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1. Measurement of spacetime curvature by its influence on the wave function of individual atoms

As distinct from free-fall acceleration expressed in terms of the gravitational potential gradient, gravitational tidal forces depend on second derivatives of the potential and are related to the spacetime curvature. The spacetime curvature has already been measured using three separate atomic interferometers in which the atomic states were not quantum-coherent among themselves. In a new experiment carried out by M A Kasevich (Stanford University, USA) and his colleagues, the effect of gravitational tidal forces on the wave function of individual atoms in a dual light-pulse atom interferometer has been measured for the first time. A freely falling cloud of ultracold gas of ^{87}Rb atoms experienced an impact of laser pulses, transferring the atoms into different states of motion. This splitting into trajectories is analogous to the emergence of different interferometer arms. The wave function of atoms flying simultaneously through two arms experienced a difference of gravitational forces on the scale of 10 cm. The tidal forces were generated by an 84-kg lead weight, and the interference of output atoms was observed with the aid of a CCD matrix from the photon scattering by atoms. Thus, from the difference of the wave-function phase shift, it became possible to measure the variations of gravitational acceleration as small as $10^{-10}g$. Such an atom interferometer can be applied to verify gravitation theories and to search for minerals by gravitational anomalies.

Source: *Phys. Rev. Lett.* **118** 183602 (2017)
https://doi.org/10.1103/PhysRevLett.118.183602

2. Nonmonotonic behavior of Casimir force

An experimental determination of the Casimir force acting between two surfaces covered by periodic T-shaped protrusions has been made by H B Chan (Hong Kong University of Science and Technology) and his colleagues. The surfaces, devices for their displacements (electrostatic actuators), and sensors were fabricated on a single silicon plate by the lithography and etching methods. This allowed the surfaces obtained to feature precise protrusion leveling. The Casimir force gradient was measured from the frequency shift of the silicon-rod mechanical oscillations. When the surfaces came closer to each other and the protrusions on them began going behind one another, the Casimir force twice changed sign, thus transforming from attractive to repulsive in the intermediate distance region. The repulsive character of the Casimir force in such a configuration was theoretically predicted by A W Rodriguez (Princeton University) and his colleagues in 2008. This experiment was the first to demonstrate the nonmonotonic character of the Casimir force. The repulsive Casimir force may appear to be useful in nanomechanics for the reduction of surface adhesion.

Source: *Nature Photonics* **11** 97 (2017)
https://doi.org/10.1038/nphoton.2016.254

3. Quantum state control of a molecular ion

The possibility of controling the quantum states of trapped ions is of importance for many applications. For monatomic ions, great progress was achieved on this issue, whereas with molecular ions there are difficulties because of a large number of quantum levels. C-w Chou (National Institute of Standards and Technology, USA) and colleagues have elaborated a new method based on a simultaneous Paul trapping of molecular $^{40}CaH^+$ and atomic $^{40}Ca^+$ ions. Laser photons induced interlevel transitions and a $^{40}CaH^+$ molecule assumed translatory motion, which was transferred to the atomic ion through Coulomb interaction. The state of $^{40}Ca^+$ is easier to measure (from photon scattering), which made it possible to indirectly determine the state of the molecular ion. Through a series of measurements and laser actions, the $^{40}CaH^+$ ion was transferred to desired quantum states, including the superposition of rotational levels with the prescribed orientation of the rotation axis.

Source: *Nature* **545** 203 (2017)
https://arXiv.org/abs/1612.03926

4. Laser cooling of triatomic molecules

J Doyle (Harvard University, USA) and his colleagues have developed a new method of polyatomic molecule cooling in a molecular beam, referred to as the 'Sisyphus method'. Cooled by laser irradiation, the molecules rise to the top of the interaction potential graph, roll down to the state in which cooling is ineffective, but then, affected by the magnetic field, are again transferred to the initial state, and this process repeats many times (up to about 200 times in the described experiment), as long as the molecules fly through the laser beams that are repeatedly reflected from mirrors and cross the molecular beam. The method was demonstrated through the example of triatomic SrOH molecules. The gas of SrOH molecules in the beam was cooled in one of the transverse directions by two orders of magnitude to a temperature of $\sim 750\ \mu K$.

Source: *Phys. Rev. Lett.* **118** 173201 (2017)
https://doi.org/10.1103/PhysRevLett.118.173201

5. Observations of fast radio bursts

The origin of fast radio bursts (FRB), cosmic radio emission millisecond pulses with a large dispersion measure, has not yet been clarified and is being intensely studied to date. The radiation polarization of the FRB 150215 that came from the direction close to the galactic disc (25 deg away from the Galactic Center) has been investigated using the radio telescope at the Australian Parkes Observatory. The radiation was linearly polarized at the level of $43 \pm 5\%$, and its

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specific feature is a small angle of Faraday rotation. A possible explanation may be either an opposite direction of the magnetic field in different regions along the line of sight, which leads to compensation, or else it may be a low electron column density. The FRB 121102, which yields repeat pulses, is also under study. The survey in the optical, near- and mid-IR ranges established that FRB 121102 is generated in the region of active star formation at the periphery of the irregular dwarf galaxy. A steady compact radio source which is likely to relate to the burst is projected onto the same region. Conditions in the Galaxy are favorable for explosions of powerful supernovae, and therefore this localization testifies in favor of the burst origin on newly born neutron stars or magnetars. An extremely bright FRB 170107 with a fluence of 58 ± 6 Jy ms was registered with the new ASKAP (Australian square kilometre array pathfinder) radio telescope consisting of 36 antennas. Its observation confirms the existence of a separate population of ultrabright (> 20 Jy ms) FRBs, which already number six. A new technology of observations was deployed on the array allowing instantaneous coverage of a large effective area of the celestial sphere — 160 deg^2.

Sources: https://arXiv.org/abs/1705.02911
https://arXiv.org/abs/1705.07698
https://arXiv.org/abs/1705.07581

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