## W-boson

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<u>In news</u>— 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, the 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, the 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 highenergy 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.