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Physics news on the Internet (based on electronic preprints)

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1. Hyperhydrogen $^{6}_{\Lambda}$H

The FINUDA Collaboration operating at DAΦNE in the Frascati Laboratory (Italy) has reported for the first time the production of hypernuclei consisting of four neutrons, a proton, and a Λ-hyperon. The possibility of the existence of the $^{6}_{\Lambda}$H hypernucleous was predicted in 1963. Two redundant neutrons form a nuclear 'halo'. In the absence of the Λ-hyperon, they would be ejected from the nucleus over a time of 10^{-22} s, but the Λ-hyperon stabilizes ^{5}H, increasing its lifetime to 0.1 ns. $^{6}_{\Lambda}$H nuclei were produced in the accelerator in collisions of K^- mesons with a lithium target in the reaction $K^- + {}^{6}\mathrm{Li} \to {}^{6}_{\Lambda}\mathrm{H} + \pi^+$ and then decayed through the weak channel $^{6}_{\Lambda}\mathrm{H} \to {}^{6}\mathrm{He} + \pi^-$. A search for correlated $\pi^+\pi^-$ pairs was conducted; as a result, three events of the production of $^{6}_{\Lambda}$H were identified in five years among approximately 3×10^7 interactions of K^- with the target. The mass of these nuclei was equal to (5801.4 ± 1.1) MeV, and their binding energy evaluated jointly from production and decay reached (4.0 ± 1.1) MeV (energy of separation into $^{5}\mathrm{H} + \Lambda$). Masses of nuclei found in production reactions are higher by approximately 1 MeV than masses found in decay reactions. This bears evidence to the production of the $^{6}_{\Lambda}$H hypernucleous in the first excited state, the fast transition of the nucleus to the ground state with the emission of a photon (photons were not recorded), followed by decay in the ground state.

Source: *Phys. Rev. Lett.* **108** 042501 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.042501

2. Photon formation length

K Andersen (Aarhus University, Denmark) and his colleagues have studied the effects of finite photon formation length in matter. The NA63 experiment performed at CERN measured the spectrum of radiation emitted by 197-GeV electrons flying across two thin and closely spaced gold foils. After transit, the electrons were deflected in a magnetic field, and the spectrum of the emitted photons was measured by a detector on the beam line. While in the foil, electrons undergo Coulomb interactions with atoms and emit photons as a result of accelerations (bremsstrahlung radiation) with the Bethe–Heitler spectrum (modified by the Landau–Pomeranchuk–Migdal effect in the range of low energies). An individual photon is formed not at a point but over a certain length. A maximum was observed in the emission spectrum around ≈ 0.5 GeV, with the gap between the two gold foils being 45 μm. The phenomenon responsible for this specific feature of the spectrum was the fact that the emission of the photon would start within the first foil but would be completed in the second one. This extension of the formation length of photons beyond the physical limits of the structured target is described by the Ternovskii–Shul'ga–Fomin effect. Calculations using the formalism developed by R Blankenbecler fit experimental data quite well.

Source: *Phys. Rev. Lett.* **108** 071802 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.071802

3. Rate of propagation of quantum correlations

M Cheneau (Max Planck Institute of Quantum Optics, Germany) and his colleagues have measured for the first time the propagation speed of quantum correlations. For some many-body systems, such as spins on a lattice, we are aware of the maximum speed, known as the Lieb–Robinson bound, that limits the propagation speed of quantum information, in analogy to the speed of light in vacuum setting the limit in relativity theory. In their experiment, Cheneau et al. created one-dimensional sequences of ^{87}Rb atoms placed in an optical lattice, one atom per potential minimum. These minima are separated by potential barriers — dark areas of the lattice. Rapid reduction of the barrier height produces quasiparticles — doublons (pairs of particles in one potential well) and neighboring holons (empty vacancies — holes). These quasiparticles were quantum-correlated: if a doublon was observed, this meant that the second particle was a holon, and vice versa. Quasiparticle positions were not fixed — they could tunnel into neighboring potential wells. The fluorescent emission of atoms was monitored through a microscope and the velocities of quasiparticles were measured by recording the time quasiparticles took to move over a specific distance. These velocities were approximately twice the speed of sound in superfluid gas and were always below the Lieb–Robinson bound.

Source: *Nature* **481** 484 (2012)
http://arXiv.org/abs/1111.0776

4. Generation of a magnetic field in shock waves

G Gregori (Oxford University, United Kingdom) and his colleagues have conducted an experiment at the LULI laboratory (France) on the generation of a magnetic field in shock waves. The mechanism of generation was described theoretically by L Biermann (the 'Biermann battery' process). Closed currents emerge in asymmetric shock waves with pressure and temperature gradients, producing a magnetic field as a result. Note that this process requires no seed magnetic fields. In this experiment, powerful laser pulses heated a small carbon rod in a vessel with helium at low pressure. Solenoids recording the magnetic field in three planes (via induced currents) were placed around the rod at a distance of about 3 cm. A microexplosion in carbon produced a shock wave in helium, which was observed by optical means, and 1–2 μs later bursts of the magnetic field of 10–30 G were detected in the shock plane. The experiment simulated the generation of seed magnetic fields by shock waves in the gas which moved in gravitational fields at the early stages of galaxy formation. Despite scale differences,

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these very different conditions obey quantitatively simple scaling relations. Cosmic shock waves could generate seed magnetic fields of up to 10^{-21} G; these galactic fields could be amplified by turbulence acting on timescales of about 700 million years or via the dynamo effect and thus constitute an important factor in galaxy evolution.

Source: *Nature* **481** 480 (2012)
http://dx.doi.org/10.1038/nature10747

5. New data from the Planck telescope

New data collected by the ESA's Planck space radio telescope have been reported at an international astronomy conference in Bologna (Italy). Among other things, a complete (all-sky) map of carbon monoxide distribution in interstellar molecular clouds was produced. The main component of these clouds is molecular hydrogen, which is difficult to detect. Consequently, CO emission is typically used to study molecular clouds in the Galaxy. The existence of a diffuse glow (haze) from regions around the center of the Galaxy, which resembles synchrotron radiation but has a harder spectrum, was also confirmed. The nature of this haze remains unclear. Among the proposed hypotheses are, for instance, those implying the ejecta of supernova explosions and annihilation of dark matter particles. The main task of the Planck telescope is the study of the cosmic microwave background. The observations of the CO emission outlined above and of the diffuse glow are important not only as such but also for the elimination of the noise they create in extracting the cosmic microwave background signal.

Source: http://www.esa.int/esaCP/
SEM0FLYXHYG_index_0.html

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