NATURE | NEWS

Has a Hungarian physics lab found a fifth force of nature?

Radioactive decay anomaly could imply a new fundamental force, theorists say.

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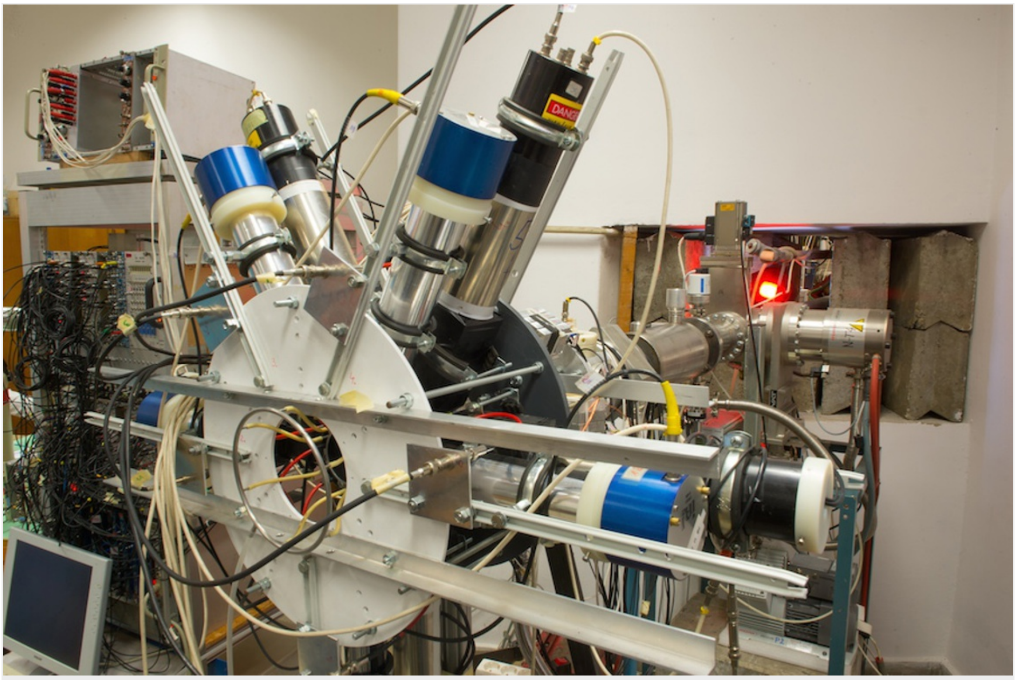

MTA-Atomki

Physicists at the Institute for Nuclear Research in Debrecen, Hungary, say this apparatus — an electron-positron spectrometer — has found evidence for a new particle.

A laboratory experiment in Hungary has spotted an anomaly in radioactive decay that could be the signature of a previously unknown fifth fundamental force of nature, physicists say – if the finding holds up.

Attila Krasznahorkay at the Hungarian Academy of Sciences's Institute for Nuclear Research in Debrecen, Hungary, and his colleagues reported their surprising result in 2015 on the arXiv preprint server, and this January in the journal *Physical Review Letters*[1]. But the report – which posited the existence of a new, light boson only 34 times heavier than the electron – was largely overlooked.

Then, on 25 April, a group of US theoretical physicists brought the finding to wider attention by publishing its own analysis of the result on arXiv[2]. The theorists showed that the data didn't conflict with any previous experiments – and concluded that it could be evidence for a fifth fundamental force. "We brought it out from relative obscurity," says Jonathan Feng, at the University of California, Irvine, the lead author of the arXiv report.

Dark matter may feel a "dark force" that the rest of the Universe does not

Four days later, two of Feng's colleagues discussed the finding at a workshop at the SLAC National Accelerator Laboratory in Menlo Park, California. Researchers there were sceptical but excited about the idea, says Bogdan Wojtsekhowski, a physicist at the Thomas Jefferson National Accelerator Facility in Newport News, Virginia. "Many participants in the workshop are thinking about different ways to check it," he says. Groups in Europe and the United States say that they should be able to confirm or rebut the Hungarian experimental results within about a year.

