Scientific Mind

Particle Physics: Unfolding the mysteries of nature

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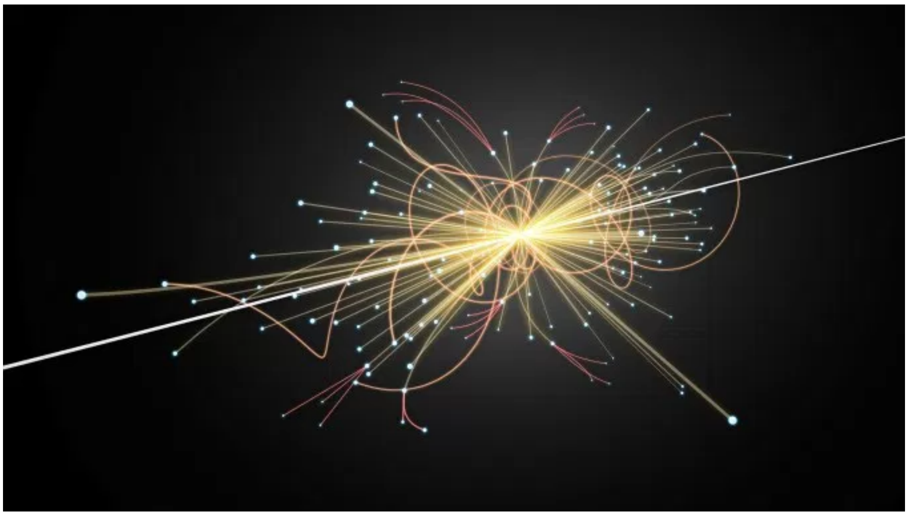

Particle Collision in LHC (Large Hadron Collider) Image: wired.com

COVER STORY
By Nischal Shrestha, Subhash Sharma

Particle physics deals with the study of the subatomic particles and their interactions. All the masses of the universes galaxies, planets, everything is made of the subatomic particles. Till today, there are many fundamental particles discovered like electrons, quarks, leptons etc. Through the study of behavior of these particles and their interactions, we can know about the universe, we can understand what principle the universe really follows. More than 95% of the mass of the universe is dark matter and dark energy. We have not known much about them. There are thousands of scientists working globally and billions of dollars is invested for understanding about the 95% mass of the universe.

The most accepted theory regarding the interpretation of the universe is the standard model. Present theories of this model were finalized in 1970s. Out of the four forces governing the nature, three forces strong force, electromagnetic force and weak force are described by this model. The weakest force, gravity cannot be explained through this model. Scientists are working in Theory of Everything which is very famous theory comprising all the four forces of nature. The ranges of the forces between the strongest force, strong force and weakest force, gravity is very large. These vast differences in ranges of the forces have led to difficulty in combing these forces and form the grand unification theory. As the standard model is not sufficient, numbers of scientists are looking beyond the standard model for understanding origin of mass, neutrino oscillations, matter-antimatter symmetry etc. Supersymmetry, String theory, M-theory are some of the popular theories made for addressing these problems in Standard Model. There are many areas where significant work has to be done theoretically and experimentally.

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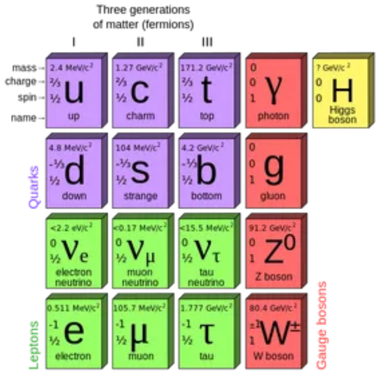


Particles of the standard model

A Nepali Physicist, Dr. Suyog Shrestha working as a scientist in world's largest physics laboratory at European Organization for Nuclear Research (CERN) said, "I got interested in particle physics because it describes the fundamental components of matter and their interactions." For the opportunities to the Nepalese students at CERN, he further added, "For high school students, there is a program called Beamline for School. This is an opportunity for high school students from all over the world to design and carry out an experiment on a CERN accelerator beamline. Students can find out more at: http://beamline-for-schools.web.cern.ch/ .In case of university students, there are several opportunities. CERN summer student program, CERN Openlab program, CERN fellowship program etc."

