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Physics news on the Internet (based on electronic preprints)

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1. Reactor neutrino oscillations

The Japanese-American experiment KamLAND has for the first time discovered oscillations in electron antineutrinos produced by an atomic reactor. The experimental facility, located in a mine in Japan, contains about 1000 tonnes of liquid scintillator and almost 2000 photomultipliers, to register scintillation glow from electrons forming in neutrino-proton collisions. The experiment registers neutrino flux from 69 atomic reactors in Japan and South Korea, the neutrino signal observed being dominated by several powerful reactors about 180 km away from the detector. The anticipated signal was calculated to an accuracy of about 1% based on the reactor characteristics. It was found that the number of electron antineutrinos reaching the detector is 40% less than what one would expect if no oscillations were present. This suggests that 40% of electron antineutrinos transform (oscillate) into other antineutrino types en route from a reactor to the detector. The finding came as no surprise. Recent solar neutrino experiments at the Sudbury neutrino observatory (see *Usp. Fiz. Nauk* **172** 700 (2002) [*Phys. Usp.* **45** 000 (2002)]) in fact proved the existence of neutrino oscillations. What the KamLAND experiment has now achieved is another, independent proof. The KamLAND results are in perfect agreement with the Sudbury data. Besides, they provide a more accurate value for the mixing angle ($0.86 < \sin^2 2\theta < 1.0$), a key parameter involved in the theoretic description of the oscillation process.

Source: *Phys. Rev. Lett.* **86** 783 (2003)
http://prl.aps.org; http://kamland.lbl.gov

2. The velocity of gravitational interactions

According to the general theory of relativity, gravitational interactions travel at the speed of light. S Kopeikin (University of Missouri-Columbia) and E Fomalont (National Radio Astronomy Observatory) in the USA have tested this prediction by measuring the deflection that radio emission from a remote quasar undergoes when passing the planet Jupiter. Using the VLBA radio telescope in the USA and a 100-meter radio telescope in Germany, they observed Jupiter passing almost exactly between the Earth and the quasar J0842 + 1835 on September 8, 2002. The deflection angle depends on the velocity at which the gravitational field propagates from the planet. From the value of the deflection angle the velocity of gravitational interaction was found to be within 25% of the speed of light. Some scientific publications have questioned the finding, however. Future observations of gravitational waves are expected to provide more accurate results.

Source: http://physicsweb.org

Uspekhi Fizicheskikh Nauk **173** (2) 218 (2003)
Translated by E G Strel'chenko

3. Brownian motion within a solid

Using an analytical electron microscope, U Dahmen of the Lawrence Berkeley National Laboratory and his colleagues have discovered the Brownian motion of microscopic (nanometer-sized) liquid droplets of lead within a solid crystal of aluminium. The motion started when the crystal was heated to 423 °C, a temperature at which aluminium, whose melting point is 660 °C, is still solid. Statistical analysis of the patterns of the lead droplets' trajectories showed that that was indeed Brownian motion. Deviations from the random Brownian behaviour were observed only for the smallest droplets, which interacted with one another and moved collectively. The motion of droplets within the crystal may occur due to diffusion, but the microscopic mechanism of this type of diffusion is not yet understood. The authors believe that this Brownian motion is related to their observation of the late 1990s that microscopic lead droplets within solid aluminium are restricted to a set of discrete sizes.

Source: paul_preuss@lbl.gov

4. Rayleigh jets

T Leisner and his colleagues in Germany have for the first time observed a phenomenon Lord Rayleigh predicted as long ago as 1882. A theoretical analysis of the stability of charged droplets of liquid led Rayleigh to conclude that for droplets below a critical size (the Rayleigh limit) the electrical repulsion should exceed the surface tension, making the droplet unstable. Rayleigh conjectured that a droplet would assume an elongated shape and eject two charge-carrying jets from either of its ends. Although the stability of charged properties has been studied in many experiments, the picture of exactly how stability is lost has been unknown until now. The German team studied the droplets of ethylene glycol using a high-speed microphotographic apparatus. The droplet size and charge-to-mass ratio were determined from the way laser light was reflected by the droplets. In one of the experiments, the initial radius of a spherical droplet, 58 μm, was reduced to the Rayleigh limit, 24 μm, due to the evaporation of neutral molecules. As predicted by Rayleigh, the droplet did indeed assume an ellipsoidal shape and did eject two microscopic jets along its major axis. These jets, consisting of about 100 still smaller droplets, carried 33% of the total electric charge and only 0.3% of the total mass of the droplet.

Source: *Nature* **421** 128 (2003); www.nature.com

5. Hot gas at a large distance from a black hole

A team of Dutch astronomers led by S Migliari has discovered two clouds of hot gas moving very fast (at one-fourth the speed of light) in opposite directions from a black hole. This black hole joins a massive star to form a binary star system SS433 in our Galaxy. The observations were made using the space-based Chandra X-ray Observatory, the key factor leading to the discovery being the presence of X-ray-emitting iron atoms in the clouds. The velocities of the clouds were measured by their Doppler redshift. Earlier Chandra and Hubble observations showed that gas in the vicinity of a black hole cools down as it moves away from it as a result of expansion. The discovery of gas clouds with a temperature of about 50 million degrees 0.25 light-years away from the binary system came therefore as a surprise. The most likely reason for the gas being reheated is the collisions of blobs of gas that are ejected with great speed from the black hole's vicinity. Such ejections occur every few minutes according to optical observations made over a long period of time.

Source: http://chandra.nasa.gov

Compiled by *Yu N Eroshenko*