[10] Steven Weinberg. Dreams of a Final Theory Vintage Books, New York, 1994. pg 167.

[8] Weinberg, Steven. Dreams of a Final Theory Vintage Books, New York, (1994).