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1. New measurements of the fine-structure constant

Using a new experimental scheme combining the Bloch oscillations effect and atom interferometry, M Cadoret and his coworkers in France were able to measure the fine-structure constant with a relative uncertainty of 4.6×10^{-9}. Other recent superhigh-precision experiments for α directly measured only the anomalous magnetic moment of the electron, after which α was calculated using the formulas of quantum electrodynamics. In the experiment conducted by M Cadoret and his colleagues, measurements of α were more direct (did not need the assumption of validity of QED formulas) as they used recoil momenta from atoms in a periodic potential. Rubidium atoms were placed in an optical lattice and illuminated by two counter-propagating laser beams with slightly different frequencies; the atoms absorbed photons from one beam and then re-emitted them into the other beam. The frequency difference was compensated for by the Doppler effect in atomic motion, and its measurement yielded the value of α. The agreement with results obtained in other experiments and with theoretical QED predictions provides the most stringent test of this theory currently available.

Source: *Phys. Rev. Lett.* **101** 230801 (2008)
http://arXiv.org/abs/0810.3152v1

2. Light pulse in an optical filament

The controversy concerning the momentum of light in a transparent medium has remained the object of debate for nearly a hundred years. The problem of choosing between the expressions given by H Minkowski (1908) and M Abraham (1909) lies in the ambiguity of dividing the total momentum into that of the field and that of the medium, and in the need to take into account the action exerted by the electromagnetic field on the medium when light is emitted or absorbed [see *Sov. Phys. Usp.* **19** (1) 94 (1976)]. Chinese researchers W She, J Yu, and R Feng of Sun-Yat-Sen University in Guangzhou carried out a new experiment which confirmed Abraham's expression. A silica fiber taper 1.5 mm in length and half a micron in diameter was suspended vertically in a hermetically sealed vessel. Light from two lasers was sent downward through the fiber taper. The first laser, at a wavelength of 650 nm and a power output of 0.5 mW, served to illuminate the fiber taper and facilitate observing its motion, which was photographed 10 frames/s through a lens installed in the wall of the vessel. When a light pulse from the second laser at a wavelength of 980 nm and a tunable power output of 0 to 78 mW emerged from the lower end of the fiber taper, it imparted to it a momentum and the upward-directed recoil caused taper bending. This behavior confirmed Abraham's expression for momentum: if Minkowski's approach had been correct, there would have been a downward stretching load on the fiber taper. The experiment was successful owing to the light weight of the fiber taper: the recoil momentum compensated for the weight of the free end segment of the fiber taper. The experiment confirmed the theoretical evaluation which predicted this compensation to occur at a laser power output of about 4 mW. A not very different result was obtained when the second laser worked in continuous, not pulsed, mode.

Source: *Phys. Rev. Lett.* **101** 243601 (2008)
http://arXiv.org/abs/0806.2442

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Translated by V I Kisin

3. The Magnus effect for light

E Hasman and his colleagues at the Technion–Israel Institute of Technology are the first to observe in the adiabatic mode the spin Hall effect for photons, also known as the optical Magnus effect. This effect was observed earlier, but only in the nonadiabatic case of strong nonuniformity, when a particle's trajectory is stopped abruptly. The spin Hall effect for photons consists in the interaction between the spin of a particle and the curvature of its trajectory, resulting in an additional force affecting the trajectory of motion. Hasman and coworkers studied the propagation of laser light along a glass cylinder. The beam went through total internal reflections and its trajectory was twisted into a helix inside the cylinder at the surface of the latter. Measured at the exit face of the cylinder were the beam direction and the Stokes parameters. The experiment, carried out at Technion, confirmed the detailed theory of the optical Magnus effect, based on the dynamic effect of the geometric Berry phase.

Source: *Nature Photonics* **2** 748 (2008)
http://arXiv.org/abs/0810.2136

4. The Lamb shift in solids

The Lamb shift of atomic energy levels is caused by the interaction between electrons and virtual electron – positron pairs created in a vacuum. Typically, it is not possible to observe the Lamb shift in solids since energy levels in them form broad bands. However, A Wallraff and his coworkers at ETH Zurich in Switzerland and the University of Sherbrooke in Quebec, Canada were able to measure the Lamb shift of the macroscopic quantum bit (qubit) in a resonator. The qubit consisted of two tiny pieces of superconductor connected by two tunnel junctions. This system is known as a transmon. The energy levels of the transmon are governed by the distribution of Cooper pairs in superconductors. A transmon was placed in a microwave resonator where it could absorb and emit photons of certain frequencies. By virtue of its shape, the transmon possessed a large electrical dipole moment; also, a special resonator configuration was chosen so as to enhance the effect of transmon interaction with virtual photons. At the same time, the Stark effect contributed only negligible corrections because it was felt only outside the area of resonance with virtual photons. As a result, the observed Lamb shift of the transmon's energy levels was approximately 1.4% of the energy difference between the neighboring levels, which is 10,000 times greater than the Lamb shift in a hydrogen atom outside the resonator. The Lamb shift results in decoherence of the qubit state. The experiment conducted by A Wallraff and his colleagues provides a recipe for avoiding undesirable decoherence in future quantum computers — choose device configurations that are not in resonance with virtual photons.

Source: *Science* **322** 1357 (2008)
http://dx.doi.org/10.1126/science.1164482

5. Stimulated emission of surface plasmon polaritons

Surface plasmons and plasmon polaritons constitute electromagnetic waves coupled to oscillations of an electron gas, localized or propagating along the metal – dielectric interface, respectively. These quasiparticles are strongly absorbed in the range of optical frequencies and have a short propagation length, which create problems for their possible practical applications. It was suggested that the problem may be solved by introducing optically active impurities. M A Noginov (Norfolk State University, USA) and his coworkers were able for the first time to use this technique and achieve both the compensation of losses of surface plasmon polaritons and the observation of their stimulated emission which is similar to the stimulated emission of photons in lasers. A 39- to 82-nm thick silver film was deposited onto a face of a glass prism. The silver layer was coated with a polymer film doped with rhodamine 6G dye molecules. Excitation of surface plasmon polaritons was produced by light pulses, first on the side of the prism [for the sake of calibration needed to measure the reflection profile $R(\theta)$] and then on the side of the polymer film. The dye molecules absorbed photons and emitted surface plasmon polaritons. The threshold for polariton emission and the spectrum of polaritons agreed with theoretical predictions for laser-like radiation. This experimental study may lead to useful applications in creating novel metamaterials and plasmon nanodevices.

Source: *Phys. Rev. Lett.* **101** 226806 (2008)
http://dx.doi.org/10.1103/PhysRevLett.101.226806

6. A very hot white dwarf

The NASA's space-based telescope FUSE detected a white dwarf KPD 0005 + 5106 with a record-high surface temperature of 200,000 °C. At this temperature an object is visible in the UV range of the spectrum. White dwarfs (their internal pressure is sustained by degenerate electron gas) evolve from massive stars after the thermonuclear fuel inside them is exhausted. High temperatures can be produced only immediately after the white dwarf is formed, before it starts to cool, so the observation of a white dwarf star with a temperature of 200,000 °C is a very rare event.

Source: http://www.space.com/scienceastronomy/081212-hot-star.html

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