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1. Direct recording of solar pp-neutrino

Solar neutrinos born in the $p + p \rightarrow {}^2H + e^+ + \nu_e$ fusion reaction were first recorded directly in the Borexino experiment being carried out at the Gran Sasso National Laboratory (Italy). In 99.76% of cases, this reaction has given rise to the proton–proton cycle in which more than 99% of the entire solar energy is released. In the region of low pp-neutrino energies, the background signals are strong, which makes their registration a fairly complicated task. To be screened from the background radiation produced by cosmic rays, the Borexino detector was placed in a tunnel under the mountain, and to lower the background from beta-decays, an ultrapure scintillator was used in Borexino, which is based on products of the ancient oil mined from deep nests retaining few radioactive ^{14}C atoms. Photomultipliers registered the radiation generated in the scintillator by electrons recoiled when neutrinos were scattered by them. The measured pp-neutrino flux of $(6.6 \pm 0.7) \times 10^{10}$ cm^{-2} s^{-1} agrees well with the value of $5.98 \times (1 \pm 0.006) \times 10^{10}$ cm^{-2} s^{-1} predicted in the Standard Model of the Sun, and the absence of pp-neutrinos is excluded at the level of 10σ. Comparison of solar radiation in the optical range and its neutrino luminosity proves the stability of the Sun over $\sim 10^5$ years in which photons are emitted from the solar core.

Source: *Nature* **512** 383 (2014)
http://dx.doi.org/10.1038/nature13702

2. Superfluid nanodrops

L F Gomez (University of Southern California, USA) and his colleagues have applied the X-ray diffraction method to study the quantum vortices in superfluid 100–1000-nm helium drops consisting of $\sim 10^8 - 10^{11}$ atoms. The nanodrops were formed upon helium expansion from a nozzle to a vacuum. For several milliseconds of the drop flight through the detector, they were exposed to femtosecond pulses of a high-power free-electron X-ray laser. X-ray photos showed that $\approx 40\%$ of the nanodrops had the shape of a flattened ellipsoid of revolution and rotated with frequencies of up to approximately $10^6 - 10^7$ rev/s. Helium has a low contrast in X-ray photos, and therefore xenon atoms were admixed to it, for they scatter X-rays well. The Bragg diffraction patterns showed the presence in nanodrops of superfluid vortices arranged in a trigonal lattice. The vortex concentration in nanodrops was up to $\sim 10^5$ times higher than had been observed before in macroscopic helium volumes. For $\sim 1\%$ of wheel-shaped nanodrops, the Bragg pattern was absent. The vortices in these nanodrops are possibly distributed chaotically because of disbalance or quantum turbulence.

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http://dx.doi.org/10.1126/science.1252395

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3. Reconnection of vortex rings in ^{4}He

P M Walmsley (University of Manchester, Great Britain) and his colleagues have studied the collision of chaotically oriented quantum vortex rings (VRs) in superfluid ^{4}He at a temperature of nearly 0.05 K. Upon collision of two VRs, they could experience reconnection to form a single VR with a larger or smaller radius. The observations were conducted using time-of-flight spectroscopy in a small vessel filled with liquid ^{4}He. Near the injector, the VRs acquired a charge from a tungsten needle, and the electric current which was carried by the VRs from injector to collector over the time from the beginning of injection was measured. The VRs being produced had similar prescribed radii of several micrometers. The VR velocity and, accordingly, the time within which they reached the collector depended on their radii, namely, larger VRs moved slower. The maximum current was reached at the instant of initial VR arrival. The signal at longer times corresponded to the arrival of larger VRs produced upon reconnection, and the discrete signals at shorter times testified to the formation of smaller VRs and even two successive joins of VRs with other VRs. The experimental data are in good quantitative agreement with the theoretical predictions of VR reconnection.

Source: *Phys. Rev. Lett.* **113** 125302 (2014)
http://arXiv.org/abs/1308.6171

4. Glass structure variation under pressure

T Edwards (University of California, Davis, USA) and colleagues have observed the instant of transformation of borosilicate (with ^{11}B isotope) glass from the BO_3 to BO_4 configurations in the course of its compression to a pressure of 2 GPa. Earlier, these configurations were observed separately before and after compression, and the very instant of transformation was not examined. The glass sample under compression was observed by nuclear magnetic resonance spectroscopy. The spectrum was continuously measured depending on the pressure at room temperature. The spectroscopic data obtained are interpreted as follows. In the course of compression, the flat BO_3 complex was elastically deformed into a trihedral pyramid owing to boron atom escape from the plane in which three oxygen atoms reside. Given this, the boron atom approached the fourth oxygen atom to form tetrahedral BO_4 complexes.

Source: *Science* **345** 1027 (2014)
http://dx.doi.org/10.1126/science.1256224

5. Lithium production in primary nucleosynthesis

The $^2H(\alpha, \gamma)\,^6Li$ lithium nucleosynthesis reaction cross section at energies that existed in the epoch of primary nucleosynthesis in the Universe, when the latter was only several minutes of age, was first measured in the LUNA experiment (Gran Sasso, Italy). Under conditions of low background, an alpha-particle beam hit a deuterium target, and γ photons from the $^2H(\alpha, \gamma)\,^6Li$ reaction were recorded, which allowed its cross section to be measured. According to the standard theory of primary nucleosynthesis with the cross section specified in the LUNA experiment, the relative ^{6}Li/^{7}Li content in the primary gas makes up $(1.5 \pm 0.3) \times 10^{-5}$, whereas in old stars (whose chemical composition was thought to be close to the primary one) this value is $\sim 5 \times 10^{-2}$. Thus, the new LUNA data confirm the conclusion that for a yet unknown reason the lithium content in the Universe must have changed considerably already after the primary nucleosynthesis. The hypotheses have been put forward that ^{6}Li is produced in stellar flares or in another yet unknown process.

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