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1. Efimov states

H-C Nägerl of Innsbruck University in Austria and his colleagues have for the first time observed three-particle bound quantum states whose existence was predicted theoretically by V I Efimov in 1970 already [*Yadernaya Fizika* **12** 1080 (1970)] — in a rare example of the complex three-body problem allowing an exact analytical solution. A universal set of low-energy bound states appears for a system of three identical particles with a strong enough resonant two-body interaction. Interestingly, because of the quantum-mechanical nature of this effect, three-particle states can even exist in the absence of two-particle bound states. The size of the three-particle system is much less than the absolute scattering length $|a|$, and the three-particle interactions are universal in character and independent of precisely how two particles interact when close together. The researchers studied in experiment a degenerate gas of caesium atoms held in an optical dipole trap at temperatures between 10 and 250 nK. The scattering length was controlled by a Feshbach resonance and could be varied over a wide range by tuning the external magnetic field. For $a < 0$, the Efimov states were identified by a sharp increase in atomic recombination losses in the trap — presumably due to the three-atom system rapidly decaying from the trimer state to the state involving a deeply bound dimer state plus a free atom. At a temperature of 10 nK, Efimov states appeared when the scattering length reached -850 Bohr radii. Another type of Efimov state appeared for $a > 0$. In this case, recombination losses are much lower and exhibit in their spectrum a recombination minimum due to the destructive interference of the three-particle system's quantum decay channels. The position of the minimum agrees well with theoretical predictions. For $a > 0$, Efimov states arise due to Feshbach resonances in collisions between single atoms and dimers and can be interpreted as a three-body generalization to the Feshbach resonance concept.

Source: *Nature* **440** 315 (2006)
http://arxiv.org/abs/cond-mat/0512394

2. Quantum telecloning

An experiment on 'quantum telecloning' has been conducted for the first time by a team of physicists in Japan and the UK. Unlike 'quantum teleportation', in this case information about a quantum state is transmitted from one sender to two, rather than one, receivers, and the input state is not reproduced perfectly but with some restrictions imposed by Heisenberg's uncertainty principle. Whereas quantum teleportation transfers the state of a particle, what was transmitted in the new experiment was information about the amplitude and phase of a laser beam wave. The beam was reproduced at two remote locations to within 58% — a rather good result considering the theoretical limit of 66% for the reproduction fidelity in such an experiment. Telecloning may have applications in quantum communications and possibly in future quantum computers.

Source: *Phys. Rev. Lett.* **96** 060504 (2006); prl.aps.org

3. A nanomotor

An experiment involving the controlled light-driven rotation of a single molecule has been conducted by a team of researchers from the Netherlands. In this experiment, an asymmetric organic molecule embedded in — and forming central carbon – carbon double bond with — a liquid-crystal film underwent photochemical isomerization from the right-handed form to the left-handed form when irradiated with the 365-nm ultraviolet light and became right-handed again when the light was switched off. Repeating this twice made the molecule rotate through 360° in the bulk of the film. The change in the helical shape of the molecule produced rotation-induced structural changes in the liquid-crystal surface profile. Importantly, small objects placed on the film surface, in particular a glass rod 10,000 times the size of the molecule itself, were forced into rotation as a result.

Source: *Nature* **440** 163 (2006); www.nature.com

4. Polarization of the cosmic microwave background

Analysis of three years of the Wilkinson Microwave Anisotropy Probe (WMAP) data has provided improved values of cosmological parameters and the first reliable information on the polarization of the cosmic microwave background. The WMAP observations covered the entire celestial sphere and were performed with polarization-sensitive radiometers at five frequencies between 23.0 and 94.0 MHz. To filter out radio noises from galactic objects, an analysis of their sources was performed in detail. Microwave background polarization may be due both to primary gravitational waves and to scattering from gas clouds in a later epoch of the first stars reionizing the universe. The new observations have allowed a tight constraint on the primary gravitational wave contribution to be placed and showed that reionization occurred at the redshift $z = 10.9^{+2.7}_{-2.3}$, i.e. much later than previously thought (implying first stars formation in an epoch when the universe was about 400 million years old and not 200 million years). The way the cosmic microwave background fluctuates is best described by a cosmological model in which the Hubble constant is 73 km s^{-1} Mpc^{-1} and ordinary matter accounts for 4% of the total density, while dark matter and dark energy, for 22% and 74%, respectively. It was also shown that the spectral power exponent of the primordial density inhomogeneities that gave rise to galaxies is $n = 0.951^{+0.015}_{-0.019}$, which is somewhat less than the $n = 1$ of Harrison — Zeldovich's flat spectrum. Thus, the WMAP observations have provided further support for those inflation models predicting $n < 1$, while ruling out models with a large contribution from the tensor perturbation mode (gravitational waves).

Source: http://arxiv.org/abs/astro-ph/0603449
http://arxiv.org/abs/astro-ph/0603450

Compiled by *Yu N Eroshenko*

Uspekhi Fizicheskikh Nauk **176** (4) 440 (2006)
Translated by E G Strel'chenko