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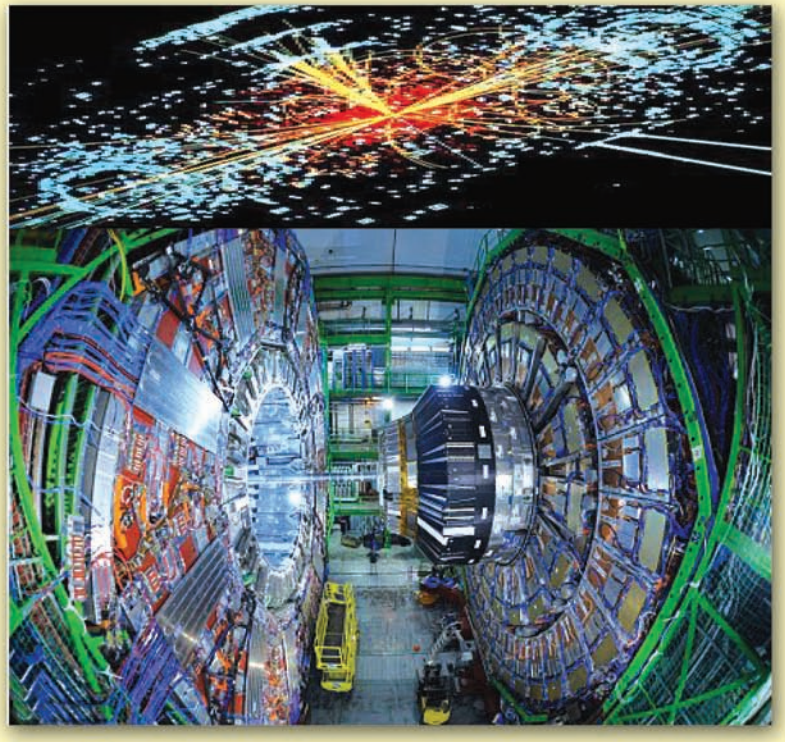

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Theme 259

THE HIGGS BOSON

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SIB STUDENTS' ECONOMIC FORUM

JUNE 2013

The South Indian Bank Ltd., H.O. : 'S.I.B. House', Thrissur, Kerala

Theme No. 259 : THE HIGGS BOSON

A well informed customer will make the policy makers as well as organisations which produce goods and services more responsive to the customer needs. This will also result in healthy competition among organisations and improve the quality of goods and services produced.

The "SIB Students' Economic Forum" is designed to kindle interest in economic affairs in the minds of our younger generation. We highlight one theme in every monthly meeting of the "Forum". This month, we discuss on one of the top scientific breakthroughs of 2012 – the discovery of the Higgs Boson, an invisible particle that explains the mystery of mass. Scientists have discovered the new sub-atomic particle consistent with the long-sought Higgs Boson. The particle's confirmation would stand out as one of the great scientific achievements of the 21st Century so far. We may discuss what exactly the Higgs Boson is, and why have particle physicists spent more than 40 years searching for it.

What does the Higgs Boson do and why is it called Boson?

The Higgs Boson belongs to a class of particles called bosons. It imparts mass to all other particles. The name boson is derived from the surname of the great Indian Scientist **Satyendra Nath Bose. FRS.** Although several Nobel Prizes were awarded for research related to the concepts of the boson, Bose–Einstein statistics and Bose - Einstein condensate - the latest being the 2001 Nobel Prize in Physics given for advancing the theory of Bose - Einstein condensates - Bose himself was not awarded the Nobel Prize.

What do you know about the Higgs Boson?

The Higgs Boson was hypothesized in 1964 by three groups of scientists – the English Physicist Peter Higgs and five others. The Higgs so far existed only in the minds of theoretical physicists. There is a sturdy theory of how much of the Universe works - all of the particles that make up atoms and molecules and all the matter we see, most of the forces that direct them, and a small zoo of more exotic particles. This is called the Standard Model.

What is the Standard Model?

