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1. Neutrino oscillations in the Daya Bay experiment

The international Daya Bay Reactor Neutrino Experiment in China has recorded oscillations of reactor-generated electron antineutrinos as found from their shortage in the beam. The researchers also determined a nonzero value for the neutrino mixing angle θ_{13}: $\sin^2(2\theta_{13}) = 0.092 \pm 0.016(\text{stat.}) \pm 0.005(\text{syst.})$, which effectively eliminated the version of $\theta_{13} = 0$ at the 5.2σ level. A similar result was obtained earlier in the K2K experiment at a lower confidence level. Six atomic reactors served as the source of $\bar{\nu}_e$ with energies of several MeV. Antineutrinos at the baseline point in the beams were detected using three detectors deployed at distances of 470–576 m from the sources, while three remote detectors were placed underground at a distance of 1648 m. As the near and remote detectors are identical, measurement errors due to differences in their design were reduced to a minimum. The inverse β decay in the process $\bar{\nu}_e + p \to e^+ + n$ was used for the observation of $\bar{\nu}_e$. A characteristic feature of the presence of $\bar{\nu}_e$ was found in correlated bursts of light caused by produced positrons and by interactions of neutrons with nuclei. Each detector utilized 20 tons of gadolinium-doped liquid scintillator as a target. During the 55 days of the experiment, the remote detectors recorded 10,416 electron antineutrino candidates, which is 6% less than their expected number deduced from the measurement data of near detectors. This deficit is due to oscillations (conversions) of $\bar{\nu}_e$ into other sorts of antineutrinos. The team of about 270 Daya Bay researchers includes some Russian scientists from JINR (Dubna).

Source: http://arXiv.org/abs/1203.1669

2. Dineutron decay of ^{16}Be nuclei

A Spyrou (Michigan State University, USA) and her colleagues have recorded the emission of ground-state dineutrons — short-lived, weakly bound states of two neutrons — from ^{16}Be nuclei at the National Superconducting Cyclotron Laboratory (East Lansing, Michigan). In the past, only indirect evidence of the formation of dineutrons inside neutron-rich nuclei was reported. ^{16}Be nuclei in the ground state were produced in the cyclotron in nuclear collisions of ^{17}Be with a beryllium target. The decay of ^{16}Be nuclei with the emission of single neutrons is unfavored, but these nuclei can emit two neutrons in the process. Very soon after leaving the nucleus, a dineutron decayed into two single neutrons; the method of detecting them was based on searching for pair coincidences. Reconstruction of decay events revealed that the dineutron scenario was the most likely explanation of the experimental data among scenarios with the emission of a single neutron, a dineutron, or two independent or three neutrons. The scenario of emission of a dineutron from a ^{16}Be nucleus agrees with the shell model computations in which these nuclei contain a halo of paired neutrons around a more compact central core.

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3. Detection of electric currents in GaAs based on second-harmonic generation

B A Ruzicka (University of Kansas, USA) and his colleagues have studied a nonlinear optical effect of electric currents in crystals via the generation of second harmonics in transmitted light. The generation of light harmonics produced by an electric field has already been observed earlier. In the experiment reported here, electric fields were responsible for only a small contribution, while the effect was mostly caused by the electric current. A GaAs crystal was illuminated by the IR laser focused pulses linearly polarized in the direction of current flow, and experimenters studied the spectrum of the transmitted light. Two versions of the experiment were run: a steady electric current was either produced by applying a voltage on a doped GaAs crystal, or it was produced for a short time in response to laser pulses. Electric current immediately generated second harmonics in the optical spectrum; the harmonics intensity was proportional to current density. As in the case of an electric field, the second-harmonic generation induced by electric currents results from asymmetric charge distribution in momentum space. This asymmetry makes it possible to emit photons at double frequency; in the case of symmetric charge distribution, the photons would remain virtual. This nonlinear optical effect was predicted theoretically by J B Khurgin in 1995.

Source: *Phys. Rev. Lett.* **108** 077403 (2012)
http://arXiv.org/abs/1112.5140

4. The transfer of single photons between molecules

Y L A Rezus (AMOLF, Amsterdam and ETH, Zurich) and his colleagues have carried out an experiment in which photons were emitted by a specific single molecule and absorbed by a second molecule, identical to the first, at a distance of several meters. Interaction with single photons is usually effective only for molecules resided in a resonant cavity, but Rezus et al. succeeded in having the molecule absorb a single photon flying in free space without special cavities or waveguides. The absorption cross section was large enough, since the photon's resonant frequency coincided with that of the molecular transition. Organic dye molecules were embedded into a tetradecane crystal cooled to 1.5 K. After laser excitation, the source molecule emitted photons which were focused onto the second molecule. Correlation measurements using splitters confirmed that the photons propagating in the beam were indeed single photons. Microelectrodes placed close to the target molecule produced the electric field, and when the frequency was driven away from the resonance by Stark frequency shift, the photons were more efficiently reflected from the molecule than absorbed by it, thus confirming the fundamental role of the resonance transition.

Source: *Phys. Rev. Lett.* **108** 093601 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.093601

5. Rapid gas flow from black hole

An investigation by the Chandra Space Observatory of a stellar-mass black hole (BH) in the system IGR J17091-3624 has revealed a high speed of matter outflow (approximately 3% of the speed of light) in the plane of the accretion disk around the BH. Observations conducted two months earlier found no such fast matter flows, which points to the variability of the effect. The binary system IGR J17091-3624 consists of a Sun-like star and a BH in the Galaxy bulge. The gas flow velocity, 9300^{+500}_{-400} km s^{-1}, was calculated from the measurement of the shift of He-like Fe XXV spectral lines. This velocity is roughly an order of magnitude greater than what one finds near other stellar-mass BHs. Contemporaneous observations with EVLA radio telescopes in 2011 showed that jets along the axis of the disk were absent when the equatorial gas flow was apparent, but they were observed earlier when there were no equatorial winds. This anticorrelation, also observed in other systems, is probably caused by a changed topology of the magnetic field in the disk region. The mass loss produced by the outgoing gas jet may exceed the rate of matter accretion onto the BH. The radiation pressure in the system IGR J17091-3624 is incapable of creating such an intense flow of matter: it probably stems from other thermal or magnetic processes in accreting black hole systems.

Sources: http://arXiv.org/abs/1112.3648
http://www.nasa.gov/mission_pages/chandra/news/H-12-056.html

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