Search for new forces

Gravity, electromagnetism and the strong and weak nuclear forces are the four fundamental forces known to physics — but researchers have made many as-yet unsubstantiated claims of a fifth. Over the past decade, the search for new forces has ramped up because of the inability of the standard model of particle physics to explain dark matter — an invisible substance thought to make up more than 80% of the Universe's mass. Theorists have proposed various exotic-matter particles and force-carriers, including "dark photons”, by analogy to conventional photons that carry the electromagnetic force.

Krasznahorkay says his group was searching for evidence of just such a dark photon – but Feng’s team think they found something different. The Hungarian team fired protons at thin targets of lithium-7, which created unstable beryllium-8 nuclei that then decayed and spat out pairs of electrons and positrons. According to the standard model, physicists should see that the number of observed pairs drops as the angle separating the trajectory of the electron and positron increases. But the team reported that at about 140º, the number of such emissions jumps — creating a ‘bump’ when the number of pairs are plotted against the angle — before dropping off again at higher angles.

Freefall space cubes are test for gravitational wave spotter

Bump in confidence

Krasznahorkay says that the bump is strong evidence that a minute fraction of the unstable beryllium-8 nuclei shed their excess energy in the form of a new particle, which then decays into an electron–positron pair. He and his colleagues calculate the particle’s mass to be about 17 megaelectronvolts (MeV).

“We are very confident about our experimental results,” says Krasznahorkay. He says that the team has repeated its test several times in the past three years, and that it has eliminated every conceivable source of error. Assuming it has done so, then the odds of seeing such an extreme anomaly if there were nothing unusual going on are about 1 in 200 billion, the team says.

Feng and colleagues say that the 17-MeV particle is not a dark photon. After analysing the anomaly and looking for properties consistent with previous experimental results, they concluded that the particle could instead be a “protophobic *X* boson”. Such a particle would carry an extremely short-range force that acts over distances only several times the width of an atomic nucleus. And where a dark photon (like a conventional photon) would couple to electrons and protons, the new boson would couple to electrons and neutrons. Feng says that his group is currently investigating other kinds of particles that could explain the anomaly. But the protophobic boson is “the most straightforward possibility”, he says.

Force of nature gave life its asymmetry

Unconventional coupling

Jesse Thaler, a theoretical physicist at the Massachusetts Institute of Technology (MIT) in Cambridge, says that the unconventional coupling proposed by Feng’s team makes him sceptical that the new particle exists. “It certainly isn’t the first thing I would have written down if I were allowed to augment the standard model at will,” he says. But he adds that he is “paying attention” to the proposal. “Perhaps we are seeing our first glimpse into physics beyond the visible Universe,” he says.

Researchers should not have to wait long to find out whether a 17-MeV particle really does exist. The DarkLight experiment at the Jefferson Laboratory is designed to search for dark photons with masses of 10–100 MeV, by firing electrons at a hydrogen gas target. Now, says collaboration spokesperson Richard Milner of MIT, it will target the 17-MeV region as a priority, and within about a year, could either find the proposed particle or set stringent limits on its coupling with normal matter.

Also searching for the proposed boson will be the LHCb experiment at CERN, Europe’s particle-physics lab near Geneva, which will study quark–antiquark decays, and two experiments that will fire positrons at a fixed target — one at the INFN Frascati National Laboratory near Rome, due to switch on in 2018, and the other at the Budker Institute of Nuclear Physics in the Siberian town of Novosibirsk, Russia.

Rouven Essig, a theoretical physicist at Stony Brook University in New York and one of the organizers of the SLAC workshop, thinks that the boson’s “somewhat unexpected” properties make a confirmation unlikely. But he welcomes the tests. “It would be crazy not to do another experiment to check this result,” he says. “Nature has surprised us before!”

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Updates

Updated: Jonathan Feng’s work has now been published in the journal *Physical Review Letters*.

References

1. Krasznahorkay, A. J. *et al*. *Physical Review Letters* **116**, 042501 (2016).

2. Feng, J. L. *et al*. *Preprint at* http://arxiv.org/abs/1604.07411 (2016).