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1. Brown – Twiss effect for atoms

The Brown – Twiss (intensity) interferometer measures wave intensity correlation between spatially scattered detectors. Brown – Twiss interferometers with two telescopes are usually used in astronomy for measuring star diameters. The first application of such an instrument to atomic optics — specifically to the study of ultracold gases — was made at the University of Tokyo in 1996. Now, C Westbrook and his colleagues from the University Paris-Sud in France and co-workers at the University of Minho in Portugal have markedly improved the measurement procedure to the point where single atoms flying out of a Bose – Einstein condensate (BEC) can be detected on a time scale of a few nanoseconds and at distances less than 200 μm. The team studied the interference properties of magnetically trapped helium atoms evaporatively cooled to about 0.5 μK. The way to eject atoms from the trap was by turning the magnetic field off. It was found that the interference pattern appeared at temperatures above the condensate transition point and disappeared when the gas was cooled and BEC formed. The apparent paradox of a coherent source failing to produce an interference pattern is explained by the quantum correlation of the BEC atoms and by the way the intensity interferometer operates. The experiment examined the dependence of the magnitude of the effect on the size of a helium gas cloud and provided a full 3D picture of the correlations observed.

Source: http://arXiv.org/abs/cond-mat/0508466

2. Molecular Bose – Einstein condensate

In recent years, molecular Bose – Einstein condensates have been created in which weak atomic binding in molecules occurs in the vicinity of the Feshbach resonance. Now, K Winkler and his colleagues at the University of Innsbruck in Austria have used the photoassociation technique to create a Bose – Einstein condensate of rubidium, whose molecules are in the ground state and bound strongly. The key difficulty with photoassociation is that the molecules turn out to be destroyed (dissociated) by the same radiation creating them. To get around this, the researchers used an approach akin to the induced transparency technique familiar from optics. Radiation from a sapphire laser caused condensate molecules to form in an excited quantum state, and a diode laser, of a different frequency and lower power, transferred them to the ground state, making them immune to the destructive action of the first laser radiation. In this way, about 100 Rb_2 molecules were created in a condensate containing a total of 4×10^5 Rb atoms. The molecular detection technique relied on the absorption spectrum of the molecules. Changing the emission range of the diode laser led to a resonance at the transition frequency between the excited and ground states of the molecules.

Source: http://arXiv.org/abs/cond-mat/0505732

3. Observation of the Casimir – Polder effect

The Casimir – Polder effect consists in the attraction of an atom to a flat surface and, like the ordinary Casimir effect, is due to the change in the spectrum of zero-point fluctuations in a vacuum. The Casimir – Polder effect has been observed in a number of experiments with ultracold gases. However, due to sensitivity limitations, measurements were only made at a very small distance (~ 0.1 μm) from the surface — the region where van der Waals forces are also very strong. D M Harber and his colleagues at the University of Colorado in Boulder and JILA have employed a new technique to investigate the Casimir – Polder effect at a distance of $\simeq 5$ μm from the surface of a dielectric. The team studied the mechanical oscillations of a cloud of Bose – Einstein condensate of ^{87}Rb atoms, located close to the specially treated flat surfaces of sapphire or silicon dioxide. Metal surfaces, although more preferable, were of no use because of surface defects and their associated disturbing electric fields. By changing the magnetic field in the trap one can vary the cloud-to-surface distance, and by applying a short duration pulse, to cause the condensate to oscillate. The presence of a gradient in the Casimir – Polder force leads to a shift in the oscillation frequency, whose measured value was found to vary with the distance from the surface much in the way predicted by theoretical calculations [M Antezza, L P Pitaevskii, and S Stringari, *Phys. Rev.* **A70** 053619 (2004)]. A spin-off of the Colorado experiment is a limit on the way in which Newton's force of gravitational attraction at small distances can be modified (the Yukawa potential being an example). This limitation is less restrictive than those obtained in other experiments, but serves as an independent confirmation.

Source: *Phys. Rev.* **A72** 033610 (2005);
http://pra.aps.org

4. Curvilinear motion of a soliton

A computer simulation experiment by N N Rosanov, S V Fedorov, and A N Shatsev of the Research Institute for Laser Physics in St.-Petersburg has revealed the possibility that a dissipative soliton can follow a curvilinear trajectory in its motion. The condition for this is asymmetry in the distribution of the field which forms the soliton and the energy flows into and out of it. The system studied was that of several vortex solitons described by nonlinear equations in the Ginzburg – Landau form. A detailed study was made of a pair of strongly coupled solitons interacting with other solitons. It was found that the complex of solitons not only rotated but its center of mass also moved along a curvilinear trajectory. It is believed that using laser radiation in an active

Uspekhi Fizicheskikh Nauk **175** (10) 1038 (2005)
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optical medium may be a way to reproduce these theoretical findings in a real-life experiment.

Source: *Phys. Rev. Lett.* **95** 053903 (2005); http://prl.aps.org

5. Cosmic deuterium

A Massachusetts Institute of Technology's Haystack Observatory team led by A Rogers has detected radio emission from deuterium in space for the first time. Deuterium is difficult to observe due to its small amount and because its spectral lines are close to those of hydrogen. Registering deuterium is of great interest for the theory of nucleosynthesis in the early Universe because its amount is a sensitive indicator of physical processes taking place during nucleosynthesis. In particular, by knowing the amount of deuterium, the average density of baryonic matter can be evaluated, thus providing a more accurate estimate of the amount of dark matter (or unseen mass) in the Universe. Further data accumulation and analysis will allow more accurate determination of these quantities.

Source: http://web.mit.edu/newsoffice/

6. The hyperfast pulsar

Measurements with the National Science Foundation's Very Long Baseline Array (VLBA) radio telescope have yielded the parallax and angular speed of the pulsar B1508+55, allowing the model-independent calculation of its distance from the Earth (2.4 kpc) and proper speed of motion (1100 km s^{-1}). The pulsar B1508+55 is thus the fastest one known and will necessarily leave the Milky Way Galaxy in the future. Measurements in the frequency range 1.4 – 1.7 MHz were made in eight series at 3-month intervals. From the rate of decrease in its pulse period, the age of the pulsar was found to be 2.34×10^6 years. The present distance of the pulsar from the disk of the Galaxy is about 2 kpc, but given the direction of its motion it is concluded that the pulsar was born in a disk near an OB type star association in the constellation Cygnus. How the pulsar has been accelerated to 1100 km s^{-1} is not yet known. Of several mechanisms proposed to explain high pulsar speeds, the most likely one is an asymmetric supernova explosion, but even this mechanism needs improvement when it comes to speeds in excess of 1000 km s^{-1}.

Source: http://www.nrao.edu

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