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Physics news on the Internet (based on electronic preprints)

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1. Pentaquark is found

The LHCb experiment at Large Hadron Collider has revealed with a significance of more than 9σ a pentaquark, i.e., a $c\bar{c}uud$ particle consisting of four quarks and one antiquark. Pentaquarks were identified as intermediate resonant states in $\Lambda_b^0 \to J/\psi K^- p$ decays of baryons Λ_b^0 produced in 7- and 8-TeV pp collisions in the center-of-mass energy units. That the existence of pentaquarks is possible, in principle, was first pointed out by D Strottman in 1979, and the properties of positive-strangeness pentaquarks were predicted by D I Dyakonov, M V Polyakov, and V Yu Petrov in their 1997 papers. Some evidence of the production of pentaquarks with $S = +1$ had been obtained before, but the data turned out to be contradictory. The $c\bar{c}uud$ pentaquark referring to another type (with hidden charm and $S = 0$) was found in LHCb in two states with masses of 4380 MeV and 4450 MeV, and with most probable spin-parity values of $J^P = 3/2^-$ and $5/2^+$, respectively.

Source: http://arXiv.org/abs/1507.03414

2. Network with quantum cryptography

The use of quantum cryptography in distributed networks (i.e., in data packet transmission without preferred communication channels) was impeded by the very low operation rate of the secret-key distribution protocol. A team of researchers headed by S Pirandola (York University, Great Britain) has managed to solve this problem through adapting the continuous quantum-variable method to the case of a network. Within this approach, the sender and the recipient create quantum states, modulate them with a signal having Gaussian distribution, and send them to an intermediate station where signal correlations are measured. Making use of their notes of quantum states and open classical data on correlations, the sender and the recipient decipher the signals, while it is inaccessible to third parties. The authors proposed this scheme theoretically and realized it in their experiment in which, as distinct from quantum entanglement schemes, linear optics appeared to suffice. The information was transmitted 25 km through the 'quantum communication network' at a rate by three orders of magnitude higher than was achieved in previous experiments. With a further increase in the distance, the transmission efficiency falls, but a distance of 25 km is actually enough to exchange quantum-encoded data within a city.

Source: *Nature Photonics* **9** 397 (2015)
http://dx.doi.org/10.1038/nphoton.2015.83

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Translated by M V Tsaplina

3. Beresinskii–Kosterlitz–Thouless phase transition in an ultracold gas

P A Murthy (Heidelberg University, Ruperto Carola, Germany) and colleagues have investigated a quasitwo-dimensional ultracold gas of ^{6}Li atoms in the BEC–BCS crossover regime (transition between the Bose–Einstein condensate and the Bardeen–Cooper–Schrieffer state) to reveal that the crossover has the form of the Beresinskii–Kosterlitz–Thouless phase transition. This became evident from the scale-invariant behavior of the first-order correlation functions in the distribution of atoms. In the experiment, the interatomic interaction force (the scattering length) was regulated by the Feshbach resonance method. The correlation functions turned out to have a power-law form with the exponent depending on temperature only. The increase in the exponent with rising temperature corresponds qualitatively to the Beresinskii–Kosterlitz–Thouless theory. The coherence of the superfluid state was investigated in the fermion region; such studies had been conducted before in 3D systems only. In the presence of density inhomogeneity, the role of phase fluctuations was shown to be significant.

Source: *Phys. Rev. Lett.* **115** 010401 (2015)
http://dx.doi.org/10.1103/PhysRevLett.115.010401

4. Quantum dot spectrometer

J Bao (Tsinghua University, China) and M G Bawendi (Massachusetts Institute of Technology, USA) have designed a simple compact spectrometer based on quantum dots (microscopic single crystals in this case). The spectrometer operation principle rests on the selective response of quantum dots to electromagnetic waves of different frequencies, which allows them to serve as filters. One hundred ninety-five quantum dots differing in size or composition and, accordingly, in spectral properties constituted an array. Each filter of this array covered several CCD-camera pixels, which served as detectors. The spectrometer works by the multiplexing scheme when several spectral regions are measured simultaneously, and then the original signal undergoes computer reconstruction. The spectrometer prototype demonstrated in the experiment overlaps the range from 390 to 690 nm with a resolution up to ~ 1 nm. Owing to the compactness and low cost of the device, the new method of spectral measurement may find application in portable microspectrometers.

Source: *Nature* **523** 67 (2015)
http://dx.doi.org/10.1038/nature14576

5. Supernova of record brightness

S Dong (Peking University, China) and colleagues have discovered a supernova, ASASSN-15lh, which is the brightest of all previously observed ones. This supernova was first registered by an ASAS-SN automated system of small telescopes and was then observed by large optical telescopes and in the UV range by the cosmic telescope Swift. The supernova has a red shift $z = 0.2326$ and its total (bolometric) luminosity makes up 2.2×10^{45} erg s^{-1}, which is about 2.5 times higher than that of the previously brightest supernovae. The spectrum of ASASSN-15lh is close to that of superbright SLSNe-I type supernovae. These supernovae are about 100 times brighter than typical supernovae, and their bursts are three orders of magnitude rarer. However, an exact classification of supernova ASASSN-15lh has been hampered, and the energy release mechanism is unknown. In the two months of observations, the energy released by the supernova was 7.5×10^{51} erg. Such a high value can hardly be explained in the magnetar model. The alternative hypothesis of tidal star destruction by a black hole is also practically excluded because of the absence of hydrogen and helium emission lines.

Source: http://arXiv.org/abs/1507.03010

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