

Muon g-2 Experiment - Challenging Known Laws of Physics

Why in news?

Newly published results of an international experiment (Muon g-2) suggest the possibility of new physics governing the laws of nature.

What is the recent finding?

- The experiment studied a subatomic particle called the **muon**.
- The results of the experiment do not match the predictions of the Standard Model.
- The Standard Model is that on which all particle physics is based.
- The results instead reconfirm a discrepancy that had been detected in an experiment 20 years previously.

What is the Standard Model?

- The Standard Model is a theory that predicts the behaviour of the building blocks of the universe.
- It lays out the rules for six types of quarks, six leptons, the Higgs boson, three fundamental forces, and how the subatomic particles behave under the influence of electromagnetic forces.
- The muon is one of the leptons. It is similar to the electron, but 200 times larger.
- It is much more unstable, surviving for a fraction of a second.

What is the Muon g-2 experiment about?

- The experiment, called Muon g-2 (g minus two), was conducted at the US Department of Energy's Fermi National Accelerator Laboratory (Fermilab).
- It measured a quantity relating to the muon.
- This followed up a previous experiment at Brookhaven National Laboratory, under the US Department of Energy.
- Concluded in 2001, the Brookhaven experiment came up with results that did not identically match predictions by the Standard Model.
- The Muon g-2 experiment measured this quantity with greater accuracy.
- It sought to find out whether the discrepancy would persist, or whether the new results would be closer to predictions.
- As it turned out, there was a discrepancy again, although smaller.

What was the quantity measured?

- It is called the **g-factor**, a measure that derives from the magnetic properties of the muon.
- As the muon is unstable, scientists study the effect it leaves behind on its surroundings.
- Muons act as if they have a tiny internal magnet.
- In a strong magnetic field, the direction of this magnet “wobbles,” just like the axis of a spinning top.
- The rate at which the muon wobbles is described by the g-factor.
- This value is known to be close to 2.
- So scientists measure the deviation from 2; hence the name g-2 (g minus two).

How was it measured?

- The g-factor can be calculated precisely using the Standard Model.
- In the g-2 experiment, scientists measured it with high-precision instruments.
- They generated muons and got them to circulate in a large magnet.
- The muons also interacted with a “quantum foam” of subatomic particles “popping in and out of existence.”
- These interactions affect the value of the g-factor, causing the muons to wobble slightly faster or slightly slower.

What do the recent findings mean?

- The results, while diverging from the Standard Model prediction, strongly agree with the Brookhaven results.
- The results from Brookhaven, and now Fermilab, hint at the existence of unknown interactions between the muon and the magnetic field.
- These are interactions that could possibly involve new particles or forces.
- To claim a discovery, scientists require results that diverge from the Standard Model by 5 standard deviations.
- The combined results from Fermilab and Brookhaven diverge by 4.2 standard deviations.
- While this may not be enough, it is very unlikely to be a fluke.
- In all, this is strong evidence that the muon is sensitive to something that is not in our best theory.
- The result thus suggests that there are forms of matter and energy vital to the nature and evolution of the cosmos that are not yet known to science.
- In other words, the physics now known could alone not explain the results measured.

Source: The Indian Express

