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1. Decay of the Higgs boson into fermions

It seems likely that new ATLAS and CMS experiments on the Large Hadron Collider has detected the decay of the Higgs boson into a pair of fermions, $\tau^+\tau^-$. Only decays into W-, Z-bosons and photons were observed earlier, and just these results served to identify the Higgs boson. The experiments under discussion accumulated a large array of data on the decays of τ-leptons into electrons and muons. The observed kinematics of the processes correspond to the creation of certain of the original τ-leptons as a result of decays of the Higgs boson possessing a mass of 125 GeV, which agrees with the predictions of the Standard Model of elementary particles, which contains only one Higgs field. In more sophisticated models, the masses of intermediate bosons and fermions are provided by various Higgs fields, and the identified channel of decay into fermions for the recently discovered Higgs boson could be absent. The reliability of registering the decay of the Higgs bosons into fermions, according to the data obtained and processed in the ATLAS experiment, points to 4.1σ, while when using the CMS data, this reliability is 3.4σ. Another search now being conducted is for the decay of the Higgs bosons into a pair of a b-quark and a b-antiquark, but the results obtained so far remain ambiguous owing to large measurement errors.

Source: http://atlas.ch/news/2013/higgs-into-fermions.html

2. Neutron lifetime

The mean lifetime τ_n of the neutron prior to its decay has been measured with maximum accuracy in two experiments; they used different methods and their results diverged. In an experiment by A Serebrov (B P Konstantinov Petersburg Nuclear Physics Institute) and his colleagues, the researchers used a source of ultracold neutrons from the Institut Laue–Langevin (Grenoble, France) and measured τ_n by recording the reduction in the number of neutrons in a trap with time. The measurement error was less than one second. In the second experiment, conducted at the National Institute of Standards and Technology (NIST), J S Niko and his colleagues studied neutron decays in a beam. The rate of decays dN/dt and the number of neutrons N in a confined part of the beam were determined, respectively, by recording the products of the reaction Li_6(n,t)He_4 and using a magnetic trap of decayed protons, and then τ_n was determined by applying the formula $dN/dt = -N/\tau_n$. The results of this experiment were recently improved at a higher accuracy by calibrating the earlier utilized detector with an aid of a new detector in which the neutron beam was completely absorbed. Such a measuring technique is free from uncertainties in the Li_6(n,t)He_4 reaction cross section. The new value, $\tau_n = 887.7 \pm 1.2(\text{stat}) \pm 1.9(\text{syst})$ s, is higher by $\Delta\tau_n = 8.4 \pm 2.2$ s than that obtained by A Serebrov et al., and the statistical significance of the distinction in the results under consideration has increased to 3.8σ. New, more precise measurements will perhaps be needed to clarify the cause of the discordance. If this circumstance turns out to be real, it may be indicative of new physical effects, for instance, neutron decays or transformations through new channels without proton production.

Source: *Phys. Rev. Lett.* **111** 222501 (2013)
http://arXiv.org/abs/arXiv:1309.2623

3. Quantum effects in a double interferometer

L Vaidman (Tel-Aviv University, Israel) and his colleagues have observed in their experiment an interesting quantum effect: namely, without passing through a certain space region photons, nevertheless, carried information about this region. A Mach–Zehnder interferometer was employed with another Mach–Zehnder interferometer built in to one of its arms. Thus, the photons had three possible paths to the detector, where their interference was observed. On the way, the photons were reflected from several mirrors oscillating with different frequencies, and so each route section had its own signal modulation frequency. For certain arm lengths, destructive interference took place in the inner interferometer — that is, the photons could not leave it. Nevertheless, the light modulation frequency corresponding to the inner mirror oscillations in the inner interferometer was also observed in the detector. It is of importance that the mirror oscillations displaced the beams by distances much smaller than their thickness, i.e., the observations of a signal modulation were 'weak quantum measurements'. The quantum nature of the revealed effect was proved by the fact that if the third route (a single arm of the external interferometer) was blocked to the photons, then the harmonics corresponding to mirror oscillations in the inner interferometer disappeared from the resultant signal as well. The result of the experiment can most obviously be imagined within the 'postselection' conception proposed by A G Aronov, P G Bergmann, and J L Lebowitz with the help of two state vectors propagating from a source to a detector and back. But the results can equally well be described within the standard interpretation when the revealed effect is explained by violation of the destructive interference owing to the oscillation of mirrors.

Source: *Phys. Rev. Lett.* **111** 240402 (2013)
http://arXiv.org/abs/1304.7469

4. Graphene oscillator

Using graphene, J Hone (Columbia University, USA) and his colleagues have created a radio frequency oscillator with a small size on record for such devices — several micrometers in diameter. In the principle of its operation, the new device is analogous to the voltage-controlled oscillator (VCO) manufactured of other materials. A piece of graphene placed into a

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polymer holder was connected with two electrodes (the source and the outfall) and was located above a third electrode, which was a shutter capable of deforming the graphene by its electric field. Mechanical oscillations of an elastic graphene sheet alter the charge density and, accordingly, the graphene conductivity. Oscillations were excited applying a simple feedback scheme where the source voltage was fed to the shutter through an amplifier and a phase shifter. By varying the electric field of the shutter, the generation frequency (the resonance frequency of mechanical oscillations) can be varied within approximately 14%. The mean frequency of ≈ 100 MHz lies within the radio-frequency range, and the modulation and signal transmission effect in the experiment was demonstrated using an ordinary domestic radio receiver. Resonance elements in radio frequency oscillators are hardly amenable to miniaturization and are, therefore, placed on electron boards separately from the other microelements. Owing to its small size, the new device can be integrated directly into microchips.

Source: *Nature Nanotechnology* **8** 923 (2013)
http://dx.doi.org/10.1038/nnano.2013.232

5. IceCube detection of high-energy neutrinos

Using the 2010–2012 data from the IceCube detector located in the ice of the South Pole, 26 new neutrino events with energies above 30 TeV have been revealed. These neutrinos, together with the two PeV neutrinos reported earlier, have the highest of any energy ever observed: up to 1200 TeV. The 28 events under discussion are unlikely to refer to the atmospheric neutrinos born in the interaction of cosmic rays with air molecules, because they have higher energies and a harder spectrum. The background due to atmospheric events (mainly muons) would, according to calculations, only give $10.6^{+5.0}_{-3.6}$ events, and therefore an atmospheric origin is excluded at the 4σ confidence level. To all appearances, these are astrophysical neutrinos originating in the interaction of cosmic rays with the interstellar gas and the radiation beyond the Solar System. Although the larger part of the events was recorded in the southern hemisphere, no statistically significant clusterization in directions or times was revealed, which testifies against the origination of these neutrinos in one source as a result of a short flare.

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