NYU's Dvali says change in laws of gravity, not 'dark energy,' source of cosmic acceleration

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New York University physicist Georgi Dvali concludes that the cosmic acceleration of the universe may be caused by the modification of standard laws of gravity at very large distances, and not by "dark energy," as posited by many in the field. This modification, Dvali argues, could be triggered by extra space dimensions to which gravity "leaks" over cosmic distances. Dvali's presentation took place at the annual meeting of the American Association for the Advancement of Science (AAAS) in Washington, D.C.

"The accelerated universe can be a window of opportunity for understanding the most fundamental aspects of gravitation, and may signal the modification of standard laws of gravity at very large distances," says Dvali.

Dvali acknowledges that physicists have yet to establish why the expansion of the universe is accelerating. Some have rationalized that because laws of physics dictate that gravity is generated by matter and energy, gravitational changes in the universe must be attributable to matter or energy. This forms the theoretical basis for dark energy, which some describe as undetectable matter or energy.

However, there are no independent experimental tests or established theoretical foundations for the existence of such a substance, which opens the door for alternative explanations.

In his AAAS talk, Dvali draws from string theory, which predicts that the universe has extra dimensions into which gravity may be able to escape. This "leakage" would alter the space-time continuum and accelerate cosmic expansion. Dvali, along with NYU colleagues Gregory Gabadadze and Massimo Porrati, propose that these extra dimensions are exactly like the three dimensions we encounter on a daily basis. Furthermore, gravitons--emitted by stars and other objects on the universe's brane (or three-dimensional surface)--can escape into extra dimensions if they travel certain critical distances.

"The gravitons behave like sound in a metal sheet," says Dvali. "Hitting the sheet with a hammer creates a sound wave that travels along its surface. But the sound propagation is not exactly two-dimensional as part of the energy is lost into the surrounding air. Near the hammer, the loss of energy is small, but further away, it's more significant."

Dvali posits that this leakage has a profound effect on the gravitational force between objects separated by more than the critical distance. Specifically, the theory of modified gravity has a characteristic length-scale r_c, or approximately 15 billion light years. This marks a crossover distance beyond which the cosmological expansion becomes accelerated, and thus, from cosmological observations r_c is fixed to be the size of the observable universe. Even though r_c scale is enormous, the imprints of modification are detectable at much shorter distances because of the additional gravitational force.

"This is the crucial difference between the dark energy and modified gravity hypothesis, since, by the former, no observable deviation is predicted at short distances," Dvali says. "Virtual gravitons exploit every possible route between the objects, and the leakage opens up a huge number of multidimensional detours, which bring about a change in the law of gravity."

Dvali adds that the impact of modified gravity is able to be tested by experiments other than the large distance cosmological observations. One example is the Lunar Laser Ranging experiment that monitors the lunar orbit with an extraordinary precision by shooting the lasers to the moon and detecting the reflected beam. The beam is reflected by retro-reflecting mirrors originally placed on the lunar surface by the astronauts of the Apollo 11 mission.

"The cosmic acceleration of the universe indicates that the laws of General Relativity get modified not only at very short but also at very large distances," Dvali says. "It is this modification, and not dark energy, that is responsible for the accelerated expansion of the universe."

Dvali's analysis is based on research that appeared in a series of articles in Physical Review and Physics Letters.

Source: New York University