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Physics news on the Internet (based on electronic preprints)

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1. Rare $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ decays

The CMS and LHCb Collaborations conducting experiments with the Large Hadron Collider have reported the detection of the very rare meson decays $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ with 6σ and 3σ confidences, respectively. The probability of these decays is so little because they proceed due to weak interactions and additional second-order diagrams. The detection of $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ decays is important because they are sensitive to effects both beyond the Standard Model or within its modifications. For example, some theories concerning additional Higgs bosons predicted a heightened probability of the decays indicated. In the new joint work, the 2011–2012 CMS and LHCb data on pp collisions were analyzed. The measured decay probabilities agree well with the Standard Model calculations, which imposes certain restrictions on new hypothetical effects.

Source: *Nature*, online publication of May 13, 2015.
http://dx.doi.org/10.1038/nature14474

2. Cooper pairing of electrons without superconductivity

J Levy (University of Pittsburgh, USA) and his colleagues have carried out an experiment where Cooper pairing of electrons in a substance not giving rise to superconductivity was observed for the first time with a high confidence. This effect was predicted in 1969 by D M Eagles. An atomic-force microscope was exploited to fabricate a single-electron transistor consisting of nanowire between $SrTiO_3$ and $LaAlO_3$ layers. The portion of the nanowire between two discontinuities (tunnel barriers) was a quantum dot to which electrons could be added by varying the transistor shutter potential. The experiment was conducted at a temperature higher than the superconducting transition temperature, and so superconductivity was absent. Nevertheless, electron pairs came to the quantum dot from the side of the $SrTiO_3$. This was established by the presence of double peaks (split as a result of the Zeeman effect) on the conductivity diagram. The splitting was originated upon increasing the external magnetic field above 3 T. The study of the phase exhibiting Cooper pairing without superconductivity will possibly provide insight into the formation mechanisms of high-temperature superconductivity.

Source: *Nature* **521** 196 (2015)
http://dx.doi.org/10.1038/nature14398

3. Deceleration of light in optical fiber

Two independent teams of researchers [J Laurat (Pierre and Marie Curie University — Paris 6, France) and colleagues and A Rauschenbeutel (Vienna University of Technology, Austria) and colleagues] have become the first to realize the method of lowering the group velocity of light in a substance, which was proposed theoretically by A K Patnaik, J Q Liang, and K Hakuta in 2002. Earlier experiments on the deceleration of light were performed directly in ultracold gases, while in the new experiment the light pulse carried by a single photon was transported along an optical fiber coming through a cloud of ultracold gas of cesium atoms in a magnetooptical trap. The optical fiber thickness was less than the wavelength of light, and therefore an evanescent electromagnetic field containing about 40% of the pulse energy appeared around the optical fiber. Owing to the interaction between the gas and the field overstepping the borders of the optical fiber, the overall light pulse was slowed down. The state of the atomic gas and, accordingly, the electromagnetically induced transparency of the medium could be controlled utilizing an additional laser and a magnetic field. In his experiment, J Laurat and coworkers achieved both the lowering of the group velocity of light to $c/3000$ and registration of the pulse: its stop due to absorption and a subsequent re-emission with a 10% efficiency. In the experiment by A Rauschenbeutel and others, the group velocity of light was lowered to 50 m s^{-1}, and it was recorded and released with a 3% efficiency. The new method of light deceleration in optical fiber is convenient because to slow down light it is unnecessary to use mirrors, lenses, etc. for a light deflection and because it can find practical applications in devices for quantum information processing.

Sources: *Phys. Rev. Lett.* **114** 180503 (2015);
Optica **2** 353 (2015)
http://arXiv.org/abs/1502.01458
http://dx.doi.org/10.1364/OPTICA.2.000353

4. Cyclotron radiation of a single electron

D M Anser (Pacific Northwest National Laboratory, USA) and colleagues have measured the characteristics of electromagnetic radiation generated by a single electron circularly orbiting in a magnetic field. The relativistic corrections to the rotation frequency depend on the electron energy, and this method is therefore good for electron energy measurements. Although investigated theoretically by O Heaviside as far back as 1904, the cyclotron radiation of a single electron has not been measured directly up to now. In their experiment, Anser and his colleagues detected the radiation of electrons emitted in beta-decays of ^{83}Kr isomer nuclei and captured in a magnetic trap. Radiation with a frequency of ~ 25 GHz and power of only one femtowatt got to a low-noise amplifier through a waveguide. This technique was applied to register single-electron radiation, which was established from the characteristic frequency increment caused by the electron energy loss, and also from the presence of sharp jumps interpreted as electron collisions with gas molecules. This method is planned to be used for recording electron radiation

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in experiments involving measurements of the masses of neutrinos ejected in radioactive decays. Simultaneously with neutrinos, which are hardly accessible for direct recording, electrons are also emitted, and the neutrino mass can be found by their energy spectrum. In the KATRIN experiment (Karlsruhe, Germany) to be performed, the electron detector is a complex massive construction. KATRIN is a large-scale analogue of the TROITSK-NU-MASS experiment which was guided by Academician V M Lobashev at the INR RAS in the town of Troitsk, in which the restriction from above on the neutrino mass was obtained. The new method of electron energy measurement with the aid of the cyclotron radiation frequency will possibly allow the creation of a more compact high-sensitivity electron spectrometer.

Source: *Phys. Rev. Lett.* **114** 162501 (2015)
http://dx.doi.org/10.1103/PhysRevLett.114.162501

5. Flavor distribution of high-energy neutrinos

Two teams of researchers [F Vissani (Gran Sasso Science Institute and Gran Sasso National Laboratory, Italy) with colleagues and the IceCube Collaboration] have independently analyzed data gathered by the IceCube neutrino detector located on the South Pole and come to the conclusion that the recorded neutrinos are approximately evenly distributed among three flavors, namely, electron, muon, and tau. The other team earlier concluded that a flux of IceCube neutrinos consists almost completely of ν_e, which is only possible in some exotic models. In the new analysis of both groups, the events were divided into track- and shower-like ones (according to the light-emission region topology) and the data on muons accompanying neutrino events were used. The revealed flavor equipartition of neutrinos corresponds well to mixing in long-lasting neutrino oscillations while neutrinos flew from far astrophysical sources, perhaps active galactic nuclei.

Sources: *Phys. Rev. Lett.* **114** 171101, 171102 (2015)
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