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1. Test of the equivalence principle

The GRAVITY Collaboration (ESO) has carried out a new test of the local position invariance (LPI) principle through the observation of stars orbiting around a supermassive black hole (SgrA*) near the Galactic center. Being a part of the Einstein equivalence principle, this principle states that local non-gravitational measurements are independent of the space–time point at which they are performed. LPI violation would signify the gravitational potential's effect on the fundamental physical constants. The VLT data on the motion of star S2 coming very close to the black hole were utilized. The star orbit was reconstructed to a high accuracy and the gravitational potential variations along the orbit were found. The gravitational frequency shifts in hydrogen and helium absorption lines were compared. The parameter characterizing a possible LPI violation is upper limited by the value of $(2.4 \pm 5.1) \times 10^{-2}$, which is compatible with a zero value. Although in observations in the Solar System and for stars — white dwarfs — this parameter is more strongly limited, the described work investigated the region of record-large gravitational potential differences $\Delta\Phi/c^2 = 3.2 \times 10^{-4}$. This result confirms once again the equivalence principle, which is one of the bases of General Relativity.

Source: https://arXiv.org/abs/1902.04193

2. Superscattering

The cross section of light scattering by a system to a single channel is limited from above by a fundamental limit associated with the wavelength. The superscattering phenomenon predicted in the theoretical paper by Z Ruan and S Fan in 2010, where the cross section may exceed this limit, is based on the presence of many scattering channels contributing to the cross section. Superscattering could not be observed earlier because it was difficult to design a low-loss superscattering system. Superscattering in the microwave range has been demonstrated for the first time in the experiment guided by H Chen (Zhejiang University, China). Metasurfaces in the form of a periodic array of subwavelength-scale copper rings were created on three concentric cylinders. Electromagnetic TE type modes were localized on them. Different scattering channels were created due to the excitation of electron oscillations with higher moments (quadrupole, octupole) at one and the same resonance frequency. The recording of radiation demonstrated the existence of superscattering with a cross section four times larger than the single-channel limit. Superscattering can find application in various telecommunication devices and sensors and is expected to be attainable in the future in other wavelength ranges, too.

Source: *Phys. Rev. Lett.* **122** 201801 (2019)
https://doi.org/10.1103/PhysRevLett.122.063901

3. Phonon spectroscopy

The creation of high-stability monochromatic electron beams paved the way for the investigation of electron scattering by phonons (quanta of acoustic vibrations) in the THz range. The phonon spectroscopy method may have important applications in examining the structure of different substances. F S Hage (SuperSTEM laboratory, United Kingdom) and colleagues have used phonon spectroscopy to scan a thin flake of a hexagonal boron nitride with a spatial resolution by an order of magnitude higher than that attained in previous experiments. An electron transmission microscope registered phonon peaks due to electron–phonon inelastic scattering in the electron spectrum. The obtained images clearly demonstrate the periodic spatial structure of a crystal with a resolution close to the atomic scale.

Source: *Phys. Rev. Lett.* **122** 016103 (2019)
https://doi.org/10.1103/PhysRevLett.122.016103

4. Entropy growth in mesoscopic quantum systems

In recent years, the thermodynamic properties of systems have been actively examined at the quantum level, in particular, the entropic properties of systems and fluctuation theorems have been studied. M Brunelli (Cavendish Laboratory, University of Cambridge, United Kingdom) and colleagues examined two mesoscopic systems that consisted of a rather large number of atoms and were connected with heat reservoirs, but, at the same time, possessed quantum properties. In the first case, oscillations of a mechanical oscillator coupled to an electromagnetic resonator were investigated. The oscillations were excited by laser pulses. The emission spectrum could be used to characterize the processes in a given optomechanical system and to calculate the entropy fluxes. The Bose–Einstein condensate of 10^5 rubidium atoms placed in an electromagnetic resonator was analyzed in the second case. Irreversible entropy production under quantum fluctuations in the systems was equal to the entropy outflux, which maintained the steady state of the systems. Such experiments are important for clarification of the transfer from quantum to classical systems and may appear to help in constructing micromechanical devices.

Source: *Phys. Rev. Lett.* **121** 160604 (2018)
https://doi.org/10.1103/PhysRevLett.121.160604

5. Second source of repeating fast radio bursts

Although already more than 60 fast radio bursts (bursts of cosmic radio emission of millisecond duration with a large measure of dispersion) have been registered to date, only one

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source of recurrent bursts, FRB 121102, was known. A second source of recurrent bursts, FRB 180814.J0422 + 73, was discovered using the CHIME telescope with a field of survey amounting to 250 degrees squared. Six bursts with similar measures of dispersion were observed from this source. Judging from the measure of dispersion, the new source is located at a distance below 500 Mpc. No galaxies that might be candidates for the role of ghost galaxy were revealed in the source localization region. Bursts from the second source are very similar to those from FRB 121102, including multiple peaks and frequency downdrifts. Type II solar flares show an analogous drift, which may imply a similar generation mechanism, although the mechanism of fast radio burst formation has not yet been reliably established. The observation of the second source of recurrent radio bursts suggests a fairly large population of recurrent sources. For fast radio bursts, see the review by S B Popov, K A Postnov, and M S Pshirkov in *Physics–Uspekhi* **61** 965 (2018).

Source: *Nature* **566** 235 (2019)
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