The most accepted theory in particle physics is called the standard model. It explains the nature and behavior of these particles. The theory describes the fundamental particles and forces of nature. The masses of the fundamental particles of nature are determined by the strength of their interaction with the Higgs Boson. However, there is a glaring hole in the

theory: it does not explain how it is that some of those particles gain their mass. Peter Higgs has an explanation to fill this hole. Without the Higgs Boson, matter in the universe will have no mass. As such the existence of these particles is a vital cornerstone in describing the universe more precisely.

What is so important about the discovery?
Mass is, quite simply, a measure of how much stuff an object - a particle, a molecule contains. If not for mass, all the fundamental particles that make up atoms would whiz around at light speed .The Higgs Mechanism proposes that there is a field permeating the Universe - the Higgs field - that allows particles to obtain their mass. Interactions with the field - with the Higgs bosons that come from it - are purported to give particles mass. The mechanism is well explained if you understand how your shoes interacting with snow particles, while walking through a snow field, slows you down.

Why do the Higgs Boson particles come to be known as God Particle?
According to the scientists, the Higgs Boson particles are extremely powerful and present anywhere. Like God, it is very hard to find them as well. Without Higgs Boson, the universe could not have been possible. Everything would have behaved like light, floating freely without combining with others. The entire universe is made of 12 different particles of matter and 4 forces.

When did the scientists first start experiments to bring out the presence of the Higgs Boson?
Experiments to confirm the presence of the Higgs Boson first started at the Large Hadron Collider (LHC) in 2010. The LHC is the biggest atom smasher in the world which is located at European Centre for Nuclear Research (CERN). The discovery of a particle consistent with the Higgs Boson was confirmed at CERN on July 4, 2012 with 99.9999% accuracy. It has opened the way to more detailed studies requiring larger statistics which will pin down the new particle's properties.

What is the Large Hadron Collider?
It is the World's biggest and most powerful particle accelerator - a 27 km looped pipe, six in a tunnel, 100 m underground along the Swiss French border. It has cost 3 billion Euros to build.

How does the LHC work?
Particles are injected in the smaller machines at the Super Proton Synchrotron (SPS). These particles are then transferred to the LHC, forming two beams travelling in opposite directions. The particles then accelerated to the approximate speed of light, collide at 4 points where the two rings intersect.

How was the particle consistent with Higgs Boson found at the LHC?
Scientists fired protons into the collider, travelling in opposite directions. Protons are

made of three quarks that are held together by gluons. Magnets accelerated protons to 99.9999% of the speed of light. Quarks inside the proton collided with enough energy to create the suspected Higgs Boson. Evidence of the possible Higgs Boson was found in the streaks left in the LHC detectors.

How do scientists search for the Higgs Boson?
Ironically, the Standard Model does not predict an exact mass for the Higgs itself. Particle accelerators such as the LHC are used to systematically search for the particle over a range of masses. The LHC works by smashing together two beams of the sub-atomic particles called protons at close to light-speed. This generates a vast shower of particles that are only created at high energies. The Higgs will probably never be observed directly, but scientists at the LHC have been looking for a Higgs that fleetingly exists in this group of particles. If it behaves as researchers think, it should decay further into yet more particles, leaving a trail that proves its existence.

How do scientists confirm the existence of these particles?
The scientists are not in a position to say they have found something. The first hurdle is to definitively nail down the particle's mass - showing up as a kind of "bump" in the data - and that part looks to be just around the corner. What is next is to make sure that it behaves as the theory predicts it should - how it interacts with other particles and in turn decays in to yet more particles. This is very much the frontier of high-energy physics and a complete and certain entry into the Standard Model is probably a long way off yet. It is those kinds of surprises that have led to great revolutions in science.

Why did it take so long to find it?
Scientists believe that the Higgs Boson, if it really exists, only exist for a fraction of a second. The theory related to it suggests that enough of such particles should become detectable, if beams of protons are collided together at excessively high energies. Until the LHC came into existence, no colliders have often been able to reach the required energy levels.

Why do the scientists believe that the discovery of the new particle should be revalidated further?
The scientists want to make sure that it fits all the predictions of the standard model. They will try to authenticate the other signatures of the observed particle to ascertain that everything is consistent with the theoretical concept related to Higgs Boson.

