

Lasers test Einstein's theory one century on

Tests of special relativity always attract interest, and they are likely to do so especially during 2005 – the centenary of the publication of Albert Einstein's first paper on the subject, and the World Year of Physics. Special relativity is in any case a hot topic, with speculation that something might be wrong with Lorentz invariance (*CERN Courier* December 2004 p27). A general theory for studying Lorentz-symmetry violation, known as the Standard Model Extension (SME), has been developed by Alan Kostelecký from Indiana University, and is being tested by

Kostelecký and a team at the Harvard-Smithsonian Center for Astrophysics, led by Ron Walsworth. In a recent paper they presented evidence that indicates that all is well with the usual Minkowski space-time.

The researchers looked for an annual variation of a daily sidereal modulation of the frequency difference between colocated ^{129}Xe and ^3He Zeeman masers. Coupling of the nuclear spins to Lorentz-violating background fields would lead to such a variation in the nuclear Zeeman splitting as the Earth rotates and revolves round the Sun.

The team found nothing at the level of 150 nHz, which translates, as the authors put it, into "the first clean test for the fermion sector of the symmetry of spacetime under boost transformations at a level of 10^{-27} GeV". The nuclear spins of ^{129}Xe and ^3He depend principally on the unpaired neutron in each case, and the results also provide equally stringent limits on CPT violation for the neutron.

Further reading

F Canè *et al.* 2004 *Phys. Rev. Lett.* **93** 230801.

The right spin for a neutrino superfluid

Right-handed neutrinos, with the intrinsic spin oriented in the direction of motion, have yet to be observed, but if they do exist then they could make neutrino superfluids possible. Joe Kapusta of the University of Minnesota has shown that such an exotic medium could arise because the right-handed particles could exchange Higgs bosons with the well known left-handed neutrinos and pair up to make bosons, which could then form a superfluid.

Kapusta points out that the condensation temperature would be well below the cosmic background temperature, so it would be quite a feat to make this superfluid. However, Kapusta also notes that a sufficiently advanced civilization might use pulses of neutrino superfluid for long-distance communications.

Further reading

J I Kapusta 2004 *Phys. Rev. Lett.* **93** 251801.

Clutter facilitates communication

Radio-reflective clutter is usually considered to be an obstacle to communications, providing unwanted echoes, television "ghost images" and the like. A little lateral thinking, however, shows that clutter can be used to achieve very useful effects. Benjamin E Henty and Daniel D Stancil of Carnegie Mellon University have shown that a multipath indoor environment can be used to focus 2.45 GHz radio waves to two locations about a half-wavelength apart.

This requires some tricky phase conjugation, essentially to undo the scattering from obstacles at the transmitter end, so the benefit does not come without effort. However, the result amounts to two separate channels, running at the same time and at the same frequency. The experiment was performed in a "cluttered" laboratory, but the real impact will be in the communications business, where buildings and other "clutter" have previously been seen as a problem not a solution.

Further reading

Benjamin E Henty and Daniel D Stancil 2004 *Phys. Rev. Lett.* **93** 243904.

Nature's parameters give perfect balance

Our sense of balance is about as good as it can possibly be. This extra "sixth" sense (in addition to smell, touch, sight, hearing and taste) is available to us via a set of three mutually perpendicular, fluid-filled tubes called vestibular semicircular canals, or SCCs. Housed in the inner ear, each is more or less doughnut-shaped, with a major radius of 3 mm and minor radius of 0.2 mm. A membrane called the cupula, which has sensory hairs, detects the motion of fluid in the SCCs and relays information about acceleration and gravity.

Interestingly, SCCs are about the same size in all vertebrates, at least within a factor of three or so, and this has long been something of a puzzle. Now Todd Squires of Caltech has provided an explanation. Varying four key parameters – the SCC major radius, minor radius, cupula thickness and height – he has found that the highest sensitivity occurs for the parameter values found in nature.

Further reading

Todd Squires 2004 *Phys. Rev. Lett.* **93** 198106.



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