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1. Bottomonium $\eta_b(1S)$

Radiative decays of resonances $\Upsilon(3S) \to \gamma\eta_b(1S)$ that create bottomonium $\eta_b(1S)$ in the lowest energy state were identified in the BaBar experiment conducted at the US Department of Energy's Stanford Linear Accelerator Center (SLAC). The family of particles with the quark composition $b\bar{b}$ (bottomonium) was discovered experimentally about 30 years ago [see *Sov Phys. Usp.* **30** (7) 553 (1987)], but the lightest of these mesons, $\eta_b(1S)$, has been detected for the first time. The particles in this family differ in several quantum numbers, including the sum S of quark and antiquark spins. The bottomonium $\eta_b(1S)$ with $2S+1=1$ is a pseudoscalar spin-singlet partner of the $\Upsilon(1S)$ meson. The $\Upsilon(3S)$ resonances were created in e^+e^- collisions at the PEP-II asymmetric-energy storage ring where about 10^8 such particles were analyzed. The state $\eta_b(1S)$ was identified using the peak in the spectrum of photons emitted in transitions of bottomonium from the level $\Upsilon(3S)$ to $\eta_b(1S)$. The significance of the result was about 10σ. The mass of $\eta_b(1S)$ is lower than that of $\Upsilon(1S)$ by approximately 71.4 MeV, which is in good agreement with 'lattice QCD' computations. The difference between the masses of $\eta_b(1S)$ and $\Upsilon(1S)$ is the key quantity for many theoretical calculations and its measured value will help test models of interaction between quarks and will perhaps help establish a more accurate value of the strong interaction coupling constant α_s. Experimenters also estimated the branching fraction for the radiative decay $\Upsilon(3S) \to \gamma\eta_b(1S)$, which was found to be $(4.8 \pm 0.5(\text{stat.}) \pm 1.2(\text{syst.})) \times 10^{-4}$.

Source: http://arXiv.org/abs/0807.1086

2. 'Classical' atom

B Dunning (Rice University, USA) and his colleagues from Oak Ridge National Laboratory and Vienna University of Technology prepared a giant, millimeter-sized potassium atom in which an electron was localized with high accuracy and revolved around the nucleus as a pointlike particle in an almost classical circular orbit. Laser light transferred the atom to a highly excited Rydberg state. Then a carefully tailored series of short electric pulses localized the electron. Localization survived for several orbits of the electron around the nucleus. The size of the electron's orbit reached a record value – approximately 1 mm. Similar quasiclassical systems had been studied earlier [see *Phys. Usp.* **47** 531 (2004)] but the new experiment produced the highest degree of resemblance between the potassium atom and Niels Bohr's planetary model of the hydrogen atom.

Source: *Phys. Rev. Lett.* **100** 243004 (2008),
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3. Structure of liquid water

The crystal structure of water ice is tetrahedral. It was normally assumed that as ice melts, the long-range crystal ordering is destroyed but that on a small scale water molecules mostly stay near the sites of the tetrahedral lattice. A Nilsson at the Stanford Linear Accelerator Center and his colleagues from RIKEN SPring-8 synchrotron and Hiroshima University in Japan and Stockholm University in Sweden conducted a new experiment to study the arrangement of water molecules in liquid water. A powerful X-ray beam from the synchrotron light source excited oxygen atoms and the pattern of ordering of water molecules was studied by recording their radiation with X-ray Emission Spectroscopy and X-ray Absorption Spectroscopy techniques. It was found that the tetrahedral structure can indeed be traced in the arrangement of molecules but that a different, less pronounced type of ordering dominates in a substantial part of the volume. Each type of ordering corresponded to an individual maximum in the radiation spectrum. The first to advance the hypothesis that water possesses two types of ordering, in an attempt to explain the unique properties of water, was Willhelm Conrad Röntgen who discovered X-rays in the late 19th century. The results obtained at SLAC may prove important for microbiology and other fields of science and technology.

Source: *Chemical Physics Letters* **460** 387 (2008),
http://dx.doi.Org/10.1016/j.cplett.2008.04.077

4. Relativistic spin precession in the double pulsar

R P Breton (McGill University, Montreal, Canada) and his colleagues from the USA, UK and Italy carried out a detailed study of the double pulsar PSR J0737-3039A/B. A very small tilt of the plane of orbit relative to our line of sight permitted observation of an eclipsing signal from pulsar A: the signal is absorbed by the magnetosphere of pulsar B. Assuming a simple geometric model of the magnetosphere, it was possible to measure the rate of relativistic precession of the spin axis of pulsar B around the direction of the total angular momentum of the binary system. The obtained estimate corresponds to the predictions of the general relativity and alternative theories of gravity within an uncertainty of 13%; furthermore, this test refers to the range of strong gravitational fields. Relativistic spin precession in a strong field was first measured for the double pulsar PSR B1534 + 12, but the accuracy was lower than that achieved now for PSR J0737-3039A/B.

Sources: Science 321 104 (2008),
http://dx.doi.org/10.1126/science.1159295,
http://arXiv.org/abs/0807.2644

5. Gamma emission from a remote quasar

The ground-based gamma telescope MAGIC recorded Vavilov – Cherenkov radiation from cascades of charge particles created in the interaction between cosmic gamma photons and atoms in the atmosphere. MAGIC recorded a gamma burst from a remote gamma source, the 3C 279 quasar, at a record distance of nearly 5 billion light years from Earth (its red shift is $z \approx 0.536$). The source of this emission is most likely the accreting black hole in the quasar core. Gamma photons are capable of interacting with the intergalactic background radiation; consequently, the fact itself of detecting photons with energies above 50 GeV indicates that for 5×10^9 years the density of background radiation in certain ranges of the spectrum was below the threshold value at which the observed gamma radiation would be absorbed. In turn, background restrictions impose limitations on the characteristics of evolution of galaxies and stars that produce the background radiation. The observation of gamma emission from 3C 279 is evidence supporting the models of evolution with a low density of background radiation. In contrast to the microwave background, low density and strong interference from nearby sources in the Galaxy make it difficult to measure directly the level of the intergalactic background of the stellar origin.

Source: *Science* **320** 1752 (2008),
http://dx.doi.org/10.1126/science.1157087

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