In case it is proved to be Higgs Boson, will there be other unresolved issues in fundamental physics?
As the standard model is an incomplete theory of cosmos, there are many issues to be resolved. The standard model does not explain gravity, nor does it explain the accelerating universe that has been attributed to a mysterious dark energy.

What is a Higgs field?
The Higgs field is like a giant vat of molasses spread throughout the universe. Most of the known types of particles that travel through it stick to the molasses, which slows them down and makes them heavier. The Higgs Boson is a particle that helps transmit the mass-giving Higgs force field, similar to the way a particle of light, the photon, transmits the electromagnetic field.

How long have physicists been looking for the Higgs Boson?
More than two decades. It started with the LEP experiments at CERN in the 1990s, continued with the Tevatron experiments at Fermilab and now continues with the Large Hadron Collider (LHC) experiments at CERN (European Organization for Nuclear Research). A discovery of the Higgs Boson would be just the beginning of a new era of particle physics research. Scientists would then focus on understanding in detail the interactions of the Higgs Boson with other particles, testing the predictions made by theorists and looking for unexpected phenomenon.

What would the world look like without the Higgs Boson or a similar particle?
Without the Higgs Boson or something like it giving mass to the basic building blocks of matter, electrons would whiz about at the speed of light. They would not form unions with protons or other would-be nuclei to make atoms. No atom means no chemical reactions, no molecules and no ordinary matter as we know it, no template for life. We would not exist.

How do physicists create a Higgs Boson?
A high-energy particle accelerator such as the Tevatron or LHC can recreate the extreme energies of the very early universe, generated shortly after the Big Bang. Scientists collide particles at these energies to produce other particles, including a Higgs Boson, using Einstein's famous relation, $E=mc^2$. At the Tevatron or LHC, only about one collision per trillion will produce a Higgs Boson.

How do physicists know the presence of a Higgs Boson?
In a report released on March 14, 2013, scientists at CERN said they were 99.9 percent certain that the new particle discovered was the elusive Higgs Boson. The Higgs Boson, like other heavy particles, decays into lighter particles, which then decay into even lighter particles. This process can follow a certain number of paths, and it's more likely to decay through some paths than others. The decay paths also depend on the particle's mass. Physicists compare the decay paths they observe after a particle collision to the decay paths they've simulated with computers and mapped out for a possible range of Higgs masses. When they observe decay path that looks similar to the one they predicted – when they see a match - it is a good sign that the particle that decayed is the particle they predicted. By adding up the energy of all the lighter particles appearing in a particular decay path, scientists can determine the Higgs Boson's mass.

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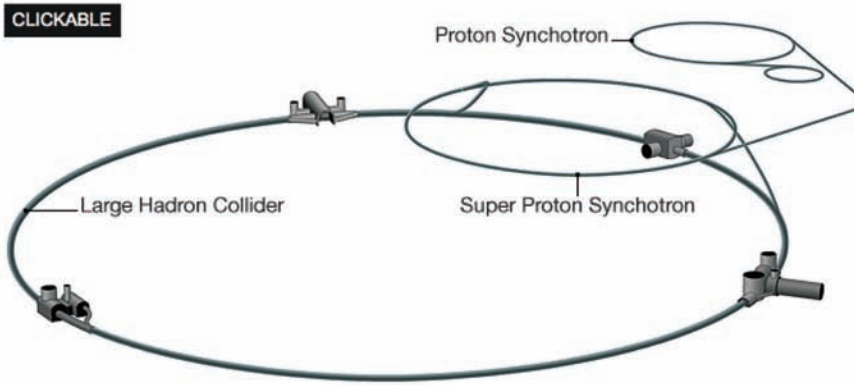

	Fermions			Bosons	
Quarks	u up	c charm	t top	γ photon	Force carriers
	d down	s strange	b bottom	Z Z boson	
Leptons	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	
	e electron	μ muon	τ tau	g gluon	
				Higgs boson	

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