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Physics news on the Internet (based on electronic preprints)

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1. New baryons discovered

Resonance particles $\Xi_b'^-$ and Ξ_b^{*-} with masses of 5935 MeV/c^2 and 5955 MeV/c^2, respectively, consisting of b-, d-, and s-quarks were recorded for the first time at the Large Hadron Collider by the LHCb Collaboration. The existence of these particles in the Ξ_b isodoublet composition had been predicted theoretically in the quark model. In the $\Xi_b'^-$ baryon with spin parity $J^P = (1/2)^+$, the d-quark spin is opposite to the s-quark spin, while the Ξ_b^{*-} baryon has $J^P = (3/2)^+$ and the spins of the indicated quarks are homomallous. New particles were born in pp collisions and were detected as peaks in the spectrum of their decay into Ξ_b^0 and π^-. The masses of the new baryons exceed only slightly the sum of Ξ_b^0 and π^- masses and are near the kinematic threshold of the decay; it had been assumed before that the $\Xi_b'^-$ mass can be below the threshold. The LHCb experiment is being conducted with the participation of Russian researchers from seven research institutes.

Source: http://arXiv.org/abs/1411.4849

2. Quantum interference on a molecule

In the well-known two-slit quantum experiment, the interference pattern disappears if it is known through which slit particles fly. This information can be obtained, for example, by measuring the slit recoil momentum. X-J Liu (SOLEIL cyclic electron accelerator, France) and colleagues have carried out a version of this experiment making use of the photoemission effect on O_2 molecules. The role of two slits was played by two atoms in the molecule, and the interference pattern was observed in the angular distribution of Auger electrons escaping after irradiation of molecules by photons from a synchrotron X-ray source. If photons were scattered by the O_2 molecule without its dissociation, it acquired recoil momentum as a whole. It was unknown in this case which of the two atoms in the molecule were responsible for the light scattering, and an interference pattern was observed. If the molecules dissociated into atoms, the O^+ ion and Auger-electron momenta were recorded. This made it possible to identify the atom-scatterer and, as had been predicted by quantum mechanics, the Auger-electron distribution showed no interference.

Source: *Nature Photonics*, on-line publication of 1.12.2014. http://dx.doi.org/10.1038/photon.2014.289

3. Structure of $^4He_3$ and $^3He^4He_2$ trimers

The spatial structure of the $^4He_3$ molecule has been theoretically discussed for already more than 20 years. This molecule has a very low binding energy because of the weak ^{4}He atom polarizability. According to some papers, ^{4}He atoms in the $^4He_3$ molecule are arranged as a regular triangle, while calculations by other authors suggest that it should be a linear molecule. A new experiment performed by R Dorner (Nuclear Physics Institute, Göthe University, Germany) and colleagues heve shown that the $^4He_3$ molecule actually has no definite structure, but instead the ^{4}He atoms form a chaotic cloud (being distributed with approximately equal probability inside a spherical volume). The experiment was performed on the COLTRIMS setup, where the $^4He_3$ and $^3He^4He_2$ molecules were produced when gaseous helium escaped from the nozzle and, having passed through a diffraction grating, were mass-separated. Then, under the influence of femtosecond laser pulses, the atoms in the molecules were ionized, scattered because of Coulomb repulsion, and registered in detectors by the coincidence method. This method allowed measurement of atomic momenta and retrieval of the form of initial $^4He_3$ molecules, i.e., determination of the interatomic distances and angles between atomic bonds. The wide statistical distance straggling and angle spread (without pronounced peaks) suggested the conclusion that these molecules have no ordered structure. The same experiment investigated the structure of $^3He^4He_2$ molecules and showed that they have the shape of a 'halo' when the ^{3}He atom orbits far from a more compact $^4He_2$ pair.

Source: *Nature Communications* **5** 5765 (2014) http://dx.doi.org/10.1038/ncomms6765

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4. Electron dynamics in silicon

M Schultze (University of California, Berkeley, USA) and colleagues have observed the real-time dynamics of the energy gap variation in silicon upon electron conduction-to-valence-band transition. With the help of laser pulses, electrons in the sample were excited and synchronous measurements were taken of sample absorption spectra upon exposure to the extreme UV pulses several dozen attoseconds long. The electrons tunneled over to the conduction band because the Keldysh adiabaticity parameter made up $\gamma \approx 0.5$. After the electron excitation, the electron gap narrowed rapidly within the time of ~ 450 as. This narrowing is a purely electronic effect and is due to the scattering of electrons by each other in the conduction band. Then, after 60 ± 10 fs, a strong absorption spectrum alteration was again detected as a result of crystal lattice vibration with a period of 64 fs under the effect of optical phonons born upon electron excitation. The results of the experiment appear to be useful in ultrafast microelectronics.

Source: *Science* **346** 1348 (2014) http://dx.doi.org/10.1126/science.1260311

5. Pulsar timing and the structure of neutron stars

Researchers from Washington University in St. Louis (USA), M G Alford and K Schwenzer, have obtained new data on the composition of neutron stars from the stability analysis of their rotation periods. The question now remains open of whether so-called quark matter is contained in the depth of a neutron star or whether neutron stars contain purely neutron matter. Alford and Schwenzer calculated the amplitude of the *r*-mode of global oscillations of the neutron star shape depending on the star matter viscosity, i.e., on the star's composition. In the presence of quark matter, the *r*-mode damping is stronger and the quadrupole moment is smaller. Hence, the star must radiate less energy in the form of gravitational waves and its rotation must decelerate more weakly. The quantitative verification of this effect made use of the observational data on small-mass X-ray binary stars (systems consisting of a neutron star and an ordinary star) and the data of radio observations of millisecond pulsars. The millisecond pulsar temperature is unknown, but Alford and Schwenzer elaborated the method independent of the temperature data. The researchers concluded that the pulsar timing data agree better with the presence of quark matter inside a neutron star than with a purely neutron composition. It seems likely that in the case of a purely neutron composition, an additional source of damping the *r*-mode oscillations that has not yet been considered is obviously needed.

Source: *Phys. Rev. Lett.* **113** 251102 (2014)
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