Physicists propose Higgs boson 'portal' as the source of this elusive entity

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One of the biggest mysteries in contemporary particle physics and cosmology is why dark energy, which is observed to dominate energy density of the universe, has a remarkably small (but not zero) value. This value is so small, it is perhaps 120 orders of magnitude less than would be expected based on fundamental physics.

Resolving this problem, often called the cosmological constant problem, has so far eluded theorists.

Now, two physicists – Lawrence Krauss of Arizona State University and James Dent of University of Louisiana-Lafayette – suggest that the recently discovered Higgs boson could provide a possible "portal" to physics that could help explain some of the attributes of the enigmatic dark energy and help resolve the cosmological constant problem.

In their paper, "Higgs Seesaw Mechanism as a Source for Dark Energy," Krauss and Dent explore how a possible small coupling between the Higgs particle, and possible new particles likely to be associated with what is conventionally called the Grand Unified Scale – a scale perhaps 16 orders of magnitude smaller than the size of a proton at which the three known non-gravitational forces in nature might converge into a single theory – could result in the existence of another background field in nature in addition to the Higgs field, which would contribute an energy density to empty space of precisely the correct scale to correspond to the observed energy density.

The paper is published on line today (Aug. 9), in *Physical Review Letters*.

Current observations of the universe show it is expanding at an accelerated rate. But this acceleration cannot be accounted for on the basis of matter alone. Putting energy in empty space produces a repulsive gravitational force opposing the attractive force produced by matter, including the dark matter that is inferred to dominate the mass of essentially all galaxies, but which doesn't interact directly with light and therefore can only be estimated by its gravitational influence.

Because of this phenomenon and because of what is observed in the universe, it is thought that such 'dark energy' contributes up to 70 percent of the total energy density in the universe, while observable matter contributes only 2 to 5 percent, with the remaining 25 percent or so coming from dark matter.

The source of this dark energy and the reason its magnitude matches the inferred magnitude of the energy in empty space currently is not understood, making it one of the leading outstanding problems in particle physics today.

"Our paper makes progress in one aspect of this problem," said Krauss, a Foundation Professor in Arizona State University's School of Earth and Space Exploration and in Physics, and the director of the Origins Project at ASU. "Now that the Higgs boson has been discovered, it provides a possible 'portal' to physics at much higher energy scales through very small possible mixings and couplings to new scalar fields which may operate at these scales."

"We demonstrate that the simplest small mixing, related to the ratios of the scale at which electroweak physics operates, and a possible Grand Unified Scale, produces a possible contribution to the vacuum energy today of precisely the correct order of magnitude to account for the observed dark energy," Krauss explained. "Our paper demonstrates that a very small energy scale can at least be naturally generated within the context of a very simple extension of the standard model of particle physics."

While a possible advance in understanding the origin of dark energy, Krauss said the construct is only one step in the direction of understanding its mysteries.

"The deeper problem of why the known physics of the standard model does not contribute a much larger energy to empty space is still not resolved," he said.

More information: prl.aps.org/abstract/PRL/v111/i6/e061802

Provided by Arizona State University

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