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1. Pressure inside the proton

The quark–gluon interactions in the interior of the proton determine its mechanical properties, including the internal pressure. The pressure can be found from the experimental data on electron scattering by quarks inside the proton: $ep \to e'p'\gamma$ and registration of escaping particles by the coincidence method (the method of 'deeply virtual Compton scattering'). Using the available data and applying the new computational approach, researchers from Jefferson Laboratory (USA), V D Burkert, L Elouadrhiri, and F X Girod, have determined the pressure distribution experience by the quarks in the proton as a function of the distance r to the proton center. At small r, the pressure is positive (repulsive); at $r \simeq 0.6$ fm it passes through zero, and farther it becomes negative, binding quarks in the proton. The dependence $p(r)$ is highly consistent with the prediction of the quark–soliton model.

Source: *Nature* **557** 396 (2018)
https://doi.org/10.1038/s41586-018-0060-z

2. Neutrino oscillations in MiniBooNE experiment

The latest and most complete data are obtained in the MiniBooNE experiment at Fermilab (USA) on muon neutrino and antineutrino oscillations to the corresponding electron constituents ν_e and $\bar{\nu}_e$ of a standard two-neutrino oscillation model. A neutrino beam is generated in the interaction of protons with a beryllium target and is registered in a mineral-oil-filled detector by observing Vavilov–Cherenkov radiation and the scintillation signal. An event excess of ν_e and $\bar{\nu}_e$ appearance data over their expected number was confirmed in the energy range of 200 to 1250 MeV, which had already been noticed before in the Liquid Scintillator Neutrino Detector (LSND) experiment. The combined LSND and MiniBooNE data testify to the presence of excess events at the confidence level of 6.1σ. This excess can be indicative of sterile neutrinos, but the result has not yet been confirmed in other neutrino experiments.

Source: https://arXiv.org/abs/1805.12028

3. A null test of the General Relativity

Researchers from the National Institute of Standards and Technology (NIST) and the University of Colorado in Boulder (USA), N Ashby, T E Parker, and B R Patla, have performed a new test of the local position invariance principle, which is a part of the equivalence principle and stipulates that nongravitational experiments conducted in differently positioned and oriented reference frames will give identical outcomes. They examined the stability of the transition frequency between the hyperfine-splitted levels in H and Cs atoms over a period of more than 14 years. During this time, the gravitational potential varied with the distance of the Earth from the Sun upon its motion along the elliptic orbit. The gravitational field of Jupiter was also taken into account. The structure of H and Cs nuclei is different, and therefore they are convenient for seeking violations of the equivalence principle. The data from four hydrogen masers located at NIST and from eight cesium frequency standards operated by leading metrological laboratories in different countries were used. The obtained limit on the correction to the fractional frequency variation $\beta = (2.2 \pm 2.5) \times 10^{-7}$ is twice as good as the previous limits. Thus, no deviations from General Relativity predictions have as yet been found.

Source: *Nature Physics*, online publication of June 4, 2018
https://doi.org/10.1038/s41567-018-0156-2

4. Maxwell's quantum demon

W-B Wang (Tsinghua University, China) and colleagues have examined Maxwell's quantum demon (the thought experiment considered by Maxwell in 1867) realized on a nitrogen-substituted vacancy in a diamond (NV-center) in a magnetic field. The spin state in this quantum cell can be controlled by radiofrequency pulses, and the states were measured with the aid of quantum tomography. The demon's memory coded by the electron spin was only 1 bit. It controlled the opening and closing of the logical cell. The measurements confirmed that in the general entropy balance the information stored in the demon's memory should be taken into account. In the second experiment, the demon state was quantum entangled with the auxiliary system, namely the spin of the ^{14}N nucleus, and the important role of quantum entanglement in the demon's work was shown for the first time. Quantum entanglement can be conveniently interpreted as a reservoir with negative entropy in a quantum thermodynamic process.

Source: *Chin. Phys. Lett.* **35** 040301 (2018)
https://doi.org/10.1088/0256-307X/35/4/040301

5. New component in electronics

In conventional bipolar and field-effect transistors, the input current or voltage controls the output current, and a load circuit is needed to convert the output current to the output voltage. S Lee (Pusan University, South Korea) has considered theoretically a new device in which input signals must directly control the output voltage. Although not yet realized in practice, a new active device is proposed to be referred to as the trancitor (transfer + capacitor). The trancitor may possibly be designed on the basis of the Hall effect. The

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combination of transistors and trancitors in electronic devices may considerably simplify the circuit-creation technique and increase the device operation speed compared to transistor-only circuits. According to S Lee's calculations, the involvement of trancitors may help to meet the empirical Moore's law, according to which the number of transistors in a microcircuit doubles every 2 years.

Source: https://arXiv.org/abs/1805.05842

6. Free energy from a nonequilibrium trajectory

Fluctuation-dissipation theorems express the difference between equilibrium free energies of a system in the final states in terms of its work upon nonequilibrium evolution. Measurement of the work typically encounters difficulties, but a method was proposed, referred to as 'relaxation fluctuation spectroscopy', in which the work need not be measured and the analysis of stochastic trajectories of the system under its relaxation turns out sufficient. D Ross (NIST) and his colleagues have become the first to realize this method. In their experiment, a DNA molecule moved along a ladder-shaped substrate consisting of several stairs. Upon thermal fluctuations (Brownian motion), the molecule predominantly moved down the stairs, but sometimes it moved upwards. From the character of its motion, which was registered by the fluorescence microscopy method, the probability distribution was found and the free energy measured.

Source: *Nature Physics*, online publication of May 28, 2018
https://doi.org/10.1038/s41567-018-0153-5

7. Stars in distant galaxies

The study of the most distant galaxies provides insight into the physical conditions in the early Universe. T Hashimoto (Osaka University and the National Astronomical Observatory of Japan) and colleagues have used the ALMA complex of radio telescopes (Chile) to perform spectroscopic observations of the gravitationally lensed galaxy MACS1149-JD1. An oxygen emission line at a red shift $z = 9.1096 \pm 0.0006$ was revealed in the far IR range. This made it possible to establish that the galactic spectrum reddening revealed earlier with the Spitzer telescope is due to the stars having been born at $z \simeq 15$, i.e., in the epoch when the Universe was about 250 mln years old, and two successive star formation episodes are needed to account for the spectrum shape.

Source: *Nature* **557** 392 (2018)
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