

# Physics news on the Internet (based on electronic preprints)

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## 1. Direct observation of $T$ -invariance violation in a system of B mesons

The direct measurements of the violation of  $T$ -invariance (invariance of processes under time reversal) for K mesons were previously performed at CERN and at the Fermi National Accelerator Laboratory, but the results obtained were not free of considerable uncertainty. Violation of  $T$ -invariance in a system of B mesons was earlier established only indirectly, by examining the violation of  $CP$ -invariance. Now, it was proved possible to measure the effect of  $T$ -invariance violation for B mesons directly, without resorting to the  $CPT$ -theorem, by using a new method of data analysis in the BaBar experiment conducted at the National Accelerator Laboratory (SLAC). In the BaBar experiment, decays of  $\Upsilon(4S)$  resonances created pairs of  $B^0\bar{B}^0$  in quantum-entangled states. Entanglement made it possible to compare the rates of the processes corresponding to different ordering of  $B^0$  and  $\bar{B}^0$  decays in time, and also under the permutation of the final states (of decay products). As a result, the violation of  $T$ -invariance has been established with high statistical significance— $14\sigma$ . The measured parameters that characterize the violation of  $T$ -invariance correspond to magnitudes previously derived from the effect of  $CP$ -invariance violation.

Source: *Phys. Rev. Lett.* **109** 211801 (2012)<http://dx.doi.org/10.1103/PhysRevLett.109.211801>

## 2. Superconductivity in $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$

A team led by Ivan Bozovic of Brookhaven National Laboratory has continued to work on the experiments described earlier [see, e.g., *Phys. Usp.* **51** 170 (2008)] and discovered that, under certain conditions, a drop in temperature, instead of resulting in the transition to superconducting state, suppresses superconductivity in the compound  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ . A  $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$  layer was grown on a substrate by an improved molecular-beam epitaxial technique which allows controlling the doping level  $x$ . Near the superconducting transition temperature, Bozovic et al. observed superconducting fluctuations which normally precede the emergence of superconductivity. Unexpectedly, superconducting fluctuations were suppressed in specimens with  $x = 0.055 - 0.06$ , plus they were completely absent in sufficiently high magnetic fields. As temperature was further reduced, suppression was enhanced, and superconductivity would not emerge. One cause of this could supposedly lie in structural defects which at low temperatures hamper electron flow (the electron localization effect). As the doping level increased, the suppression effect disappeared. For example, a

specimen with  $x = 0.07$  became superconducting when cooled to  $T_c = (9 \pm 1)$  K.

Source: *Nature Materials* **12** 47 (2013)<http://dx.doi.org/10.1038/nmat3487>

## 3. Acoustic analogue of the dynamic Casimir effect

C I Westbrook and his colleagues at the C Fabry Laboratory (Université Paris-Sud, France) have implemented an acoustic analogue of the dynamic Casimir effect, which was first observed in 2011. In the dynamic Casimir effect, virtual particles transform into real ones due to rapid nonadiabatic changes in boundary conditions. In the experiment by C I Westbrook et al., researchers varied the potential of the optical trap holding a Bose–Einstein condensate of helium atoms, which led to a change in the speed of sound and in the spectral composition of oscillations in the condensate. The potential was varied by changing the intensity of the laser beams that formed the trap. In version I of the experiment, the potential was changed sharply once, while in version II it was subjected to 10% sinusoidal modulation for 25 ms until the trap was turned off and the condensate cloud broke apart. As a result of these changes, the thermal fluctuations in the condensate transformed into pairs of elementary excitations—quasiparticles moving in opposite directions with momenta of identical magnitude and frequency equal to one half of the modulation frequency. Excitations corresponded to lateral components in the velocity distribution of gas particles in the expanding cloud. These excitations satisfied the Bogoliubov–de Gennes dispersion relation both in the phonon mode, when excitation consisted of several correlated atoms, and in the single atoms mode. The researchers are looking forward to fabricating an acoustic analogue of Hawking radiation, similarly to how in 2009 an experiment by J Steinhauer et al. generated an acoustic analogue of the black hole horizon.

Source: *Phys. Rev. Lett.* **109** 220401 (2012)<http://dx.doi.org/10.1103/PhysRevLett.109.220401>

## 4. Effect of light on the conductivity of insulators

F Krausz (Institute for Quantum Optics, Max Planck Society, Germany) and colleagues have been able to demonstrate a method of ultrafast control of dielectric conductivity using high-power femtosecond pulses of near-infrared radiation (NIR), comprising a mere several oscillations of the light wave. The conductivity of amorphous silicon dioxide ( $\text{SiO}_2$ ) exposed to these pulses increased over  $\approx 1$  fs by about 18 orders of magnitude and dropped back over the same time. A wave field with an intensity of several volts per angstrom substantially altered the electronic structure but, nevertheless, this transition occurred reversibly, without destroying the atomic structure of the specimen. Conductivity measurements were made by spectroscopic methods and

by recording the current flowing across the electrodes. The observed properties are well explained by the theoretical model developed by V Apalkov and M Stockman. Even though the conductivity of semiconductors is much simpler to control than that of insulators, the changes caused in conductivity are much slower. In principle, the new effect offers the possibility of ultrafast control of electrical signals in promising devices operating in the terahertz, and even pentahertz, ranges ( $10^{15}$  Hz).

Sources: *Nature* **493** 70 (2013), *Nature* **493** 75 (2013)

<http://dx.doi.org/10.1038/nature11567>

<http://dx.doi.org/10.1038/nature11720>

## 5. Gamma-ray bursts caused by lightning

Sometimes lightning discharges generate gamma-ray flashes several thousandths of a second long, known as terrestrial gamma-ray flashes. A GBM detector aboard the NASA's Fermi Gamma-ray Space Telescope is currently recording approximately two gamma-ray flashes due to lightning per week with a time resolution of about 2  $\mu$ s. It was assumed in the past that powerful radio bursts which are also generated by lightning discharges are not directly traceable to the generation of gamma-rays. However, as follows from the new data collected with the GBM detector, gamma-ray flashes and some broad peaks in radio bursts in fact occur simultaneously and have similar pulse shapes. Consequently, these gamma and radio signals appear to be of the same origin, being generated in one and the same area of the electrical discharge. It is highly probable that 'runaway electrons', whose theory was developed by A V Gurevich and his colleagues (Lebedev Physical Institute, RAS), are responsible for high-energy phenomena in the lightning.

Source: [http://www.nasa.gov/mission\\_pages/GLAST/news/vision-improved.html](http://www.nasa.gov/mission_pages/GLAST/news/vision-improved.html)

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