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1. Decays $B_s^0 \to \pi^+\pi^-$ and $B^0 \to K^+K^-$

The probabilities of $B_s^0 \to \pi^+\pi^-$ and $B^0 \to K^+K^-$ decays occurring through weak annihilation transitions have been measured to the currently best accuracy in the LHCb experiment. Studies of these decays provide insight into the details of the processes in quantum chromodynamics and are helpful in the search for effects beyond the Standard Model. The $B_s^0 \to \pi^+\pi^-$ decay had already been observed, while the $B^0 \to K^+K^-$ decay had not yet been reliably registered in spite of searches on various accelerators. The LHCb experiment was carried out at pp center-of-mass collision energies of 7 TeV and 8 TeV, respectively. Special event selection criteria were applied allowing identification of the $B^0 \to K^+K^-$ decays against the background of the dominating $B_s^0 \to \pi^+\pi^-$ decays. The $B^0 \to K^+K^-$ decay was first observed with a statistical significance of 5.8σ. This decay has the lowest probability among all the probabilities of purely hadron decays measured to date.

Source: *Phys. Rev. Lett.* **118** 081801 (2017)
https://doi.org/10.1103/PhysRevLett.118.081801

2. Quantum clock in a gravitational field

Researchers from the University of Vienna and the Institute for Quantum Optics and Quantum Information (Austria), E C Ruiz, F Giacomini, and Č Brukner, have studied the theoretical issue of the limiting precision of time measurements with allowance for quantum processes and the effect of the gravitational field of a clock on the spacetime metrics. It was shown that the field of one clock influences the readings of the neighboring clocks, and the joint measurability of time along two nearby world lines has a fundamental limitation independent of the clock constitution. This is explained by the fact that if the time readings of the clock are determined by quantum processes, this quantum clock must be in a superposition of the energy eigenstates, and the energy is the source of the gravitational field affecting the time flow at close points. As a result of the above-mentioned interplay, the neighboring clocks become quantum entangled. Although today's measurement accuracy is insufficient to observe this effect, it can be essential in quantum gravitation.

Source: *PNAS*, online publication of March 7, 2017
https://doi.org/10.1073/pnas.1616427114

3. Bose–Einstein condensate in the supersolid state

Supersolidity is the phenomenon combining crystal ordering and superfluidity. The effect was predicted by A A Andreev and I M Lifshits (*Soviet Physics JETP*, 1969) and independently by G V Chester (*Phys. Rev. A*, 1970) and A J Leggett (*Phys. Rev. Lett.*, 1970). However, recent reports on the observation of supersolidity in solid helium-4 were not confirmed in consequent experiments. L P Pitaevskii and other theorists predicted in their theoretical work that this phenomenon can also occur in Bose–Einstein condensate with spin-orbit coupling. W Ketterle (Massachusetts Institute of Technology, USA) and colleagues have reported the first direct observation of supersolidity in Bose–Einstein condensate. The condensate of 10^5 sodium (^{23}Na) atoms in an optical superlattice was investigated at temperatures on the order of nK. In the angular distribution of light scattered on the condensate, a singularity was observed corresponding to the so-called stripe phase, which was the hallmark of ordering. For the same gas parameters, using the free expansion method, the gas was established to be in the superfluid state. Thus, supersolidity was realized. In another independent experiment carried out at the Swiss Federal Institute of Technology in Zürich, the supersolid state in Bose–Einstein condensate was obtained by an alternative method in an optical cavity.

Sources: *Nature* **543** 87, 91 (2017)
https://doi.org/10.1038/nature21067
https://doi.org/10.1038/nature21431

4. Magnetic writing on a single atom

An experiment has been performed under the guidance of A J Heinrich at the IBM Almaden Research Center (USA) that demonstrated the reading and writing of magnetic information on single holmium (Ho) atoms on the surface of a magnesium oxide (MgO) bilayer. The state was recorded — atoms were changed to one of the two states (directions of the magnetic moment) — using current pulses from the needle of a scanning tunnel microscope. A magnetometer consisting of an iron atom located nearby an Ho atom was utilized to read the Ho atom state. The character of the Zeeman splitting of Fe atom levels depended on the magnetic moment of the Ho atom, and the frequency of transition between sublevels shifted upon moment variation. The tunnel current through the Fe atom varied by 2 to 4 %. The magnetization direction of the Ho atom was shown to remain unchanged for several hours at a temperature of 1.2 K (and in one experiment at 4.3 K). Moreover, the researchers created a structure comprising two Ho atoms and a neighboring Fe atom which served as a sensor (magnetometer), as before. Four possible states were written and read on these atomic bits. The high magnetic stability, together with the electrical reading and writing method, shows that monatomic magnetic memory is actually possible.

Source: *Nature* **543** 226 (2017)
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5. Galaxies in the epoch of reionization

The study of the reionization of the Universe is of great interest in order to comprehend the mechanism of the emergence of the first stars, galaxies, and quasars. Observed

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for the red shifts $z \geqslant 7$ are rather many early galaxies whose distribution may cast light on the course of reionization. Researchers from Chile, China, and the USA have surveyed a part of the sky of 3 sq. deg in the ongoing LAGER project (Lyman Alpha Galaxies in the Epoch of Reionization) using a specially built narrowband filter on a 4-meter telescope. By using the Ly_α emission line, 27 galaxies with $z \geqslant 7$ were identified, of which 26 were observed for the first time. The resulting luminosity distribution corresponds to the Schechter function but with a significant excess at the bright end of galaxies. This excess confirms the hypothesis that giant ionized gas bubbles originated due to inhomogeneous ionization exist in the Universe. A possible reason for the occurrence of inhomogeneities could be active galactic nuclei.

Source: https://arXiv.org/abs/1703.02985

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