tank traps set on the beaches of Normandy during the Second World War.

Few studies have explored these barriers' effects on animal populations, and there are not even any reliable baseline data on conditions before the barriers were built. Avila-Villegas has seen photos taken by border patrols of mountain lions running alongside the barriers or trying to climb over them, so he knows that the walls are causing the animals stress. But he has no real way of measuring it. A 2014 study found that the fencing in Arizona seemed to harm native wildlife, but had little impact on human movement (J. W. McCallum *et al. PLoS ONE* **9,** e93679; 2014).

In 2009, Epps published a paper setting out some of the potential threats to animal populations posed by Bush's wall, but he lacked the money to follow up with field studies (A. D. Flesch *et al. Conserv. Biol.* **24,** 171–181; 2009). Now he is not sure such research would be possible, even with sufficient funds. "The border is not a friendly place any more," Epps says. "I would be hesitant to send a grad student there."

Avila-Villegas has first-hand experience of the difficulties that researchers face there. Ten years ago, he tried to collect some baseline data before Bush's barriers were built, but gave up for his own safety. "It's easy to ask why the research hasn't been done, but that ignores the fact that the border is a war zone," he says. "I had to stop my field work because of law enforcement and the Minutemen" — groups of armed private citizens who have taken it upon themselves to 'defend' the border against illegal crossings.

And it has not got any easier. "Every time I — a Hispanic male with dark skin and long hair — am in the field, I get patrols, helicopters and ATVs [all-terrain vehicles] coming to check on what I'm doing," Avila-Villegas says. He spends much of his time trying to promote conservation issues that affect Mexico and the United States by forging links between researchers and policymakers in both countries. But his dedication to an open border has also prompted him to take a more personal stand. After a dozen years in the United States, Avila-Villegas has finally applied for citizenship — so that, come November, he can vote against Trump and his wall. ■

PHYSICS

Neutrino clue to Universe riddle

Hint that elusive particles behave differently in matter and antimatter forms might explain matter's predominance.

BY ELIZABETH GIBNEY

It is one of physics' greatest mysteries: why the Universe is filled with matter, rather than antimatter. An experiment in Japan now hints at a possible explanation: subatomic particles called neutrinos might behave differently in their matter and antimatter forms.

The disparity, announced at the International Conference on High Energy Physics (ICHEP) in Chicago, Illinois, on 6 August, may yet turn out not to be real: more data will need to be gathered to be sure. "You would probably bet that this difference exists in neutrinos, but it would be premature to state that we can see it," says André de Gouvêa, a theoretical physicist at Northwestern University in Evanston, Illinois.

Even so, the announcement is likely to increase excitement over studies of neutrinos, the abundant but elusive particles that seem increasingly key to solving all kinds of puzzles in physics.

"For the timescales of particle physics, this is changing really, really quickly."

In the 1990s, neutrinos were found to defy the predictions of physics' standard model — a successful, but incomplete, description of nature — by virtue of possessing mass, rather than being entirely massless (Y. Fukuda *et al. Phys. Rev. Lett.* **81,** 1562; 1998). Since then, neutrino experiments have sprouted up around the world, and researchers are realizing that they should look to these particles for new explanations in physics, says Keith Matera, a physicist on a US-based neutrino experiment called NOvA at the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. "They are the crack in the standard model," he says.

If matter and antimatter were produced in equal quantities after the Big Bang, they would have annihilated each other, leaving nothing but radiation. Physicists have observed differences in the behaviour of some matter particles and antimatter particles, such as kaons and B mesons — but not enough to explain the dominance of matter in the Universe.

AN ODD ABUNDANCE

One answer might be that super-heavy particles decayed in the early Universe in an asymmetrical fashion and produced more matter than antimatter. Some physicists think that a heavyweight relative of the neutrino could be the culprit. Under this theory, if neutrinos and antineutrinos behave differently today, then a similar imbalance in their ancient counterparts could explain the overabundance of matter.

