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1. Overcoming the standard quantum limit in measurements

In 1967, V B Braginskii derived the limit on the sensitivity of optomechanical measuring devices, which has a quantum origin (*Zh. Eksp. Teor. Fiz.* **53** 1434 (1967) [*Sov. Phys. JETP* **26** 831 (1968)], see also the review by V B Braginskii and Yu I Vorontsov in *Usp. Fiz. Nauk* **114** 41 (1974) [*Phys. Usp.* **18** 644 (1974)]) and is called the 'standard quantum limit'. The limit is associated with noises and with the backreaction effect of the device on the system. The laser interferometers LIGO/Virgo registering the gravitational waves from the merging of black holes and neutron stars have closely approached this limit (see *Usp. Fiz. Nauk* **170** 743 (2000) [*Phys. Usp.* **43** 691 (2000)] and *Usp. Fiz. Nauk* **186** 1059 (2016) [*Phys. Usp.* **59** 968 (2016)]). It was shown theoretically that the standard quantum limit can be overcome using quantum nondemolition measurements, but early attempts were not successful in optical mechanics. D Mason (University of Copenhagen, Denmark) and colleagues have become the first to overcome the standard quantum limit. In their experiment, the backreaction and noises were correlated and partially compensated each other under destructive interference. A lattice of holes — a photon crystal — was made in a 3.6-mm $\times$ 3.6-mm $\times$ 20-nm membrane. The reflected laser light contained information about noises that influenced the membrane position measurement by a synchronous detector. The sensitivity reached in the experiment was by 30% higher than the standard quantum limit.

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2. Quantum C-NOT gate teleportation between ion qubits

In quantum information devices, one of the methods of spatially separated qubit interaction is quantum teleportation of quantum gates implementing logical operations. An efficient protocol of quantum 'controlled NOT gate' (C-NOT) teleportation exists that had already been demonstrated for photon and superconducting qubits. Y Wan (National Institute of Standards and Technology and University of Colorado, USA) and co-authors have applied for the first time the protocol for the interaction of ion-based qubits. The protocol only contains local operations, interaction through the classical channel, and one pair of quantum entangled particles. The qubits were realized on states of the hyperfine splitting of $^9Be^+$ ions in a Paul trap. Quantum tomography showed the precision of C-NOT gate teleportation between qubits equal to 0.845–0.872.

Source: *Science* **364** 875 (2019)
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3. Soliton gas

Solitons are stable configurations of a medium moving almost without changing their profile. A multisoliton system can be represented as a gas of some particle-like objects. In 1971, V E Zakharov (FIAN, ITP RAS, and NSU) derived a kinetic equation for the gas of interacting solitons, and in 2009 he formulated a theory describing solitons in the wave theory. N Mordant (Grenoble Alps University, France) and his colleagues examined experimentally a one-dimensional soliton gas in water. A sinusoidal wave excited in a 34-m pool fell to solitons of different sizes. When reflected at the edge of the pool and undergoing oncoming and accompanying collisions, the solitons formed a chaotic gas that was observed by video cameras. The stationary state of the soliton gas was in good agreement with theoretical calculations and with the results of numerical simulations conducted earlier by E Pelinovskii and A Sergeeva from IAP RAS and the NSTU. The study of soliton gas in water is a step towards understanding the properties of such a gas in plasma and in nonlinear optics. For solitons and wave collapses, see *Usp. Fiz. Nauk* **182** 569 (2012) [*Phys. Usp.* **55** 535 (2012)].

Source: *Phys. Rev. Lett.* **122** 214502 (2019)
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4. Cold gas at the galactic center

The distribution of hydrogen with temperature $T \sim 10^4$ K around the supermassive black hole in the center of our Galaxy has been investigated using the ALMA array of radio telescopes in Chili. The radiation was registered on a wave of 1.3 mm generated under transitions $n = 31 \rightarrow 30$. E Murchikova (Princeton Institute for Advanced Study and California Institute of Technology, USA) and coauthors managed to single out the indicated recombination line, although its intensity is only 0.1% from the radiation in continuum. The cold gas appeared to form an accretion disc around the black hole. The disc radius is 0.004 pc and its mass is $(10^{-5} - 10^{-4}) M_{\odot}$. The measured Doppler gas velocities are much lower than the calculated Kepler velocities, indicative of a small slope angle of the disc rotation axis to the view axis or of the great role of pressure and/or magnetic fields in the disc dynamics.

Source: *Nature* **570** 83 (2019)
https://arxiv.org/abs/1906.08289

5. Search for non-Gaussianity of cosmological perturbations

According to many-year observations, perturbations in the microwave background (relic) radiation filling the Universe obey the Gaussian statistical distribution law. Some small deviations from the Gaussian law are, however, not ruled out. This would mean the presence in the early Universe of exotic objects such as cosmic strings, or else non-Gaussianity might be a consequence of more sophisticated inflation models or a new physics. The Planck results of the search for non-Gaussianity of perturbations over the whole period of observations are presented. In particular, the E-mode of radiation polarization sensitive to non-Gaussianity was examined in detail. Compared to previous studies, the analysis included low multipoles of $4 \leqslant l \leqslant 40$. At the state-of-the-art high precision level, no non-Gaussian contribution to the perturbations was found. This, in turn, imposes restrictions on the parameters of the processes that could in principle lead to non-Gaussianity. For the methods of the search for non-Gaussianity, see *Usp. Fiz. Nauk* **182** 1177 (2012) [*Phys. Usp.* **55** 1098 (2012)], and for quantum fluctuations and relic radiation perturbations see *Usp. Fiz. Nauk* **186** 1117 (2016) [*Phys. Usp.* **59** 1021 (2016)].

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