

Einstein's relativity survives neutrino test

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Physicists working to disprove "Lorentz invariance" -- Einstein's prediction that matter and massless particles will behave the same no matter how they're turned or how fast they go -- won't get that satisfaction from muon neutrinos, at least for the time being, says a consortium of scientists.

The test of Lorentz invariance, conducted by MINOS Experiment scientists and reported in the Oct. 10 issue of *Physical Review Letters*, started with a stream of muon neutrinos produced at Fermilab particle accelerator, near Chicago, and ended with a neutrino detector 750 meters away and 103 meters below ground. As the Earth does its daily rotation, the neutrino beam rotates too.

"If there's a field out there that can cause violations of Lorentz invariance, we should be able to see its effects as the beam rotates in space," said Indiana University Bloomington astrophysicist Stuart Mufson, a project leader. "But we did not. Einsteinian relativity lives to see another day."

Mufson is quick to point out that the *Physical Review Letters* report does not disprove the existence of a Lorentz-violating field. Despite the sophistication and power of MINOS's detector, "It may be that the field's effects are so exceedingly small that you'd need extraordinary tools to detect it," Mufson said.

Mufson is a member of the MINOS Experiment, an international consortium of physicists dedicated to studying the mysterious properties

of neutrinos, particularly their wave-like oscillations. MINOS stands for Main Injector Neutrino Oscillation Search. MINOS scientists utilize the facilities at Fermilab to create a neutrino beam. The neutrinos are aimed at two detectors: one at Fermilab (the near detector) and another in the Soudan Mine in northern Minnesota (the far detector).

To produce the neutrinos, the MINOS scientists point a proton beam at a carbon target. The interaction causes a spray of pions (or pi mesons, a type of subatomic particle), some of which decay into muon neutrinos in the direction of the detector. Neutrinos travel at close to the speed of light, are unaffected by gravitational and magnetic fields, and because of their peculiar properties, can travel right through the crust of the Earth unaffected.

The notion of a Lorentz-violating field has become popular among theoretical physicists. Known physical rules do not do a very good job of explaining the cataclysmically chaotic moments immediately following the Big Bang, so some physicists are developing new theories to sort out the mess. The possibility that some of these new theories violate relativity was proposed by Mufson colleague Alan Kostelecky, distinguished professor of physics at IU Bloomington. Kostelecky provided some advice to MINOS scientists for the present report.

Kostelecky's "Standard-Model Extension" describes the most general possible Lorentz-violating fields that could arise in the universe's beginnings and also ties together Einstein's relativity rules and post-Einsteinian quantum mechanics.

One of the implications of Kostelecky's ideas is that the Lorentz-violating field could have been very strong during the mind-numbingly brief first moments of our universe. Now that the universe has expanded to considerable size, however, the strength of the Lorentz violating field may be severely reduced, making its existence hard to detect, if it is,

indeed, actually there.

"Every experiment so far has not found violations of Lorentz invariance," Mufson said. "That doesn't mean we'll stop looking. We knew the MINOS Experiment presented a new way of seeking out violations, and in a different place. We do things that are simple and look for something profound."

Source: Indiana University

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