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1. Search for the Higgs boson at the Large Hadron Collider

The ATLAS and CMS experiments at the Large Hadron Collider are registering particles into which, according to theoretical predictions, Higgs bosons (H) created in pp collisions could decay. According to the ATLAS data accumulated in 2011, the mass of the Higgs — if it exists — is constrained at 95% probability to the range 116–130 GeV, while CMS data constrain the Higgs mass to the 115–127 GeV range. Both experiments revealed a small event excess which may indicate the creation of the H. ATLAS points to an excess in decay channels $H \to \gamma\gamma$, $H \to ZZ$, and $H \to WW$. With the most conservative interpretation, the global confidence of detection of the Higgs with a mass of about 126 GeV over these channels is 2.3σ. In the CMS experiment, a similar excess is observed at about 123 GeV at a 2σ confidence level in five independent decay channels simultaneously. It is necessary to additionally verify that this excess does indeed correspond to the Higgs boson of the Standard Model, not to some other particle. So far, the low statistical significance does not permit drawing a reliable conclusion on the detection or absence of the Higgs but it is expected that the statistics sufficient for this may be accumulated some time in 2012.Recent review by S V Troitsky in *Phys. Usp.* **55** (1) 72 (2012) report on the status of experimental searches for the Standard Model Higgs boson.

Source: http://press.web.cern.ch/press/PressReleases/Releases2011/PR25.11E.html

2. Quantum correlations in diamonds

I A Walmsley (Clarendon Laboratory,University of Oxford, UK) and colleagues have succeeded in creating an entangled quantum state for phonons, namely vibrations of a crystal lattice excited by laser pulses in two diamonds in the course of Raman scattering at room temperature. Diamond crystals 3 mm in size were separated by about 15 cm. Photons emitted by the pump laser passed through a polarizing beamsplitter and entered two crystals following different optical paths which combined into one after the passage through the crystals. Signals of the single-photon detector at the output could not reveal through which of the two crystals the photon had passed and consequently phonons excited in one of the crystals were quantum-correlated with the phonons in the second crystal. The area covered by each of the phonons was approximately 0.05×0.25 mm; in this area, approximately 10^{16} atoms vibrated coherently at a frequency of about 40 THz. Phonons were detected as they scattered pulses of the second laser sent after a fixed time of 350 fs after the main pumping pulses, i.e., during the time of phonon decoherence (≈ 7 ps). The presence of quantum entanglement was confirmed by the correlations of the polarization states of Raman-scattered Stokes and anti-Stokes photons.

Source: *Science* **334** 1253 (2011)
http://dx.doi.org/10.1126/science.1211914

3. The homodyne detector for atoms

M K Oberthaler (Universität Heidelberg, Germany) and his colleagues have implemented a method of homodyne detection of quantum correlations in a Bose–Einstein condensate of rubidium atoms at a temperature of 10^{-7} K. This experiment revealed, for the first time in the case of atoms, quantum correlations of continuous variables, namely oscillation phases. The atoms were trapped in a one-dimensional optical lattice holding several hundred atoms per cell. Initially, the condensate was prepared in the hyperfine-splitted state $(F, m_F) = (2, 0)$ which was an analogue of the state of photons in the pumping beam in optical experiments. Spin-changing collisions between atoms created a nonlinear binding of the Zeeman states with $m_F = \pm 1$. The authors studied fluctuations involving at most several atoms of the condensate. According to the measurements, fluctuations in the number of atoms in the states $m_F = +1$ and $m_F = -1$ were certainly correlated. The quantum nature of correlations was confirmed by measuring the phase of oscillations of the number of atoms relative to the phase of the local oscillator (atoms prepared in the state $(1, \pm 1)$).

Source: *Nature* **480** 219 (2011)
http://dx.doi.org/10.1038/nature10654

4. Friction at the nanoscale

R W Carpick (University of Pennsylvania, USA) and his colleagues have explored the ageing of static friction on the nanometer scale using an atomic force microscope. Frictional strength may be enhanced through a gradual increase in the contact area of the samples, or by the formation of new connections between them. In this experiment, one of the surfaces was the quartz tip of the atomic force microscope. Its intermittent slipping along the quartz specimen surface was recorded in reflected light. The measurements were performed over a time of up to ≈ 100 s. Analogous to experiments with macroscopic samples, it was found in this particular case that static friction force grows approximately as a logarithm of time. It is most probable that silanol Si–OH groups entered the chemical reaction, producing siloxane Si–O–Si bonds between two surfaces. The chemical nature of the strengthening of the friction force was confirmed by the fact that, in the case of the second surface made of diamond or graphite, no strengthening was observed, as the chemical interfacial bounds were too weak. This study may also have shed light on the mechanism of earthquakes, owing to certain common features of behavior. It is assumed that the intermittent sliding of rocks occurs in seismically active zones and the frictional strength increases

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with time, thereby enhancing earthquakes in subsequent strike-slip faults.

Source: *Nature* **480** 233 (2011)
http://dx.doi.org/10.1038/nature10589

5. Indirect search for dark matter particles

Dwarf spheroidal galaxies — satellites of our Galaxy — are among the most promising objects in searching for annihilation of particles of dark matter, as these dwarfs are characterized by low gas content and a low rate of star formation; hence, the level of gamma-ray background generated by cosmic rays must be low too. In principle, this should facilitate detection of the gamma-ray signal of annihilation. A search for gamma emission from 10 dwarf galaxies was conducted using the Fermi Gamma-Ray Space Telescope; new constraints, the strongest at the moment, on the annihilation cross section of weakly interacting massive particles of dark matter were obtained. These constraints came very closely to the magnitude of $\langle \sigma v \rangle = 3 \times 10^{-26}$ cm^3 s^{-1} at which particles were born in the early Universe, in the amounts exactly right for explaining dark matter. Researchers in the Fermi-LAT Collaboration applied the condition where $\langle \sigma v \rangle$ is less than 3×10^{-26} cm^3 s^{-1} and found the minimum possible mass of the particles to be ≈ 27 GeV in the hadronic channel of annihilation, and ≈ 37 GeV in the leptonic channel. A Geringer-Sameth and S M Koushiappas of Brown University (USA) concluded, using an alternative analysis of the signals and backgrounds, that data on dwarf galaxies obtained by the Fermi Large Area Telescope exclude, with a 95% probability, dark matter particles with a mass of less than 40 GeV in the hadronic channel of annihilation.

Sources: *Phys. Rev. Lett.* **107** 241302, 241303 (2011)
http://arXiv.org/abs/1108.3546,
http://arXiv.org/abs/1108.2914

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