

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: https://doi.org/10.3367/UFNe.2018.10.038451

1. Measurement of qubit states

R McDermott (University of Wisconsin — Madison, USA) and colleagues have demonstrated a new method of measuring superconducting qubit states. In their experiment, along with the resonance cavity of the qubit itself, they employed a supplementary cavity tuned to the frequency of the qubit excited state. A microwave photon counter was used to readily distinguish between the qubit ground and excited states. The quantum fidelity of the new method reaches 92%. It surpasses in its capability the heterodyne measurements normally exploited for these purposes. They may be applied to error correction algorithms and the interfaces between quantum and classical systems. M D Lukin (Harvard University, USA) and colleagues have demonstrated another measuring method. In their experiment, they examined two SiV (silicon vacancies) centers embedded in a nanophotonic cavity and coherently interacting with each other through its electromagnetic modes. The quality of interaction between the SiV centers was improved by about an order of magnitude over that attained in other similar experiments. The magnetic field and radio pulses controlled the spin states of SiV centers and the spectral transfer function was measured and employed to determine the states of the system.

Sources: *Science* **361** 1239 (2018),
Science **362** 662 (2018)
https://doi.org/10.1126/science.aat4625
https://doi.org/10.1126/science.aau4691

2. Vortex pairs in a ferromagnetic superconductor

A group of Russian researchers from MIPT, ISSP, MISiS, MSU, and KFU (Kazan Federal University) and their colleagues from Japan, France, China, and Great Britain have investigated the compound $EuFe_2(As_{0.79}P_{0.21})_2$, in which superconductivity and ferromagnetism coexist at a temperature below 19 K. Ferromagnetism typically suppresses superconductivity, but it is not the case here because of the weak exchange field produced by the subsystem of Eu atoms. A magnetic force microscopy was applied to construct a 3D distribution of magnetic fields at the sample surface at different temperatures. Below the Curie point, a new phase was revealed, namely Meissner domains, which is due to magnetic Eu subsystem screening. As the temperature fell below 17 K, this phase became transformed into 'vortex domains' through the first-order phase transition. Under this transition, Abrikosov vortex–antivortex pairs were spontaneously generated in Meissner domains and the domain size increased. V S Stolyarov and colleagues formulated a quantitative theory successfully explaining these phenomena.

Source: *Science Advances* **4** eaat1061 (2018)
https://doi.org/10.1126/sciadv.aat1061

3. Pomeranchuk instability in Fermi liquids

At the present time, several substances with an electronic nematic order are known for which the rotational symmetry is spontaneously broken. The understanding of some important features of the nematic order is associated with the Pomeranchuk instability effect. K Lee (Ohio State University, USA) and colleagues calculated the parameters F_l of a composite fermion Fermi liquid. They considered the case of half-filled Landau levels when the nematic order borders on the non-Abelian quantum Hall state. For three lower Landau levels — $n = 0$, 1, and 2 — F_l were found numerically. Monte Carlo calculations with Coulomb potential cutoff on a small scale and with the wave function defined on a torus were carried out. For the lowest Landau level with $n = 0$, Pomeranchuk instabilities were not revealed. For the higher levels with $n = 1$ and 2, the calculations showed Pomeranchuk instability in the nematic ($l = 2$) channel for a wide range of cutoff parameter values. The theoretical result obtained was the first clear demonstration of the fact that the nematic Pomeranchuk instability may appear to be responsible for the nematic quantum Hall states with isotropic screening of Coulomb interactions.

Source: *Phys. Rev. Lett.* **121** 147601 (2018)
https://doi.org/10.1103/PhysRevLett.121.147601

4. Information recording on a single atom

Researchers from Nijmegen University (Netherlands) have demonstrated a new magnetic mechanism of information storage on a single cobalt atom placed on a black phosphorus surface. The atom was observed and its state controlled with a scanning tunnel microscope. The atom was found to have stable states at various distances from the surface. The density functional calculations showed that transition from one state to another is due to redistribution of 3s- and 3d-orbital populations, the magnetic anisotropy playing a large role. A high energy barrier between the states makes them applicable for information recording. Information was recorded earlier on the spin state of an individual atom and a long storage time was reached, but there remained the problem of fluctuations under a spin-sensitive data readout. In the case of a cobalt atom, all the manipulations were performed by an electric field, spin-sensitive measurements being unnecessary. The experiment was conducted at a surface temperature of 4.4 K, but it is hoped that in future the method will be adopted at room temperature, too.

Source: *Nature Communications* **9** 3904 (2018)
https://www.nature.com/articles/s41467-018-06337-4

Uspekhi Fizicheskikh Nauk **188** (11) 1178 (2018)
DOI: https://doi.org/10.3367/UFNr.2018.10.038451
Translated by M V Tsaplina

5. New limits on primordial black holes

In 1967, Ya B Zeldovich and I D Novikov predicted the possibility of stellar-mass primordial black hole (PBH) formation in the very early Universe (for PBHs, see the *UFN* reviews *Phys. Usp.* **28** 213 (1985) and *Phys. Usp.* **61** 115 (2018)). The gravitational-wave signals from black-hole coalescence registered by the LIGO/Virgo detectors aroused more interest in the PBH model, as PBHs, together with stellar-origin black holes, might account for these signals. In particular, the question was put again of whether the entire dark matter can consist of PBHs. M Zumalacárregui and U Seljak (University of California at Berkeley) were searching for gravitational lensing of distant supernova light by black holes that occasionally found themselves in the line of sight. A PBH would focus the light by its gravitational field, thus forming characteristic singularities in the supernova outburst profile. After processing the data on 740 type Ia supernovae, from the lack of lensing signs it became clear that PBHs with masses $\geqslant 0.01 M_{\odot}$ amount to no more than $\approx 37\%$ of the total dark matter. Thus, the overwhelming part of dark matter must consist of something different, because other effects restrict the number of PBHs with masses less than $< 0.01 M_{\odot}$. New elementary particles not yet registered by the present detectors are now being considered as one of the most probable candidates for the role of dark matter content.

Source: *Phys. Rev. Lett.* **121** 141101 (2018)
https://doi.org/10.1103/PhysRevLett.121.141101

Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)