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1. Unconventional gamma resonance in LHC experiments

In the ATLAS and CMS experiments at the Large Hadron Collider, the diphoton distribution showed a maximum which has not yet been convincingly explained. ATLAS registered this resonance at an energy of 750 GeV in 14 events involving a pair of photons, the statistical significance being $(2.3-3.9)\sigma$ (depending on the assumptions about the process structure). The CMS-recorded resonance decaying into two photons has a peak at 760 GeV. It was distinguished with a significance of $(2.0-2.6)\sigma$ in 10 events. In theoretical work, a number of hypotheses concerning the origin of the discovered resonance were put forward. This resonance, if it is not due to statistical fluctuation, can be a slight indication of the existence of new particles. For example, it may correspond to a boson resembling the heavy version of the Higgs boson. It is also possible that the resonance is related to a heavy particle in whose decay products the dark matter particles (hidden mass of the Universe) can exist.

Sources: http://arXiv.org/abs/1512.04933
http://arXiv.org/abs/1512.07616

2. Feshbach resonance for two-electron fermions

Two independent groups of researchers have applied Feshbach orbital resonance to control the pair interaction of ^{173}Yb fermionic atoms where each atom has two valence electrons. Feshbach resonance for such atoms was earlier considered to be impossible, because the resultant spin of the electrons is zero, but R Zhang and colleagues proposed a new type of Feshbach resonance, namely, orbital resonance. In experiments carried out using their method, the magnetic field causes the mixing of the singlet and triplet states $^1S_0$ and $^3P_0$, respectively, of ^{173}Yb atoms in an ultracold gas in an optical lattice, which is responsible for establishing the coupling between the spin and orbital degrees of freedom. Furthermore, the energy difference in magnetic interactions for nuclei that are in different spin states (Zeeman effect) was used. The combination of spin states of electrons and nuclei made it possible to achieve resonance. L Fallani (University of Florence, Italy) and his colleagues observed resonance by examining the behavior of expanding gas cloud, while S Folling (Ludwig Maximilian University of Münich, Germany) and colleagues studied for this purpose thermalization of a gas after its local heating. The thermalization rate is proportional to the atomic scattering cross section and, accordingly, to the strength of atomic interaction. Both groups revealed that this strength passes through maximum in a magnetic field of about 50 G.

Sources: *Phys. Rev. Lett.* **115** 265301, 265302 (2015)
http://dx.doi.org/10.1103/PhysRevLett.115.265301
http://dx.doi.org/10.1103/PhysRevLett.115.265302

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3. Autonomous Maxwell demon on a chip

J P Pekola (Aalto University, Finland) and his colleagues from Finland, Russia, and the USA have realized experimentally an autonomous Maxwell demon (the control device from the thought experiment considered by J C Maxwell in 1867). The Maxwell demons designed earlier consumed energy from alien sources. However, the conception of an autonomous Maxwell demon operating only at the expense of internal power has been discussed beginning with L Szilard's work. The setup of Pekola and his colleagues comprises a single-electron transistor and auxiliary elements placed on an electron chip. The superconducting aluminum comprises were attached to a nanometer-sized lead island. If an electron tunnels from the contact to the island, a positive potential is produced, which confines this electron. If, on the contrary, an electron tunnels from the island, a negative potential appears. Owing to this, the electron always overcomes the potential barrier, and the system gets cooler under quantum tunneling. These processes are the equivalent of an open and closed door for fast and slow molecules in the original Maxwell demon conception. The work of a demon was shown to lead to rising its temperature, which, in accordance with R Landauer's principle, is the thermodynamic cost of information about the presence of electrons.

Source: *Phys. Rev. Lett.* **115** 260602 (2015)
http://dx.doi.org/10.1103/PhysRevLett.115.260602

4. Borophene

A J Mannix (Argonne National Laboratory, USA) and colleagues have synthesized deep in a vacuum a one-atom-thick crystal layer of boron on a silver substrate. This layer, resembling graphene, was called 'borophene', but, as opposed to graphene, free borophene without a substrate is most likely to be unstable. Deposition of boron atoms onto silver proceeded at a temperature of 450 to 700 °C, and the structures obtained were investigated by a scanning tunneling microscope and by the electron diffraction method. The borophene crystal lattice has a rectangular configuration that showed structures resembling a unification of different-scale atomic clusters with out-of-plane bulging. As distinct from bulk boron allotropes, borophene possesses highly anisotropic metal properties: it is a conductor along the layer, and a semiconductor across the layer. The mechanical properties of borophene are predicted to be also highly anisotropic.

Source: *Science* **350** 1513 (2016)
http://dx.doi.org/10.1126/science.aad1080

5. Jet base in galaxy M87

In cores of galaxies with active nuclei, particle jets are formed that are ejected far beyond the galaxies. The mechanisms of the generation and collimation of these jets have not yet been completely clarified. The main role is assumed to be played by the magnetic field in the interior parts of accretion discs around supermassive black holes. Making use of VLBI and Green Bank radio telescopes, K Hada (National Radio Astronomical Observatory of Japan and National Institute for Astrophysics, Italy) and colleagues investigated the jet base (the starting portion) at a frequency of 86 GHz (3.5 mm) in galaxy M87. The joint observation with two telescopes allowed a decrease in the effect of atmospheric fluctuations making noise at this wavelength and achieving the resolution of ~ 10 Schwarzschild radii (R_S) for the central black hole. The specific features of a jet structure known from observations at lower frequencies were confirmed, and new specificities were also revealed. Bright spots with limbs can be seen at distances of $\sim 10R_S$ to $28R_S$ from the core, where the jet opening angle is $\sim 100°$. At distances of $\sim 35R_S$, the jet opening angle decreases to $\sim 60°$ and further the jet has a conical shape up to $\sim 84R_S$, and at even larger distances it undergoes collimation according to the parabolic law. At distances of $\sim 35R_S$, the jet cross section locally shrinks and again increases. A weak counter jet is also observed. Comparison of the velocities in a jet ($\sim 0.32c$) and a counter jet ($\sim 0.17c$) gave an estimate of the angle at which the jet can be seen ($29° - 45°$). This value is higher than that given by examination of optical kinematics with the Hubble telescope ($11° - 19°$) probably because of the curvature of the optical marker trajectories. Polarimetric measurements at a wavelength of 86 GHz were taken for the first time for this source. In some jet regions, its radiation is weakly polarized (at a level of $\sim 3-4\%$), but highly polarized ($\sim 20\%$) structures are also seen that are indicative of the presence of an ordered magnetic field.

Source: http://arXiv.org/abs/1512.03783

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