Is there a fifth force in nature?

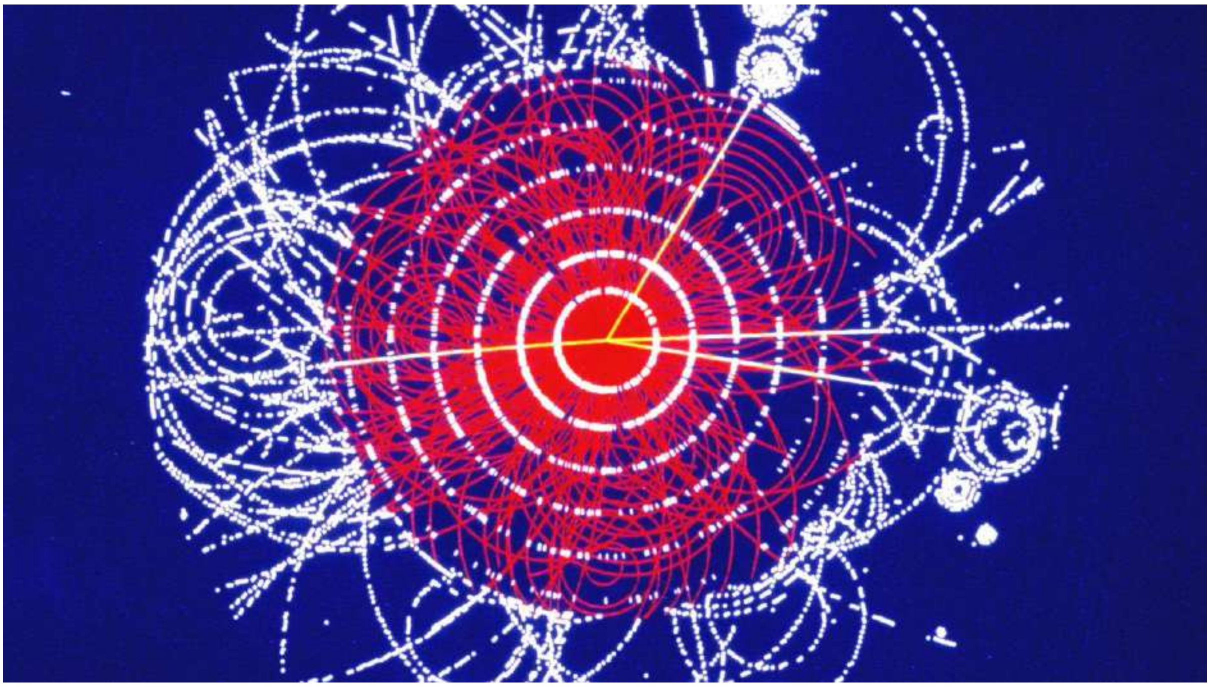
Aseem Talukdar, Associate Professor of Physics and Astronomy,

Madisonville Community College, USA

Our everyday world is controlled by forces from getting out of bed to doing any work. Physical forces are acting all around us. Centuries of tireless work by pioneering scientists have revealed that all the forces that we experience directly or indirectly, can be grouped into four fundamental categories: gravity, electromagnetic force, the weak force, and the strong force. However, recent speculations about a possible fifth force with the potential of changing our very perception of the universe have taken the scientific community aback. The research on this published in the journal Physical Review Letters in 2016 was led by Prof. Attila Krasznahorkay of the Hungarian Institute for Nuclear Research. The published article reports on how they focused an intense beam of protons on thin lithium targets. The high energy collisions create 'excited and unstable beryllium-8 nuclei' which subsequently decay into ordinary 'beryllium-8 and electron-positron pairs'. The electrons and positrons so produced tend to disperse away from each other at about 140 degrees. The observation appears to violate the law of conservation of energy. However, these results can be explained provided a previously unknown particle about thirty times heavier than an electron is involved in the decay. Subsequent analyses suggested that this particle was probably a new type of boson which could help explain the elusive dark matter and other phenomena and/or could indicate the existence of a fifth force in nature. More recently the same group also saw an excited, decaying helium atom emit light when the particles split strangely at an unusual angle of 115 degrees that could not be explained by the current understanding of physics.

