Where Do the Laws of Nature Come From?: Steven Weinberg

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Transcript - Long

Robert Lawrence Kuhn:

Steve, when you think about the laws of nature, laws of physics, how do you characterize them or categorize them?

Steven Weinberg:

That's great discovery that nature is governed by laws. This is something that wasn't apparent for a long time. It used to be thought that everything had to be explained by the intervention of some nymph or god or something. In fact, the idea of laws of nature was rejected by a Muslim philosopher Al-Ghazali in the 13th Century on the grounds that the very concept put god in chains. You know, that things happen not because there are laws of nature, but because god wants them to happen that way. And he gave, for example, the idea of burning a piece of cotton, the cotton burns not, turns black not because of the fire but because god wants it to turn black. Of course, that attitude makes science difficult. We have all kinds of laws and the engineering student learns various laws, Ohm's law which tells you how current and resistance and voltage are related and electric circuit and so on. Many of these laws are derived by deeper laws. In fact, that's true of most of the laws we learn as, as students. And some of them are purely empirical; we don't know why they work. But most of the ones that have been well tested have then been understood on the basis of deeper laws, I mean, for example, Ohm's law, we understand on the basis of theory of electricity and magnetism, together with certain assumptions about the way electric currents move in, in solids. We keep peeling away deeper laws and deeper laws. The most useful laws are not necessarily the deepest ones. An electrician doesn't need to know about why Ohm's law is true. And, in fact, for many purposes the laws of nature that we have now are perfectly adequate. For example, I think it's very unlikely that any future discovery in physics will have any implications at all for biology, because the laws of chemistry and biology ... the laws of chemistry and physics that we have are adequate now insofar as they, insofar as we all can understand biology, the lack of understanding is not because of any failure of understanding the laws. And we know why chemistry works the way it does in terms of the laws of physics, at least in the sense that there are no future discoveries in physics that will improve our understanding of chemistry. But we desperately want to know why things are the way they are and we want to peel away and understand why the laws that we have now are the way they are. The deepest laws that we have at present, the laws that, from which all other laws can be deduced insofar as they can be deduced from anything are the laws of the standard model, a set of equations governing quantum fields which manifest themselves as various particles, electrons and quarks and photons. And the next big step is to say why is the standard model the way it is. That's not a final law. What is underneath that, we don't know.

Robert Lawrence Kuhn:

You've talked about beauty and elegance in describing physics and the physical world. Tell me what you mean by that.

Steven Weinberg:

I'm not too sure what I mean by elegance. Elegance is usually used as a term of approval of intellectually athleticism, you know, someone does something very elegantly, if he or she does it with a minimum of mathematical effort. Beauty I think is, is a more serious quality. We, or at least I, think of a theory as being beautiful if you can see that it is the way it is, that it hasn't been jiggered to work out, to fit the data. None of our theories is entirely beautiful in that sense; they all have certain arbitrary features. But the more rigid they are, the more they are based on a simple principle without any fine tuning, the way, the more they flow from a simple assumption and...

Robert Lawrence Kuhn:

And the richness they produce.

Steven Weinberg:

Yes, and yet produce, and yet encompass a tremendous variety of phenomenon, the more beautiful they are. Einstein's general theory of relativity is very beautiful because it, it describes all the phenomenon associated with gravity in terms of a simple assumption about the equivalence of gravitation with inertia, and it, it, plus a little bit of extra assumption which Einstein didn't actually recognize adequately, that the equations shouldn't be too complicated in their form. He rejected certain complications he could have included in the equations, somewhat arbitrarily. We understand now better than he did, why those equations have to take the simple form he assumed. But it's a very beautiful theory, in some ways it's an archetype of a beautiful theory. Quantum electro dynamics is another beautiful theory. It's the theory of electrons and photons. And again, with certain assumptions about the equations not being too complicated it can't be, you can't fool around with it, it is the way it is, it makes predications that are accurate to nine decimal places, fantastically accurate assumptions. But today, we understand quantum electro dynamics on the basis of a deeper theory, the modern standard model of elementary particles, which is, describes a much richer variety of phenomenon, in a way is less beautiful, but much more comprehensive and has quantum electro dynamics as a consequence.