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1. Short-range gravity

While an overwhelmingly dominant factor on cosmic scales, under laboratory conditions the force of gravity is generally negligible compared to electrical and magnetic forces, and it is virtually non-existent at the atomic and subatomic levels where the strong and weak interactions come into play. Since 1798, when the gravitational attraction between two laboratory masses was first detected by Cavendish, such experiments have been growing continuously in accuracy, and now a new high precision measurement has been reported at an American Physical Society meeting at Long Beach. E Adelberger of the University of Washington and his colleagues managed to measure the force of gravity over distances as small as 150 microns using a disk-shaped pendulum suspended above another disk, with a copper foil stretched between them to shield undesired electrical fields and thus to eliminate additional forces they produce. Importantly, no departure from Newton's law of gravity was detected. Short-range gravity studies are of interest as a testing ground for theories which assume extra spatial dimensions and predict departures from Newton's inverse-square law of gravity at small distances.

At the same meeting, a nearly order-of-magnitude improvement in the accuracy of the gravitational constant G was announced by J H Gundlach, also of the University of Washington. He and his colleagues obtained a value $G = 6.67390 \times 10^{-8}$ cm^3 g^{-1} s^{-2} with an uncertainty of only 0.0014% using a feedback mechanism to move the test weights and thus keeping pendulum twisting to a minimum.

Source: *Physics News Update*, Number 478
http://www.hep.net/documents/newsletters/pnu/pnu.html#RECENT

2. Quantizing heat flow

Electrical conduction is known to be quantized, i.e., to change in tiny discrete quantum units, the effect being particularly pronounced when the electronic de Broglie wavelength approaches the diameter of the conductor. Since heat likewise is carried by discrete quasiparticles (known as phonons), thermal conductivity has also been theoretically expected to possess this quantization property. This effect has now been seen for the first time in a Caltech experiment where heat flow along a thermally conducting wire only 500 atoms wide was studied between two microscopic 'phonon cavities.' The temperature of the cavities was measured by squids, measuring devices that depend on the Josephson effect in superconductors for their operation. As expected, the values of the heat flow along the wire were multiples of a quantity equal to a quantum heat unit.

Source: *Nature* 27 April 2000
http://www.nature.com/

3. Magnetic fields inside superconductors

A British-Swiss collaboration has managed to achieve a spatial resolution of tens of nm by using low-energy muons to map magnetic fields inside a superconductor. Because the magnetic moment of a muon undergoes precession when in a magnetic field, a positron, one of the muon's decay particles, carries information about the magnetic field the muon has passed through before decaying, thus enabling the spatial structure of the magnetic field to be mapped up by registering positron signals. While an external magnetic field can penetrate a superconductor to a limited depth, standard techniques fail to measure the magnetic field in the bulk of a sample. The new technique has confirmed the prediction that the magnetic field decreases strictly exponentially with increasing depth, both for normal and high-temperature superconductors.

Source: http://publish.aps.org/FOCUS/

4. Cosmic microwave background fluctuations

Radio telescopes suspended beneath the balloon of the international Boomerang experiment have yielded new results on the angular fluctuations in the temperature of the cosmic background radiation. Years ago, a prediction was made by A D Sakharov and worked out in detail by J Silk, Ya B Zel'dovich, and R A Syunyaev that the average value of such fluctuations depends periodically on the angular scale due to the interaction between the adiabatic mass-density fluctuations and the radiation in sound waves that are close in time to the hydrogen recombination process. Of this periodic variation, only the first acoustic peak was found in previous work. The new data, in addition to locating the first peak more accurately, demonstrated the existence of a second peak. Both the position and magnitude of the acoustic peaks depend on the parameters of the cosmological model used — in particular on the magnitude of the baryonic matter contribution to the total cosmological density. From the new observations, the first peak is located at somewhat large-than-expected angular scales and the second one is a bit lower than expected theoretically. Explanations for these findings are lacking. One possibility, a large baryon contribution, would be inconsistent with the standard picture of big bang nucleosynthesis. Accordingly, attempts at modifying this picture by introducing, for example, a decaying tau-neutrino or lepton asymmetry, have been made.

The Boomerang experiment has also confirmed that the total matter density in the universe (including the hidden mass, baryonic matter, and the Λ terms) is close to the critical value, and in this case the geometry of the universe is close to Euclidean, the Λ term accounting for two thirds of the total density.

Source: http://xxx.lanl.gov/abs/astro-ph/0004385

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