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1. Magnetoresistance of a cuprate superconductor in the normal phase

The properties of high-temperature cuprate superconductors in their 'normal' (nonsuperconducting) phase near the superconducting transition point may cast light on the mechanism of high-temperature superconductivity and are therefore of great interest. To investigate this state, cuprate superconductivity is artificially suppressed by a strong magnetic field, thus giving rise to the so-called 'strange metal' phase with a linear temperature dependence of magnetoresistivity. The effect of the employed magnetic field on this phase has, however, not yet been studied enough. P Giraldo-Gallo (University of Florida, USA) and colleagues have examined thin $La_{2-x}Sr_xCuO_4$ films in magnetic fields up to 80 T to find that their specific resistance increases linearly with an increase in the field, as distinct from the quadratic dependence observed in usual metals. The described behavior takes place for a doping parameter smaller than its critical value $p \approx 0.19$. The observed double linear dependence of resistivity on the temperature and magnetic field has not yet been completely explained theoretically, but can testify to the fact that electric current in the 'strange metal' phase is transported not by free quasiparticles but in some other way.

Source: *Science* **361** 479 (2018)
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2. Qubits based on the geometric phase

The geometric phase, also referred to as the Berry phase (see *Usp. Fiz. Nauk* **160** 1 (1990) [*Phys. Usp.* **33** 1 (1990)] and *Usp. Fiz. Nauk* **163** 1 (1993) [*Phys. Usp.* **36** 1 (1993)]), is a promising effect which can be utilized to create a circuitry base for quantum computations and quantum communication. Qubits based on the geometric phase have already been demonstrated, but they had a low quantum fidelity. K Nagata (Yokohama National University, Japan) and colleagues have managed to heighten the quantum fidelity by realizing qubits on a degenerate subspace in the Gilbert space of the triplet state. Their system is a nitrogen-vacancy (NV) center in a diamond in which the spins of the nucleus and electron interact with the electromagnetic field generated by two crossed wires. The device operates at room temperature under a zero external magnetic field. Polarized radio emission generated by the wires interacts in a certain way with the spin states of the NV center, which are then read out by registering fluorescence radiation photons. The experiment demonstrated both a single qubit and a two-qubit system produced by quantum-entangled spins of the electron and nucleus in the NV center, with the quantum fidelity reaching 90%.

Source: *Nature Communications* **9** 3227 (2018)
https://doi.org/10.1038/s41467-018-05664-w

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Translated by M V Tsaplina

3. Quasiparticle statistics in an exciton-polariton condensate

Statistics concerning particles in quantum condensates was earlier studied experimentally for photons in laser light and in superconducting qubits, and for massive particles (atoms) in a Bose–Einstein condensate. In the last case, the form of distribution is considerably influenced by atomic interactions. However, such studies have not been performed for quasiparticles that are a combination of photons and massive particles. M Klaas (University of Würzburg, Germany) and colleagues have measured for the first time the distribution of the number of photons spontaneously emitted by the Bose–Einstein condensate of exciton polaritons. These quasiparticles consisting of photons and electron–hole pairs were generated in a micron-size cavity in a semiconductor under the action of pump light. Transition edge sensors were used that allowed detecting unit photons, and the photon-number distribution suggested a conclusion concerning condensate quasiparticle statistics. After the condensate was formed, with a further increase in the pump power the condensate changed from the thermal state with an exponential distribution of the particle number to the coherent state with a Poisson distribution. The exciton-polariton condensate turned out to be closer to laser light than to atomic condensate in their statistical properties.

Source: *Phys. Rev. Lett.* **121** 047401 (2018)
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4. Quantum synchronization

Synchronization of periodic processes is most often realized through an oscillation phase lock using an external signal. In recent years, this conception of synchronization has been reformulated for a quantum region, as well. In their theoretical work, researchers from the University of Basel (Switzerland) A Roulet and C Bruder have investigated conditions necessary for quantum system synchronization. On symmetry grounds, it was shown that the minimal systems–qubits that have two energy levels — cannot be synchronized with an external signal due to the lack of a limit cycle on the Bloch sphere on which the Hilbert space of a qubit is plotted. Next in complexity is a three-level system which can be represented by a particle with spin $S = 1$. To examine it, a set of coherent spin states providing an extension of the Bloch sphere to the case $S > 1/2$ was introduced. A Roulet and C Bruder considered the case where there is energy dissipation from states with the spin projections $S_z = \pm 1$ to the state $S_z = 0$. The study of the phase portrait of such a system showed that phase capture and synchronization are possible if the dissipation coefficients in states $S_z = \pm 1$ differ in values. Thus, the quantum oscillator requires at least three energy levels for synchronization with a periodic signal.

Source: *Phys. Rev. Lett.* **121** 053601 (2018)
https://doi.org/10.1103/PhysRevLett.121.053601

5. Relativistic effects in the motion of star S2

Several stars are observed in the center of the Galaxy that, speeding up to high velocities in the pericenter, come close to the supermassive black hole Sgr A^*. Since the 1990s, star S2 has been monitored over the past 26 years, which revolved more than once around Sgr A^* during this time. Using observational VLT data obtained in Chili, in particular, during the last passage through the pericenter, the GRAVITY Collaboration has revealed for the first time the effects of the Special Relativity in the motion of star S2, namely, the gravitational redshift and the relativistic transverse Doppler effect. These observational data cannot be explained by the Newtonian theory alone. The relativistic precession of the orbit of star S2 predicted by General Relativity is expected to be detected in the nearest future.

Source: *Astron. & Astrophys.* **615** L15 (2018)
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