To test this, researchers on the Tokai to Kamioka (T2K) experiment in Japan looked for differences in the way that matter and antimatter neutrinos oscillate between three types, or 'flavours', as they travel. They shot beams of neutrinos of one flavour — muon neutrinos — from the Japan Proton Accelerator Research Complex in the seaside village of Tokaimura to the Super-Kamiokande detector, an underground steel tank more than 295 kilometres away and filled with 50,000 tonnes of water. The team counted how many electron neutrinos appeared — a sign that the muon neutrinos had morphed into a different flavour along the journey. They then repeated the experiment with a beam of muon antineutrinos. ▶

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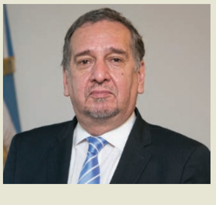

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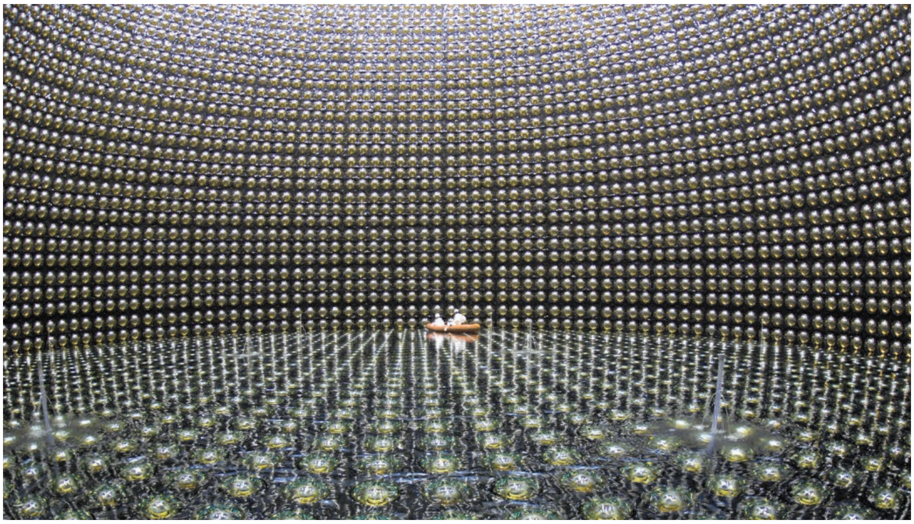
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Japan's Super-Kamiokande detector near Hida is analysing matter and antimatter neutrinos.

The two beams behaved slightly differently, said Konosuke Iwamoto, a physicist at the University of Rochester, New York, during his presentation at ICHEP.

The team expected that if there were no difference between matter and antimatter, their detector would have, after almost 6 years of experiments, seen 24 electron neutrinos and — because antimatter is harder to produce and detect — 7 electron antineutrinos. Instead, they saw 32 neutrinos and 4 antineutrinos arrive in their detector. "Without getting into complicated mathematics, this suggests that matter and antimatter do not oscillate in the same way," says Chang Kee Jung, a physicist at Stony Brook University in New York and a member of the T2K experiment.

Preliminary findings from the T2K and NOvA experiments had hinted at the same idea. But the observations so far could be chance fluctuations; there is a 1 in 20 chance (or in statistical terms, about 2 sigma) of seeing these results if neutrinos and antineutrinos behave identically, says Jung. By the end of its current run in 2021, the T2K experiment should have five times more data than it has today. But the team will need 13 times more data to push statistical confidence in the finding to 3 sigma, a statistical threshold beyond which most physicists would accept the data as reasonable — but not completely convincing — evidence of the asymmetry.

The T2K team has proposed extending its experiment to 2025 to gather the necessary data. But it is trying to speed up data-gathering by combining results with those from NOvA, which sends a neutrino beam 810 kilometres from Fermilab to a mine in northern Minnesota. NOvA has been shooting neutrino beams; it will switch to antineutrino beams in 2017. The two groups have agreed to produce a joint analysis and could together reach 3 sigma by around 2020, says Jung. Reaching the statistical certainty needed for a formal discovery, 5 sigma, might require a new generation of neutrino experiments, which are already being planned around the world.

Physicists are racking up discoveries about neutrinos on an almost annual basis, says de Gouvêa. "For the timescales of particle physics, this is changing really, really quickly." ■