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Physics news on the Internet (based on electronic preprints)

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1. Testing the general theory of relativity

Lense – Thirring effect

I Ciufolini of the University of Lecce in Italy, and E Pavlis of the University of Michigan in the US have measured the magnitude of the Lense – Thirring effect. This effect — also known as frame-dragging — consists in the fact that space – time near a massive body is additionally curved — and hence probe body trajectories are additionally altered — if the body rotates. Over a span of 11 years, laser pulse round trip times have been measured between the Earth and the mirrors mounted on the LAGEOS and LAGEOS II small satellites orbiting at a distance about 5900 km. In this way, the distances to and the orbit shape of the satellites were determined with high precision. The Lense-Thirring effect gives a correction of about two meters per year to the orbit's parameters. The orbit as a whole plays the role of a giant, slowly precessing gyroscope. Although the measured Lense – Thirring effect was 99% of the general relativity prediction, there was a 10% uncertainty in their measurements — due primarily to nonuniformities in the gravitational field of the Earth. To account for the nonuniformities, preliminary data from the GRACE mission of a pair of satellites were used. With data from the Gravity Probe B mission that are forthcoming in the very near future, the error in measuring the magnitude of the effect will be reduced to 1%.

Source: http://physicsweb.org/articles/news/8/10/12/1

Equivalence principle for isotopes

The equivalence principle for macroscopic bodies was tested with an accuracy of 10^{-13}. The most accurate test on individual atoms has been performed by S Fray and his colleagues at the Max Planck Institute for Quantum Optics in Garching and the Universities of Münich and Tuebingen in Germany. The researchers used atomic spectroscopy to study the relative acceleration of the ^{85}Rb and ^{87}Rb isotopes falling in the Earth's gravitational field. The relative acceleration — and hence the accuracy of testing the equivalence principle — was $\Delta g/g = (1.2 \pm 1.7) \times 10^{-7}$. A similar test with approximately the same accuracy was performed for isotopes of one type residing in different substates of hyperfine-split energy levels. The measurement data have about three times the accuracy of previous experiments with atoms.

Source: http://arxiv.org/abs/physics/0411052

2. A new type of superconductivity

Cooper pairs of electrons in superconductors that are known to date have an even value of the orbital angular momentum, $L = 0$ or $L = 2$. Odd-parity superconductivity with $L = 1$ was predicted theoretically some 40 years ago, but decisive experimental confirmation of its existence has been lacking — until now. A team of physicists from the US and Japan have seen the first strong evidence for the existence of odd-parity superconductivity in strontium ruthenate (Sr_2RuO_4). In their experiment, a sample of superconducting strontium ruthenate was connected by two Josephson junctions to a conventional superconductor. Cooper pairs could tunnel through the junctions in both directions and interfere. By measuring the electric current through the junctions as a function of the external magnetic field, the researchers found that the superconducting currents passing through each junction had interfered in full compliance with the theoretical predictions for the case of $L = 1$.

Source: *Science* **306** 1151 (2004)
http://physicsweb.org/articles/news/8/11/6/1

3. 'Signal velocity' of a light pulse

Recent experiments have shown that for a light pulse propagating in a dispersive medium both the phase and group velocities can exceed the speed of light c in a vacuum. This does not violate the principles of the special relativity, however, because the rate of information transfer is always less than c. Researchers at the University of Geneva in Switzerland have for the first time confirmed this in a direct experimental way by studying how polarized laser pulses propagate in an optical fiber. As expected, the speed at which the front of the light pulse propagates — the so-called 'signal velocity' at which information in the pulse is transmitted — did not exceed c even though the pulse's mean group velocity was $1.76c$.

Source: http://arxiv.org/abs/quant-ph/0407155
Phys. Rev. Lett. **93** 203902 (2004)
http://prl.aps.org

4. Unusual dark matter halo

NGC 4555, an elliptic galaxy which is alone in the sense of not belonging to any cluster or group, has a very extended and massive halo of dark matter, according to the Chandra space X-ray observatory. The X-ray-emitting gaseous halo of the galaxy extends to a distance of about 60 kpc. Dynamic structure modeling of NGC 4555 showed that the surrounding dark matter halo is 300 times more massive than the gaseous halo. and is much larger than its counterparts around other galaxies with similar optical properties that have been studied. The formation mechanism of the galaxy NGC 4555 is not yet known.

Source: http://arxiv.org/abs/astro-ph/0407552

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