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1. Casimir – Lifshitz force in repulsion mode

In 1961, E M Lifshitz, I E Dzyaloshinskii, and L P Pitaevskii, formulated in *Adv. Phys.* **10** 165 (1961) [see also *Sov. Phys. Usp.* **4** 153 (1961)] the conditions at which the Casimir – Lifshitz force acting between two plates becomes repulsive; it is necessary that the permittivity of the intermediate dielectric layer be lower than that of one of the plates but higher than that of the other. The Casimir – Lifshitz force in repulsion mode was measured in a number of experiments but only at distances not larger than several nanometers, where the Casimir effect shows itself in the van der Waals mode and the contribution of intermolecular forces is large. Harvard University's F Capasso and J Munday, and A Parsegian of the NIH in Bethesda, Maryland were the first to conduct detailed measurements of the Casimir – Lifshitz force at distances from 20 to 300 nm in which the effect of repulsion stemming from the distortion of the spectrum of zero quantum oscillations in vacuum is directly measurable. They observed the interaction between a polystyrene sphere 40 μm in diameter coated with a 200-nm thick gold layer and a quartz plate in liquid bromobenzene. Using a small sphere instead of the second plate proved to be very convenient, as this removed the need in the complicated procedure of setting the plates parallel to one another at a small separating distance. Moreover, this method allowed determining the force from the velocity of travel of the sphere, and determining this velocity by measuring the displacement of the beam of light reflected from the sphere. Preliminary calibration was carried out far from the quartz plate (where the Casimir effect is very weak); various velocities of the sphere travel through the liquid were put in correspondence with hydrodynamic forces. The measured force of repulsion of the sphere from the plate was in good agreement with calculations in terms of the Lifshitz – Dzyaloshinskii – Pitaevskii theory. The quartz plate was replaced in the control experiment with a gold plate; as was expected, in this case the sphere was attracted to the plate.

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2. Symmetry of the energy gap in $Ba_{0.6}K_{0.4}Fe_2As_2$

Experiments show that the energy gap in high-temperature superconducting cuprates (the binding energy of a Cooper pair) has different signs in different regions of the Fermi surface. Angle-resolved photoelectron spectroscopy has not confirmed the existence of a similar asymmetry of the energy gap in iron-based superconductors such as $Ba_{0.6}K_{0.4}Fe_2As_2$. In fact, however, these superconductors cannot be described in terms of the Bardeen – Cooper – Schrieffer theory in which the gap is assumed to be symmetrical. A hypothesis was advanced that the result is negative because the spectroscopic techniques used to study these materials are not sensitive to the phase of the wave function of electrons, which carries the symmetry information. R Osborn and colleagues at Argonne and Oak Ridge National Labs and Northwestern University in the US and the Rutherford Appleton Lab in the UK conducted new studies of the energy gap in $Ba_{0.6}K_{0.4}Fe_2As_2$ by using inelastic neutron scattering, which makes it possible to measure the phase. The characteristic effect on the magnetic moments of neutrons established that the symmetry of the gap in $Ba_{0.6}K_{0.4}Fe_2As_2$ superconductors differs from the gap d-symmetry in cuprate superconductors and is most likely of the type $s_{\pm}$, in which case electrons split into groups with the opposite phase of the wave function. In this case, the pairing of electrons is created through antiferromagnetic fluctuations.

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Translated by V I Kisin

3. Stability of the coherence of laser light

M Bellini (University of Florence, Italy) and colleagues confirmed a theoretical prediction of R Glauber (1963) stating that the removal of individual photons from a laser beam leaves the beam in a coherent quantum state. A laser beam was passed through two optical splitters. The first splitter split the beam in two and their interference gave the measure of the degree of coherence. One of these beams was sent through the second splitter with very little splitting efficiency, which allowed the authors to single out individual photons from this beam. These photons were recorded by a detector that could be triggered by single photons. In accordance with R Glauber's theoretical prediction, it was found that the removal of individual photons did not destroy the coherence of the laser beam. Furthermore, M Bellini and his coworkers developed a technique for adding single photons to a beam; in this manner, they confirmed that the operations of removing and injecting photons are noncommutative. The authors believe that the ability to remove photons from a beam of coherent laser light could be utilized in developing quantum information and metrology systems.

Source: http://physicsworld.com/cws/article/news/37106

4. Quantum cascade lasers

C Gmachl (Princeton University) and colleagues were the first to discover in 2007 that the quantum cascade laser they built generated, in addition to the 'normal' beam, a laser beam at a second frequency but of lower power [see *Appl. Phys. Lett.* **90** 091104 (2007)]. The lasing area of the laser in question consists of hundreds of layers of various semiconductors, each only a few atoms thick. Later on, the same team of researchers obtained further interesting results. It was found that the radiations at the two frequencies are in anticorrelation, which is caused by a 'competition' for charge carriers that can take part in the radiation at both the principal and the second frequency: as temperature increases, the output power of the second beam grows, while that of the first one decreases. A possible theoretical explanation for the discovered effect was also suggested. It is assumed that the second beam is generated by electrons with momenta $k = p/\hbar \approx 3.6 \times 10^8\ \mathrm{m}^{-1}$ in nonequilibrium states, while quasi-nonequilibrium electrons with zero momenta are responsible for the first beam. Lasers emitting via the new mechanism may find useful practical implementations. Unlike other lasers, quantum cascade lasers operate in the mid- and far-IR range. The nearest task facing the researchers is to suppress the emission of the laser beam at the principal frequency, so as to achieve emission of the second type only.

Source: *Nature Photonics* **3** 50 (2008)
http://dx.doi.org/10.1038/nphoton.2008.250
http://engineering.princeton.edu/news/laser_08

5. Fast-moving stars

A group of astronomers led by R Sahai of NASA's Jet Propulsion Lab in Pasadena, California using NASA's Hubble Space Telescope found 14 young, runaway stars moving at huge velocities through the interstellar gas and creating a bow shock $\approx 10^{11} - 10^{12}$ km in size, leaving behind a trace of glowing gas. The shock wave is produced by the collision of the powerful stellar wind with the surrounding gas. The stars were found to be fairly young — not older than a million years or so — and have masses not more than eight times the solar mass. Hubble's observations yielded the shape and structure of the shock waves. The stars are moving at about 180,000 km h^{-1}, which is roughly five times higher than the characteristic velocities of ordinary young stars. It is assumed that these stars get such high velocities from slingshot ejection out of stellar clusters in a close flyby, or from gravitational interaction between two binary stars or a binary and a single star, or when the second component of a pair explodes as a supernova. Such fast-moving stars were first detected by the IRAS telescope at the end of the 1980s; however, the stars observed then by IRAS were considerably more massive.

Source: http://hubblesite.org/newscenter/archive/releases/2009/03/full/

Prepared by *Yu N Eroshenko*