Texas Physicist Makes New Advance For Theory Of Quantum Gravity College Station - Feb. 21, 2001

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In 1905, Einstein made major changes to laws of physics when he established his theory of relativity. Now Einstein's laws might also undergo significant changes.

Dimitri Nanopoulos, who holds the rank of Distinguished Professor of Physics at Texas A&M University and heads the Houston Advanced Research Center's Group for Astroparticle Physics, established, along with other physicists, that the speed of light, instead of being the constant value of 186,282 miles per second, might change.

In 1905, Einstein established that light was the only object to have a constant speed in all reference frames. This idea was the cornerstone to his theory of relativity, and later to laws of physics.

"If the speed of light proves not to be constant any more, even by a very small changeable amount, laws of physics - the theory of relativity included - will have to undergo significant changes," says Nanopoulos.

Nanopoulos, who chairs the Theoretical Physics Division of the Academy of Athens, is among the many physicists who are trying to establish the basis of quantum gravity, a theory that has been dreamed of by physicists since the 1920s.

While they were doing mathematical calculations, Nanopoulos and physicists Nikolaos Mavromatos of King's College in London and John Ellis of the European Center for Particle Physics (CERN) in Geneva, discovered a new expression for the speed of light, which depends on its frequency.

"Through our calculations, we found that the speed of light is frequency - dependent," says Nanopoulos. "But a change in the usual speed of light value of 186,282 miles per second is noticeable only for light coming from astronomical objects situated very far from Earth, which is why this frequency dependence has not been noticed so far."

Physicists are setting up the theory of quantum gravity to put together two major discoveries of physics in the 20th Century: the theory of relativity and quantum physics.

The theory of relativity explains both how space and time are related to each other and how gravitation works. Quantum physics describes the workings of the microscopic world, where laws of probability replace the deterministic view used to describe our everyday world.

Until now, physicists have been considering many scenarios for quantum gravity, but these scenarios have never been experimentally confirmed.

The hypotheses put forward by Nanopoulos and his collaborators has been under experimental scrutiny, and the results obtained during the last few months are encouraging.

"One way to experimentally test our hypothesis is to consider galaxies or other objects in the sky that are very far from us," says Nanopoulos. "Then we collect the photons (particles of light) simultaneously emitted by these sources, and we look at differences of arrival times in a detector on earth between photons of different frequencies. The photons of higher frequencies should come later."

The frequency - dependent expression of the speed of light depends on the gravitational constant, a quantity that is known since Newton established his law of gravitation.

By using the differences in photon arrival times of six astronomical sources, Nanopoulos and his collaborators estimated an upper bound of the value of the gravitational constant from the data, and compared their results with the expected value.

"We were amazed to see that if we use all these astronomical data, we find very reasonable values for the gravitational constant," says Nanopoulos. "That was our first surprise: the fact that, put together, a bunch of data that had nothing to do with the gravitational constant, gave us values so close to what we would expect to find."

A second experimental encouraging result about the frequency - dependence of the speed of light was provided by the HEGRA (High Energy Gamma Ray Astronomy) experiment, which is detecting photons from outer space, and is situated in La Palma, Canary Islands.

The frequency - dependent expression of the speed of light was used to solve a problem faced by three physicists: Tadashi Kifune, from the University of Tokyo in Japan, Ray Protheroe, from the University of Adelaide in Australia, and Hinrich Meyer, from the University of Wuppertal in Germany.

The problem occurred when HEGRA physicists detected very energetic photons emitted by the galaxy Markarian 501.

"The most energetic of these photons were expected to interact with other very low-energy photons from the infrared background radiation, which is a radiation present since the early universe," says Nanopoulos. "When a very energetic photon interacts with a low-energy photon, they have just the right quantity of energy to create an electron-antielectron pair. But physicists at HEGRA did not see the expected electron-antielectron pairs, but did observe very energetic photons instead.

"By using the frequency-dependent expression of the speed of light, Kifune, Protheroe and Meyer found that the combined energy of each type of photon was not enough to create an electron-antielectron pair," adds Nanopoulos. "That is why no electron-antielectron pair has been observed."

If by looking at more energetic photons, HEGRA never detects the expected electron-antielectron pairs, this would provide further support of the new hypothesis put forward by Nanopoulos and his collaborators.

"This frequency-dependence of the speed of light changes drastically our view of the theory of relativity," Nanopoulos says. "It is also the first time that we have a window of opportunity to study quantum gravity, and thus scientifically study the origin of the universe. It is a fantastic thing that we can experimentally magnify such a tiny effect."

Nanopoulos says that if the frequency-dependence of the speed of light is further confirmed by other experiments, the theory of relativity would still be valid under certain circumstances.

"There is nothing wrong with Einstein's theory of relativity. If the energy of an object is much smaller than 10^19 proton masses or if the distance between two objects is smaller than millions of light years, Einstein's equations are still valid," he says.