Human body is also composed of particles. Hydrogen, oxygen, carbon and nitrogen comprise more than 99% of the body. These elements in our body were made billions of years before. Hydrogen was made during the big bang and other three elements in the burning stars. Actually much of the space of the atom is empty. The space occupied by nuclei is 100,000 smaller than the actual size of the atom. The large part of mass of the atom is due to the energy of the particle called gluon which holds the subatomic particles together.

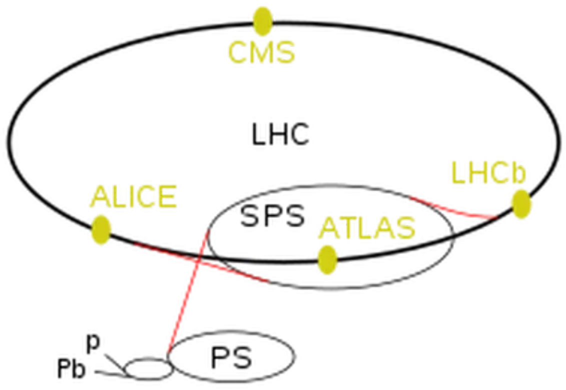
For digging deep in the nature, the particles in the nature have to be captured and studied. This is only possible at the high energies. Thus, the particle accelerators are built where these energetic particles are collided and the resulting particles are detected.

Particle accelerator

Accelerator is something that makes something else moves faster. In particle physics, we use a machine that uses electromagnetic field to propel charged particles to nearly speed of light and to contain them in well-defined beams. We can see the particle accelerators all around us, like in ours home! Television sets has small electron accelerators on the inside of the screen they are made of a phosphor dots. The accelerator shoots out a stream of electrons and steers the electrons with magnets onto the phosphor dots. This process lights the dots one at a time. Because the whole process is faster than what ours eye can detect, ours brain mixes the dots into a picture.
X-ray machine also contains a tiny electron accelerator. This particular kind of accelerator propels electrons towards a heavy metal target. The electrons strike the target and cause a stream of X-rays to come out then go through ours body and expose the film inside your body.

Ernest O. Lawrence invented the earliest circular accelerators called cyclotrons in 1929 at the University of California, Berkeley. Cyclotrons have a single pair of hollow 'D'-shaped plates to accelerate the particles and a single large dipole magnet to bend their path into a circular orbit. It has been estimated that there are approximately 30,000 accelerators over the world. Of these, only about 1% is research machines with energies above 1 GeV, while about 44% are for radiotherapy, 41% for ion implantation, 9% for industrial processing and research, and 4% for biomedical and other low-energy research. Till now, the largest and highest energy particle accelerator used for elementary particle physics is the Large Hadron Collider (LHC) at CERN, operating since 2009. It was built by the European Organization for Nuclear Research (CERN) between 1998 and 2008 in collaboration with over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories which runs under the French-Swiss border contains more than 1,000 cylindrical magnets arranged end-to-end. The magnets are there to steer the beam around this vast circuit.

The aim of LHC is to search the large family of new particles predicted by super-symmetric theories of particle physics and allow physicists to test the predictions of different theories of particle physics, including measuring the properties of the Higgs boson.
LHC has seven detectors located underground in large caverns excavated at the LHC's intersection points. Two of them, the ATLAS experiment and the Compact Muon Solenoid (CMS) are large, general purpose is to detect the new particle. ALICE is studying a "fluid" form of matter called quark-gluon plasma that existed shortly after the Big Bang. There are equal amounts of matters and antimatters were created during the Big Bang, LHCb investigates what happened to the "missing" antimatter and last three TOTEM, MoEDAL and LHCf, are very much smaller and are for very specialized research.



