W-boson

May 12, 2022

In news– Recently, researchers from Collider Detector at Fermilab (CDF) Collaboration in the U.S., announced that they have made a precise measurement of the mass of the W boson.

Key updates-

- According to the researchers, this precisely determined value **did not match with the estimates from the standard model of particle physics.**
- The recent experiment which measured the mass of the W boson as 80,433.5 +/- 9.4 Mev/c2 is more than what is expected from the standard model (80,357 +/- 8 MeV/c2).
- This result is highly significant because **this implies the incompleteness of the standard model description.**
- This is a major claim, since the standard model has been extraordinarily successful in the past decades.
- However, this is not the last word, as the mass discrepancy of the W boson needs to be checked and confirmed to the same accuracy by other facilities, for example, the Large Hadron Collider (LHC).

What is W-boson?

- The **W boson is an elementary particle that plays an important role in mediating weak nuclear interactions.**
- The **weak nuclear force is one of the four fundamental interactions between matter particles in physics,** the others being *electromagnetic interaction, strong nuclear interaction and gravitational interactions.*
- In particle physics, th**e W and Z bosons are vector bosons** that are together known as the weak bosons or more generally as the intermediate vector bosons.
- **In weak interactions there are three such 'gauge bosons' – the** W+ (W-plus), W- (W-minus) and Z particles.

- **The W boson was first seen in 1983 at CERN, located on the Franco-Swiss border.**

- **Unlike the photon, which is massless, the W bosons are quite massive**, which results in the force they mediate, the weak force being very short ranged.
- **Unlike the photon, the W-plus and W-minus are charged** and by exchanging such bosons, a neutron can change into a proton, for example. This helps in the transmutation of elements.
- **The W boson helps the interactions that make the Sun burn and produce energy.**

The standard model of elementary particle physics-

- It is **a theoretical construct in physics that describes particles of matter and their interaction.**
- It is a **description that views the elementary particles of the world as being connected by mathematical symmetries,** just as an object and its mirror image are connected by a bilateral (left–right) symmetry.
- These are **mathematical groups generated by continuous transformations** from, say, one particle to another.
- **According to this model there are a finite number of fundamental particles** which are represented by the characteristic "eigen" states of these groups.
- The particles predicted by the model, such as the Z boson, have been seen in experiments and the last to be discovered, in 2012, was the Higgs boson which gives mass to the heavy particles.
- **The standard model is thought to be incomplete because it gives a unified picture of only three of the four fundamental forces of nature** – electromagnetic, weak nuclear, strong nuclear and gravitational interactions – it totally omits gravity.
- So, in the grand plan of unifying all forces so that a single equation would describe all the interactions of matter, **the standard model was found to be lacking.**

- The **other gap in the standard model is that it does not include a description of dark matter particles.** So far these have been detected only through their gravitational pull on surrounding matter.
- **The symmetries of the standard model are known as gauge symmetries**, as they are generated by "gauge transformations" which are a set of continuous transformations (like rotation is a continuous transformation). Each symmetry is associated with a gauge boson.
- For example, t**he gauge boson associated with electromagnetic interactions is the photon**.
- The gauge bosons associated with weak interactions are the W and Z bosons.

About CERN-

- The **European Organization for Nuclear Research known as CERN**(derived from the name *Conseil européen pour la recherche nucléaire*), is a European research organization that operates the **largest particle physics laboratory in the world.**
- **Established in 1954,** the organization is **based in a northwest suburb of Geneva on the Franco–Swiss border and has 23 member states.**
- **Israel is the only non-European country** granted full membership.
- CERN is an official United Nations Observer.
- CERN's main function is to provide the particle accelerators and other infrastructure needed for high-energy physics research – as a result, numerous experiments have been constructed at CERN through international collaborations.
- **CERN is the site of the Large Hadron Collider (LHC),** the world's largest and highest-energy particle collider.
- **12 founding Member States of CERN:** Belgium, Denmark, France, the Federal Republic of Germany, Greece, Italy,

the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and Yugoslavia.

Note- **CERN is also the birthplace of the World Wide Web.**