Higgs-Boson Decay

Why in news?

Physicists detected a Higgs boson decaying into a Z boson particle and a photon in the Large Hadron Collider (LHC) at CERN.

What is the Higgs boson?

- The Higgs boson is the fundamental force-carrying particle of the Higgs field, which is responsible for granting other particles their mass.
- Known as *'God's Particle'*, it was first discovered by the ATLAS and CMS detectors in 2012.
- **Properties -** The Higgs boson has mass but is chargeless.
- It has a mass of 125 billion electron volts.
- It has zero spin, making it the only elementary particle with no spin.

How mass of other particles is related to Higgs Boson?

- The mass of the subatomic particle depends on the particle's interaction with the Higgs boson.
- The stronger the interaction the more the mass it has.
- **Mass -** Photons (particles of light) have no mass because they don't interact with Higgs bosons.
- The Higgs boson has a mass of 125 billion electron volts which is 130 times more massive than a proton.
- A Higgs boson's mass is greater than that of protons or neutrons because a Higgs boson can interact with another Higgs boson.

How universe could be studied using Higgs boson particles?

- **Universe -** Higgs bosons can tell us a lot about the universe on studying two factors -
  - Understanding the properties of Higgs bosons
  - How strongly each type of atomic particle couples to Higgs bosons.
- **Virtual particles -** According to quantum field theory, space at the subatomic level is filled with virtual particles.
- They are particles that quickly pop in and out of existence which can't be detected directly but their effects sometimes linger.

What is the Higgs Boson decay?

- The LHC creates a Higgs boson by accelerating billions of highly energetic protons into a head-on collision.
- This releases a tremendous amount of energy that condenses into different particles.

- When a Higgs boson is created in LLHC, it has a brief interaction with virtual particles that creates a Z boson and a photon.
- The Z boson is also unstable and decays to two muons some 3% of the time.

What is the Standard Model?

- The Standard Model of particle physics explains how the basic building blocks of matter interact, governed by 4 fundamental forces.
- The Standard Model is an established and well-tested theory of particle physics.
- It successfully explained how these particles and 3 of the forces are related to each other.

Weak force, Strong force, Gravitational force and Electromagnetic force are the 4 Fundamental forces.

- But it could not explain dark energy or the warping of space and time or hoe neutrinos have mass.
- The Standard Model theory states that a Higgs boson will decay to a Z boson and a photon 0.1% of the time if its mass is 125 billion eV/c2.

How significant is the decay?

- According to the Standard Model, the LHC needed to have created at least 1,000 Higgs bosons to have been able to spot one of them decaying to a Z boson and a photon.
- The LHC would have had to create at least 30,000 Higgs bosons to observe the decay just once to spot a pair of muons plus a photon created at the same time.
- Testing Standard models predictions as precisely as possible is a way to find whether there are any cracks in the Model.
- Some theories predict a higher rate of decay through this pathway.
- The experimental proof of this can validate new theories of physics and open new realm of science.

Quick Facts

Large Hadron Collider

- The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator.
- Started in 2008, it is located in the CERN's accelerator complex.
- It consists of a 27-kilometre ring in which two high-energy particle beams travelling in opposite directions are made to collide.
- It has 4 particle detectors - ATLAS, CMS, ALICE and LHCb at 4 colliding locations around the accelerator ring.

References

1. The Hindu - The decade-long search for a rare Higgs boson decay

2. Science Alert - First Signs of Rare Higgs Boson Decay