Scientists, on 4 July 2012 announced that they have observed the new particle consistent with Higgs Boson predicted by standard model in the mass region around 125-126 GeV. The Nobel Prize in physics of 2013, was awarded jointly to François Englert and Peter Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider."
All the matter that we can see, however, appears to be no more than about 4% of the total. A more exotic version of the Higgs particle could be a bridge to understanding the 96% of the universe that remains obscure.

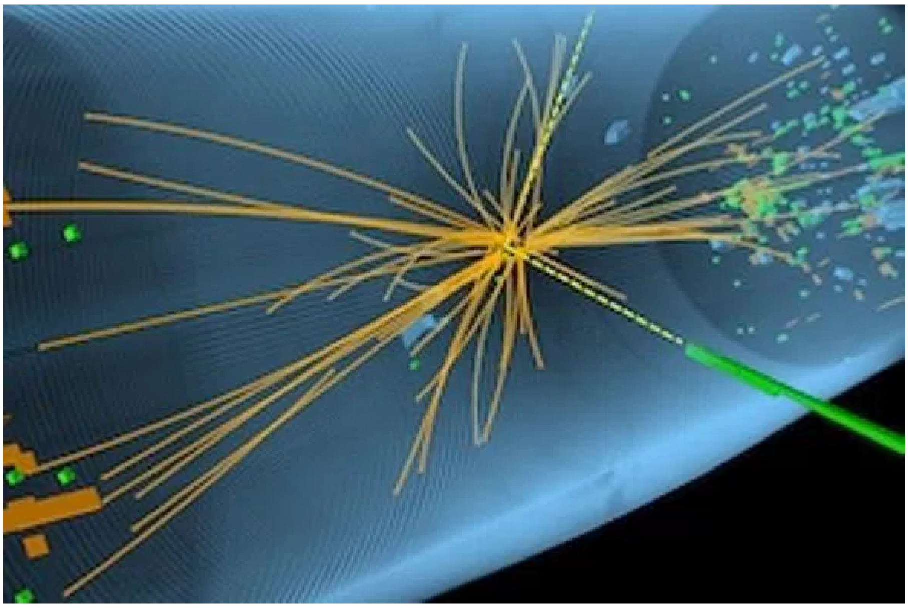


Image: cern

On, 14 July 2015 the LHCb experiment at CERN's Large Hadron Collider has reported the discovery of a class of particles known as pentaquarks. The pentaquark is not just any new particle; it represents a way to aggregate quarks, namely the fundamental constituents of ordinary protons and neutrons. Our understanding of the structure of matter was revolutionized in 1964 when American physicist Murray Gell-Mann proposed that a category of particles known as baryons, which includes protons and neutrons, are comprised of three fractionally charged objects called quarks, and that another category, mesons, are formed of quark-antiquark pairs. Antiquarks are quarks of antimatter. Gell-Mann was awarded the Nobel Prize in physics for this work in 1969. This quark model also allows the existence of other quark composite states, such as pentaquarks composed of four quarks and an antiquark. It was also another landmark discovery of LHC.

Humans are thriving to know more about nature, to understand the secrets that lie hidden. This is still a very long way to go, there are many mysteries yet to be revealed. In the quest to understand the principles, to unravel the mysteries it may take effort of generations. The search is still going on.

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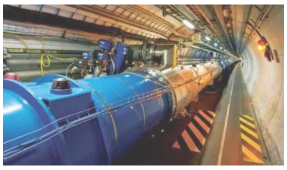

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sahadev bahing OCTOBER 31, 2017 AT 7:04 AM

its really informational and knowledgable article Cause even including the programs of LHC.
Keep publishing such a articles.

thanks to the writers Nischal shrestha Dai and Subhas Dai.

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