THE MARTIAN
OCTOBER 2
WATCH TRAILER

The New York Times | http://nyti.ms/1cAi5hg

SCIENCE

Finding the Higgs Leads to More Puzzles

NOV. 4, 2013

Dennis Overbye
OUT THERE

Near the end of "The Tempest," in what has been taken as Shakespeare's farewell speech, the sorcerer Prospero breaks his staff and declares, "Our revels now are ended." And he goes on:

"These our actors, as I foretold you, were all spirits and are melted into air, into thin air: and ...leave not a rack behind."

The latest word from physics is that something like that ending may be in store for the universe. In this case, the role of Prospero is played by the Higgs field, an invisible ocean of energy that permeates space, confers mass on elementary particles and gives elementary forces their distinct features and strengths.

The field, theoretical for 50 years, took on real life last year when physicists at CERN in Europe discovered the Higgs boson, a sort of droplet of Higgs energy. The world rejoiced, and two of the chief theorists, Peter Higgs and François Englert, will share a Nobel Prize. But studies of the new boson suggest it could have a fatal disease.

As Joseph Lykken, a theorist at the Fermi National Accelerator Laboratory, and Maria Spiropulu, of the California Institute of Technology, put it in a new paper reviewing the history and future of the Higgs boson:

"Taken at face value, the result implies that eventually (in 10^{100} years or so) an unlucky quantum fluctuation will produce a bubble of a different vacuum, which

will then expand at the speed of light, destroying everything."

The idea is that the Higgs field could someday twitch and drop to a lower energy state, like water freezing into ice, thereby obliterating the workings of reality as we know it. Naturally, we would have no warning. Just blink and it's over.

End times are part of a science reporter's stock in trade, of course. The death of the sun, dark energy sucking galaxies, greenhouse gas catastrophes, comets and asteroids boiling the oceans, apocalyptic earthquakes and plagues are regularly paraded through these pages.

Maybe I'm just getting old and I've lost whatever Zen detachment I might have pretended to have, but to me this is the most depressing end-of-days vision I've encountered. It would be as if we'd never existed at all. Talk about a particle with Godlike properties.

But cheer up. That is only one of many scenarios that are emerging as physicists try to reconcile the CERN discovery with what they thought they knew. You might think that finding the Higgs boson, after 50 years and $10 billion or so, would bring clarity to physics and to the cosmos. But just the opposite is true: they may have found the Higgs boson, but they don't understand it.

In particular, they don't understand why it weighs what it does — it is about 125 times as massive as the protons that were collided to make it, not gazillions of times as heavy, as standard quantum mechanical calculations would suggest.

That is because when they do the math, physicists have to include the effects of the Higgs's interactions with all other particles, even the ones that aren't there, so-called virtual particles that wink in and out of existence on borrowed energy. This zooms the mass all the way up to the top of the scale, like one of those carnival games where you hit a scale with a sledgehammer: 10 quadrillion trillion electron volts, otherwise known as the Planck energy, where gravity and the other particle forces are theoretically equal.

For years the preferred solution to this conundrum has been a theory called supersymmetry, which, among other things, predicted the existence of a whole new spectrum of particles, superpartners of the ones we already know, that would

cancel out the quantum calculations and keep the Higgs light. One of these particles might also be the dark matter that makes up a quarter of the universe by weight.

It's such a beautiful theory that if Einstein were alive today he might say, as he did of his theory of general relativity, that "I would have been sorry for the dear Lord" if it were disproved.

Alas for the Lord, experiments at CERN's Large Hadron Collider have already eliminated the simplest versions of supersymmetry. That doesn't mean anything yet. Two years ago, many physicists were about to give up on the standard version of the Higgs boson, because it hadn't shown up. Then it did.

Likewise, some advocates of supersymmetry are now suggesting that it could take an even more powerful collider — say, tunneling under Lake Geneva — to smoke out a supersymmetric particle.

The most talked-about alternative to supersymmetry is the idea of the multiverse, an almost infinite ensemble of universes in which the value of the Higgs — as well as many other crucial parameters — is random. We just happen to live in the one in which the conditions and parameters are fit for us. This is a notion that flows naturally from string theory and modern theories of the Big Bang, but accepting multiple universes means giving up the Einsteinian dream of a single explanation for the cosmos, a painful concession.

Steven Weinberg, of the University of Texas at Austin, who won his Nobel in 1979 for using the Higgs theory to unify two of the forces of nature, declared mournfully in The New York Review of Books: "Physical science has historically progressed not only by finding precise explanations of natural phenomena, but also by discovering what sorts of things *can* be precisely explained. These may be fewer than we had thought."

But there is still hope, at least for Einstein.

In a talk this spring in Germany, Dr. Lykken called the choice between supersymmetry and multiple universes "a false dichotomy."

There is a third way, he says, to keep the Higgs mass in bounds. That is by

saying that its mass comes entirely from the virtual particles winking in and out of life around the particle. To make this scheme work, however, physicists have to abandon popular speculations of how the forces of nature are unified at "superhigh energies," Dr. Lykken admitted in an email.

The bonus, he said, is that the same idea can generate the mass for dark matter particles, the invisible swarm in vast clouds that form the gravitational cradles for galaxies. In that case, dark matter could interact with the visible matter by means of a "dark" Higgs boson, something that will be testable in underground dark matter experiments like LUX, in South Dakota, which just announced it had come up empty so far.

It's an exotic but hardly irrelevant subject. "The details of how dark matter works will end up determining whether the vacuum is unstable and, if so, how long it will last," Dr. Lykken wrote.

It may all depend on the exact mass of another particle, the top quark. Gian Giudice of CERN, who did some of the first calculations of the new Higgs and found the universe teetering on Shakespearean dissolution, said, "The near criticality of the universe is the most important thing we have learned from the discovery of the Higgs boson so far."

It might be, as Prospero put it, that we really are such stuff as dreams are made on. But we may have to wait longer than the age of the universe to find out.

A version of this article appears in print on November 5, 2013, on page D1 of the New York edition with the headline: Finding Higgs Merely Opens More Puzzles.

© 2015 The New York Times Company