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1. Test of the equivalence principle for spin-polarized atoms

Z-K Hu (Huazhong University of Science and Technology, China) and colleagues have performed an experiment comparing the free-fall acceleration of ^{87}Rb atoms having opposite total spin directions. Some theories predict the spin dependence of the free-fall acceleration. A possible reason is spin interaction with the acceleration vector or with the torsion tensor. The equivalence principle has already been checked for large spin-polarized ensembles of atoms, but if the number of atoms was small, the measurement accuracy was low. In the new experiment, the precision was heightened by the double differential measurements method, which rules out the effect of magnetic field inhomogeneities. Atoms in the states $m_F = +1$ or $m_F = -1$ of hyperfine splitting of level $5^2S_{1/2}$ in which spins have opposite directions fell in an atomic Mach–Zehnder interferometer. At the attained level of accuracy, no differences in the free-fall accelerations were revealed, and for their relative difference the constraint $\eta_S = (0.2 \pm 1.2) \times 10^{-7}$ was obtained, which, in turn, gives the constraint $< 5.4 \times 10^{-6}$ m^{-2} on the possible value of the torsion field gradient.

Source: *Phys. Rev. Lett.* **117** 023001 (2016)
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2. T+He$_3$ reaction cross section

A B Zylstra (Massachusetts Institute of Technology, USA) and colleagues have become the first to measure the cross section of the nuclear reaction $T(He_3, \gamma)^6Li$ at energies inherent in the epoch of primordial nucleosynthesis in the early Universe. Although the theory of primordial nucleosynthesis is on the whole consistent with the observed chemical composition of the Universe, the ^{6}Li content in some stars is much larger according to available data than predicted. One of the assumptions is that the $T(He_3, \gamma)^6Li$ reaction cross section has a higher value than that used in the calculations. To check this hypothesis, a capsule with a mixture of T and He$_3$ was exposed in the new experiment to high-power laser pulses. Upon evaporation of the external shell of the capsule, a convergent shock wave was formed, a temperature of 2.3×10^8 K was reached in the capsule center upon compression, and the $T(He_3, \gamma)^6Li$ nuclear reactions proceeded in the dense plasma for ~ 100 pc. The gas Cherenkov detector registered γ-photons, and the reaction cross section was found from their spectrum. The cross section proved to be close to the theoretically predicted one and it also corresponds to extrapolation of the data of other experiments performed earlier at higher energies. Thus, the hypothesis of a heightened $T(He_3, \gamma)^6Li$ reaction cross section was not confirmed, and the reaction rate turns out to be too low to solve the ^{6}Li problem. If the ^{6}Li content is actually anomalous, it might have been produced directly in stars or, alternatively, its synthesis in the early Universe was affected by supersymmetry or by some other yet unknown processes.

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3. Spin wave emitter

S Wintz (Helmholtz-Center Dresden–Rossendorf, Germany) and colleagues have designed a new antenna for emission of spin waves with a wavelength of ~ 100 nm. The spin wave is a collective electron spin excitation transferred through magnetic and exchange interactions. Spin waves are typically excited by small metallic antennas, but such antennas are ineffective in the nanometer region. The new emitter is a $Co/Ru/Ni_{81}Fe_{19}$ heterostructure consisting of two thin ferromagnetic discs separated by a nonmagnetic layer. Under the action of a magnetic field generated by alternating current in a nearby conductor, a pair of magnetic vortices appears in the disc center and emits spin waves. The propagation of spin waves generated by this device was observed by the transmission X-ray microscopy method.

Source: *Nature Nanotechnology*,
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http://dx.doi.org/10.1038/nnano.2016.117

4. Refraction and reflection of spin waves

C Back (University of Regensburg, Germany) and his colleagues have investigated the laws of spin wave refraction and reflection at the interface between two ferromagnetic (iron-nickel alloy) film sections of different thicknesses (30 nm and 60 nm). The refraction occurs because the spin wave velocity depends on the film thickness. The spin waves were observed through registration of laser pulses reflected from the film, the rotation of whose polarization vector depends on magnetization at one point or another. The second method, based on interference between the reflected and reference beams, provided information about the phase of the spin waves and the direction of their propagation. The obtained refraction law at small angles of incidence corresponds to Snell's law, but for the angles larger than 25° a deviation was observed due to anisotropy of the medium that occurred owing to magnetization in the external field. The authors of the experiment deduced a generalized Snell's law for spin waves with allowance for anisotropy and showed good agreement with the results of their measurements. The refraction of spin waves makes it possible to change their direction, which is important for practical applications. Spin waves are attractive in that they have a much smaller wavelength than that of electromagnetic waves at the same frequency. Furthermore, the charges remain motionless under spin wave propagation, and therefore Joule energy loss is absent.

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5. Search for cosmogenic neutrinos with IceCube

New constraints on the properties of the sources of ultra-high-energy cosmic rays (UHECRs), i.e., charged particles with energies above 10^9 GeV, whose origin is not yet known, were obtained with the neutrino IceCube telescope deployed in the ice of Antarctica. The interaction of UHECRs with the cosmic background radiation must lead to the generation of neutrinos with energies $E_\nu \geqslant 10^7$ GeV, called cosmogenic neutrinos. During seven years of observations, two neutrinos with $E_\nu \sim 10^6$ GeV that are most likely to be of astrophysical origin were detected; however, cosmogenic neutrinos with $E_\nu \geqslant 10^7$ GeV were not observed. Their flux appeared to be much smaller than is predicted in ordinary UHECR models. This implies that evolution of UHECR sources cannot go faster than the evolution of the star formation rate in galaxies. This constraint presents certain problems for the models of the UHECR origin in galactic nuclei, in sources of gamma-ray bursts, or in young pulsars, provided that protons dominate in the UHECR composition.

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