Jonathan Feng a professor of physics at the University of California, said the findings are incredibly impressive and could pave the way to uncovering currently unknown forces. He further added that "If these results can be replicated then this would be a no-brainer Nobel Prize. And there's no reason to stop at the fifth - there could be a sixth, seventh, and eighth force."

The attraction between any two objects which have mass or energy is gravity. Gravity is the most familiar fundamental force which explains events such as objects falling on Earth, ocean tides and the movement of planets around the Sun. Sir Isaac Newton explained gravity as the interaction between two objects. Albert Einstein proposed the theory of general relativity which states that gravity is not an attraction or a force, rather a consequence of objects bending the space-time around it. Although gravity is the weakest of all the forces, however, without it the universe would be just an ever-expanding cloud of gas and dust without any planet or a star or galaxy.



The electromagnetic force acts between charged particles. No extended solid or liquid structures can form without this force. The electromagnetic force consists of two components: the electric and magnetic force. Electric and magnetic forces were regarded as mutually distinct until Michael Faraday and James Clark Maxwell unified them. The electromagnetic force is much stronger than gravity. This is the force responsible for the commonly experienced interactions such as friction, elasticity, the normal force etc. Another ever-present consequence of electromagnetism is light. These actions occur as a result of charged particles interacting with one another.

The weak force is the force that is responsible for the radioactive decay of atoms and particles. Although named as the 'weak' force, it is much stronger than gravity. An example of weak interaction would be the beta decay where a neutron breaks to produce a proton, an electron and an anti-neutrino. The Sun would not have formed without the weak force. It becomes crucial during the initial stage of energy generation inside a star. This interaction allows protons and neutrons to fuse and form deuterium. The excess energy from this fusion is the source of heat from the sun essential for most life forms here on Earth. The weak force also enables archaeologists to use the radioactivity of carbon-14 to date ancient bone, wood and other formerly living artefacts.

The fourth and strongest force is the ‘strong force’ which acts between subatomic particles of matter. This is the interaction that binds quarks together in clusters to form subatomic particles such as protons and neutrons. It also holds the atomic nucleus together and underlies interactions between all particles containing quarks.

In a Nobel Prize-winning effort, physicists Glashow, Weinberg and Salam unified the electromagnetic force with the weak force to form the electroweak force. Since then physicists have been working to find a grand unified theory that will unite the electroweak force with the strong force to define an ‘electronuclear force’. Models are predicting the outcomes of this proposition, but researchers are yet to confirm it. The final objective is of course to unify gravity with the electronuclear force to develop a single ‘theory of everything which could explain the entire universe. Scientists believe that all four fundamental forces were once a part of a single unified force. Shortly after the big bang, the unified force began to break apart and manifest as the four different forces we experience today. A theory of everything therefore would be one crucial step towards understanding the mystery of our universe.

Physicists believe that the above mentioned fundamental forces are responsible for all interactions that occur in the universe. They describe the interaction as an exchange of force-carrying particles called bosons. Specific kinds of bosons are responsible for each force; for example, photons for the electromagnetic force, W and Z bosons for the weak force and gluons for the strong force. However, such a particle for the gravitational force is yet to be detected.

One fundamental issue that physicists struggle with is finding an explanation of the existence of dark matter and dark energy which can’t be observed directly. This bizarre ingredient does not emit light or energy yet dominates the universe. It has been hypothesized that 80%-95% of the mass of the universe is made up of dark matter. Current interest is on a ‘dark photon’ which will carry dark matter thereby mediating interactions between the visible and invisible universe. If dark photons exist, it could be the key to detecting the invisible world of dark matter. It would also lead to the discovery of a fifth fundamental force. Until now there has been no experimentally confirmed evidence of their existence. The recent claim by the Hungarian group speaks about this type of photons. A team of researchers at the University of California, Irvine, proposed that the unknown particle reported by the Hungarian group was not a dark photon, but rather a boson that would be indicative of a fifth fundamental force.

Either way, their results have the potential of unsettling many of the long-standing pillars of modern physics. Future studies and experiments will elucidate whether we have a more precise understanding of the universe or whether the status quo continues to linger on.

****