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1. Check of Lorentz invariance

In model theories aimed at unifying General Relativity and the Standard Model (for example, in string theories), Lorentz invariance is often assumed to be violated, which can manifest itself in the dependence of the velocity of light on the direction. The violation is expected to occur near the Planck energy, but its consequences, although in a suppressed form, must manifest themselves at lower energies, as well. Experiments checking Lorentz invariance and beginning with the Michelson–Morley experiment have thus far confirmed Lorentz invariance. In a new experiment, M Nagel (Humboldt University of Berlin, Germany) and colleagues have attained a now record accuracy of $\sim 10^{-18}$, at which the violations could be noticeable already at ~ 100 GeV. Compared were the electromagnetic oscillation frequencies in two cavities — sapphire crystals oriented at a right angle to each other. The crystals were placed in a vacuum chamber cooled from the outside by liquid helium. The stability of the frequency was restricted by the external magnetic field effect on the magnetic impurities in the crystals. The setup was rotated with a period of 100 seconds. Should the velocity of light be dependent upon the direction, rotations would induce periodic frequency shifts in the cavities and beat frequency shifts in the resultant signal. The data accumulated during the year of experiment were analyzed. The frequency shift was not detected to a relative accuracy of $(9.2 \pm 10.7) \times 10^{-19}$. This constrains the parameters responsible for a possible Lorentz invariance violation. For different parameters, the obtained restrictions were 4 to 20 times better than those of the preceding experiments.

Source: *Nature Communications* **6** 8174 (2015)
http://dx.doi.org/10.1038/ncomms9174

2. Quantum entanglement distillation

Quantum entanglement distillation may in the future become an important element of quantum communications and calculations. This procedure consists in the fact that from a large ensemble of weakly entangled quantum states a smaller strongly entangled subsystem is singled out. A group of researchers, including scientists from the Russian Quantum Center in Skolkovo, MIPT (Moscow Institute of Physics and Technology) (State University) and LPI (Lebedev Physical Institute), demonstrated the effect of quantum entanglement distillation for EPR pairs of photons. One of the photons from the EPR pair obtained in a nonlinear crystal was mixed with an auxiliary photon in a beam-splitting plate, and then both photons of the EPR pair were registered by synchronous detection technique. This way of entanglement distillation, known as 'quantum catalysis', was earlier proposed by A I Lvovsky and J Mlynek. It is of importance that continuous quantum variables (field quadratures) were distilled, which gave some advantages over the case of discrete variables. The experimental method made it possible to retrieve the level of entanglement after its 20-fold decrease upon a loss-inducing photon passage through the channel.

Source: *Nature Photonics* **9** 764 (2015)
http://dx.doi.org/10.1038/nphoton.2015.195

3. Motion of submicron particles by slowed-down light

M G Scullion (York University, UK) and colleagues have worked out the method of dielectric particle displacement over the photon crystal surface utilizing slowed-down light. The crystal was a triangular array of holes in a silicon plate. The group velocity of light in it was 20 times lower than that in a vacuum. The particle motion was induced by an evanescent field of an electromagnetic wave, the slowed-down light having a stronger effect on particles than ordinary light. The displacements of particles were traced by their fluorescent radiation, and the typical measured particle velocity constituted 5 μm s^{-1} with a radiation power of 2.5 mW. This method may turn out to be useful for manipulations with microscopic objects, including microbiological objects.

Source: *Optica* **2** 816 (2015)
http://dx.doi.org/10.1364.OPTICA.2.000816

4. Observation of coherent quantum states in proteins

Almost 50 years ago, H Fröhlich predicted that protein molecule oscillations can become ordered and be condensed in a process resembling Bose–Einstein condensation. Parts of the molecules then behave as a group of coupled oscillators that can be condensed to a low-frequency mode. G Katona (Göteborgs Universitet, Sweden) and his colleagues received the first experimental confirmation of this effect in a protein crystal. The lysozyme enzyme examined had been obtained from a hen-egg protein and was subjected to crystallization. The sample was exposed to terahertz radiation and was observed by the method of X-ray crystallography. Absorption of electromagnetic radiation with a frequency of 0.4 THz caused structure changes in the crystal, namely, collective excitations of the portions of protein molecules. In doing so, the excitation attenuation time was three to six orders of magnitude longer than in the case of ordinary thermal relaxation. This effect is best explained by condensation through the Fröhlich mechanism.

Source: *Struct. Dyn.* **2** 054702 (2015)
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5. Constraints on intergalactic magnetic fields by gamma-ray blazars

Intergalactic magnetic fields have not yet been measured, and only certain constraints 10^{-16} G $\leqslant B \leqslant 10^{-9}$ G on their possible values exist. One promising method of magnetic field exploration is the search for their influence on the motion of e^+ and e^- in electromagnetic cascades generated by primary gamma-ray emission of blazars (the class of galaxies with active nuclei) upon their interaction with intergalactic microwave background radiation. J D Finke (Naval Research Laboratory, USA) and colleagues compared the spectra of five blazars obtained at high energies by ground-based detectors with their low-energy spectra measured by the Fermi Telescope. Low magnetic fields are excluded from the requirement that the cascade gamma-ray emission generated by $e^{\pm}$ under inverse Compton scattering by relic photons not exceed the values measured by the Fermi Telescope. Thus, the restriction $B \geqslant 10^{-19}$ G was obtained, with the coherence length being $\geqslant 1$ Mpc at a confidence level of 5σ. B had already been earlier restricted from below by another indirect method relying on the absence of observed gamma-ray halos around blazars: $B \geqslant 10^{-16}$ G.

Source: http://arXiv.org/abs/1510.02485

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