

PACS number: **01.90. + g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0184.201406e.0652

1. Photon polarization in $b \to s\gamma$ decay

Photon polarization in radiative $B^{\pm} \to K^{\pm}\pi^{\pm}\pi^{\mp}\gamma$ decays has been registered for the first time in the LHCb experiment carried out at the Large Hadron Collider. $b \to s\gamma$ decays of b quarks from the B-meson composition are due to the weak interaction violating the invariance with respect to mirror reflection; therefore, the photons are produced in this reaction mainly with left-handed circular polarization. The $b \to s\gamma$ reaction rate measured in previous experiments agrees well with the predictions of the Standard Model, but no data on the polarizations have as yet been obtained. In the LHCb experiment, $B^{\pm}$ mesons were produced upon pp collisions. The products of their decay, namely charged hadrons, were registered by Cherenkov detectors, while photons were recorded by electromagnetic calorimeters; the kinematics of 14,000 decays were reconstructed. In the center-of-mass system, the take-off directions of newly born hadrons formed a plane relative to which the photons escaped asymmetrically: the difference between their number above and below the plane is proportional to the extent of polarization. It was found that at a 5.2σ confidence level the photon polarization is nonzero, as had been predicted by the Standard Model. These results impose restrictions on some extensions of the Standard Model in which γ are polarized in a different way.

Source: *Phys. Rev. Lett.* **112** 161801 (2014)
http://dx.doi.org/10.1103/PhysRevLett.112.161801

2. Quantum tunneling and the Aharonov–Bohm effect

A Noguchi and his colleagues of Osaka University (Japan) have performed an experiment exploring the dynamics of quantum tunneling of particles under conditions when their wave functions experienced the Aharonov–Bohm effect. In a linear Penning trap placed in a magnetic field, three calcium $^{40}Ca^{+}$ ions found themselves at vertices of two triangles. They could tunnel between two triangular configurations, upper and lower, and also had a rotational mode, i.e., tunneling could proceed through the six vertices around the two triangles. The mean rate of tunnel transitions between the upper and lower configurations was measured near the ground state of the rotational mode, which was attained through cooling first by the side band method, and then by adiabatic cooling to a temperature of 40 nK. The position of ions at the vertices was determined by laser radiation scattering from ions. The tunneling probability measured in the experiment endured oscillations as the magnetic field increased with a period equal to the integer quantity of the magnetic flux quantum $\phi_0 = hc/2e$, precisely what was predicted with allowance for the Aharonov–Bohm effect.

Source: *Nature Communications* **5** 3868 (2014)
http://dx.doi.org/10.1038/ncomms4868

Uspekhi Fizicheskikh Nauk **184** (6) 652 (2014)
DOI: 10.3367/UFNr.0184.201406e.0652
Translated by M V Tsaplina

3. Dissipation in a superconducting junction

In 1962, B D Josephson predicted theoretically that the dissipation of an alternating current passing through the superconducting junction, caused by quasiparticles excited above a superconducting gap, must decrease radically provided that the wave-function phase difference across the junction is equal to π. This is due to the destructive interference of two separate dissipative channels related to electrons and holes. To date, this way of dissipation suppression has not been explicitly demonstrated in experiments. The predicted coherent decrease in dissipation was first observed and studied in a new experiment performed by I M Pop (Yale University, USA) and his colleagues. The Josephson junction was studied, which constitutes an 'artificial atom' (fluxonium), at two energy states of which a quantum qubit was realized. The junction was shunted by a chain of other superconducting junctions and integrated into the electric circuit with the help of inductive–capacitive couplings. The character of radio-frequency pulse transmission through the junction, which depends on the qubit state, determined the qubit relaxation time, i.e., its transition to the lower energy state following pulsed excitation. The phase bias across the junction was realized with the aid of an external magnetic field creating the flux ϕ_{ext} through the closed circuit formed by a chain of junctions. As ϕ_{ext} approached $0.5\phi_0$, the phase bias tended to π and the relaxation time increased by more than an order of magnitude, precisely as it should be according to the Josephson theory. This method of dissipation suppression will probably find application in experiments with quantum information for weakening qubit decoherence.

Source: *Nature* **508** 369 (2014)
http://dx.doi.org/10.1038/nature13017

4. Energy gap control in graphene

C R Woods et al. leaded by A K Geim and K S Novoselov (University of Manchester, Great Britain) have revealed that the energy gap (the energy separation between the valence and conduction bands) in graphene on top of hexagonal boron nitride (hBN) depends on the mutual orientation of graphene and hBN crystal lattice directions. The periodic potential of the hBN substrate (van der Waals forces) causes graphene lattice deformation, changing its electronic properties depending on the rotational angle α between the graphene and hBN hexagonal lattices. A set of samples having different α was experimentally studied by atomic force and scanning tunneling microscopies, as well as Raman spectroscopy methods. In the case of a small angle, $\alpha \leqslant 1^{\circ}$, the graphene lattice gets stretched to become commensurate to the hBN lattice. The spacing between the carbon atoms in the strained lattice increases by 1.8%, and the energy gap appears due to the so-called 'pseudomagnetic field'. The strain is heterogeneous, as the domains of the commensurate lattice are separated by domain walls that accumulate the resulting mechanical strain. For $\alpha > 1^\circ$, the graphene lattice is not strained, and the energy gap is absent. Several earlier experiments yielded contradictory data on the electronic and optical properties of graphene on an hBN substrate. Now, it can be readily explained by the fact that the angles α were different in various experiments. The revealed dependence of the gap on α is likely to help in creating new graphene-hBN semiconductor devices.

Source: *Nature Physics* **10** 451 (2014)
http://dx.doi.org/10.1038/nphys2954

5. Toroidal magnetic field and neutron star precession

Magnetars constitute a special type of neutron stars with an extremely strong dipole magnetic field reaching $\sim 10^{10}$ – 10^{11} T. K Makishima (University of Tokyo, Japan) and his colleagues have observed magnetar 4U 0142+61 with the Suzaku X-ray space telescope. For energies of 15–40 keV, X-ray pulses with a period of 8.69 s suffered phase modulations by ± 0.7 s with a period of ~ 15 h. Such a modulation can be due to a free precession of a nonaxisymmetric neutron star if the relative difference in its principal moments of inertia is about 1.6×10^{-4}. The radiation maximum direction precesses together with the neutron star, which is responsible for phase modulation of the observed signal. The mechanical strain of the neutron star could be ascribed to a magnetic pressure exerted by a toroidal magnetic field of about 10^{12} T. If this interpretation holds true, the described observations are the first to reveal the toroidal magnetic field predicted by theoretical models.

Source: *Phys. Rev. Lett.* **112** 171102 (2014)
http://arXiv.org/abs/1404.3705

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