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

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## 1. Search for supersymmetry effects in rare decays

The LHCb Collaboration at the Large Hadron Collider has studied ultrarare particle decay channel, $B_s^0 \to \mu^+\mu^-$, and reported certain new constraints on the possible contribution of supersymmetry effects to the physics of these decays. The theory of supersymmetry, which unites bosons and fermions in a certain unifying scheme, is able to resolve a number of problems in elementary particle physics and offers several candidates the role of dark matter particles. $B_s^0$ mesons produced in pp-collisions consist of a b-quark and an s-antiquark and decay in the framework of the Standard Model to $\mu^+\mu^-$ with a probability of $(3.1 \pm 0.2) \times 10^{-9}$. If Supersymmetry were a reality, the decays would occur more often (up to twice as often) via the exchange of neutral Higgs bosons. By the beginning of 2012, several events of $B_s^0 \to \mu^+\mu^-$ decays were detected in the LHCb experiment and a bound from above on the decay probability, $< 4.5 \times 10^{-9}$ at a 95% confidence level, was obtained. This result agrees with the expectation of the Standard Model, while the absence of a significant contribution of Supersymmetry constrains minimum supersymmetric models that would predict higher probabilities; however, this does not preclude the possibility of more complex models of Supersymmetry.

Sources: http://arXiv.org/abs/1208.3355
http://www.cam.ac.uk/research/news/supersymmetry-squeezed-as-lhc-spots-ultra-rare-particle-decay/

## 2. Quantum delayed-choice experiment

A Peruzzo (University of Bristol, UK) and his colleagues have carried out a new version of the quantum experiment with delayed choice (the general idea of such a thought experiment was suggested by John Wheeler), in which the observer chooses the method of measurement, while the recorded photons manifest themselves as waves or particles depending on the choice made. In this experiment, which was carried out using a 'photonic chip', the triggering of the method of measurement was implemented using a quantum key — a splitter, whose on or off configurations were dictated by the quantum state of the auxiliary control photons. The superposition of two states of the control photon corresponded to the superposition of the measurement types, and, therefore, in a certain sense, a simultaneous measurement of corpuscular and wave properties was carried out. Note also that by changing the statistical weights of the states of the control photon it was possible to achieve a continuous transition from measuring the corpuscular to measuring the wave properties. The experiment also studied Bell's inequality for the states of photons at the output. The maximum violation of these inequalities implied that quantum effects showed their worth in the course of measurements, which were not reducible to classical effects, for example, in the form of 'hidden parameters'.

Source: *Science* **338** 634 (2012)
http://dx.doi.org/10.1126/science.1226719

## 3. Amplification of quantum bits

G J Pryde (Griffit University, Australia) and his colleagues have demonstrated a technique for amplifying quantum bits — that is, cubits encoded in the polarization states of photons. When quantum information is transmitted, we face the unavoidable problem of state decoherence due to noise, absorption, and the scattering of photons in transmission channels. To amplify the useful signal, the researchers transferred the state of a photon that carried the cubit and passed through the noisy channel to another photon located in better environment. It is important that states were transferred through the interferometer in a random manner, since otherwise the deterministic transfer would result in quantum decoherence. Using polarization splitters, independent two-channel amplification of states with orthogonal polarizations was carried out, and these states were again mixed at the amplifier output. As a result, it was possible to achieve a nearly fivefold enhancement in the transmission fidelity of a quantum signal through a realistic qubit channel. This technique may prove important for devices designed for quantum calculations and the transmission of quantum information.

Source: *Nature Physics*, online publication of 11.11.2012
*Nature Physics* **9** 23 (2013)
http://dx.doi.org/10.1038/nphys2469

## 4. Cooper pairs in aromatic hydrocarbons

R Wehlitz (University of Wisconsin–Madison, USA) and his colleagues have found the formation effect of short-lived pairs of electrons similar to Cooper pairs, under the double photoionization of molecules of aromatic hydrocarbons by photons from a synchrotron source. To measure the spectra of photoelectrons, the researchers used electrostatic analyzers. Pairs of electrons were produced in molecules of benzene, naphthalene, anthracene, and coronene, which have a ring structure with one or several carbon-based rings. If the energy of a photon was roughly 40 eV higher than the double-ionization threshold, a situation was possible where oscillations of the wave function of an electron pair corresponded to the periodic structure of the carbon atom arrangement in the ring, and the ring length was equal to a multiple of the de Broglie wavelength of the electron pair. This resulted in the formation of short-lived bound pairs of the electrons, which decayed soon after photoemission from the molecule. As a rule, the electrons of the decayed pair did not move in strictly opposite directions, because they

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interacted with the positive ions in the molecule. In molecules of pyrrole and furan, which have 5-atom rings, the change in geometric configuration precluded the pairing of electrons. Note that in contrast to Cooper pairs in superconductors, the electron pairs discovered in hydrocarbons are weakly coupled and rapidly decay; nevertheless, their investigation can be useful for producing new organic superconductors.

Source: *Phys. Rev. Lett.* **109** 193001 (2012)
http://dx.doi.org/10.1103/PhysRevLett.109.193001

## 5. Effect of intergalactic background on blazer spectra

NASA's Fermi Gamma-ray Space Telescope has detected specific features in the spectra of blazers (one of the classes of galaxies with active nuclei) at red shifts of up to $z = 1.6$, which could be explained in terms of the absorption of gamma photons in the interaction with the intergalactic background radiation in the optical and ultraviolet ranges in the $\gamma + \gamma' \to e^+e^-$ process. The sources of the background radiation, which also could be significant in re-ionization of the Universe, were the aggregate emission by stars in galaxies beginning from very early epochs, as well as the radiation that was generated in the accretion of matter onto black holes. Measurement of a radiation absorption in the spectra of individual blazers is also quite difficult, but it was found to be statistically at a $6\sigma$ level for an array of 150 blazers. Direct measurement of this flux proved infeasible due to absorption by dust in our Galaxy. The detected flux of intergalactic background radiation at the frequency of optical and UV ranges measures $3(\pm 1)$ nW m$^{-2}$ sr$^{-1}$ at $z \approx 1$. This quantity is not very different from the flux generated by the active galactic nuclei. The measured flux provides an upper bound on the possible types of sources, for instance, bounds from above for the rate of star formation in the early Universe.

Source: *Science*, online publication of 1 November 2012
*Science* **338** 1190 (2012)
http://arXiv.org/abs/1211.1671

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