

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

1. Bose – Einstein condensation of hydrogen atoms

D Kleppner, T Greytak and their collaborators at MIT for the first time produced a Bose – Einstein condensate (BEC) of hydrogen atoms. The condensate forms at low temperatures due to particle accumulation in the zero-momentum zero-energy state. While BEC has been achieved for alkali atoms over the last few years, the ultraviolet nature of the transition between the 1s and 2s hydrogen states poses large technical challenges when it comes to this simplest element because no UV laser generators are available for working with atoms. As a way out, a modified evaporative cooling technique was employed in which ultralow temperatures result from high-energy atoms being driven out of the trap by an alternating electromagnetic field. To investigate the condensate, complex spectroscopic techniques involving two-photon transitions were used in which an atom absorbs two photons simultaneously, each having half the transition energy; the reverse 2s-to-1s transition then produces the UV photon which is detected. Since the atom is not isolated, the transition frequency depends on the atomic gas density. A sharp shift in frequency signals the formation of a dense BEC. The transition to the BEC state occurs at 40 μK, with the number of condensed atoms reaching 10^8. In the course of the study a narrow beam of condensate-ejected atoms was obtained, expected to be useful in 'atomic laser' applications.

Source: *Physics News Update*, Number 382
http://www.hep.net/documents/newsletters/pnu/pnu.html#RECENT

2. A liquid helium analogue of the Josephson effect

The ordinary Josephson effect arises at the junction of two superconductors separated by a very thin insulating layer. The electric current through the junction is due to Cooper pair tunneling and is determined by the wave function phase gradient. When the junction is under a dc voltage, the current shows sinusoidal oscillations (non-steady-state Josephson effect). This phenomenon underlies the working of high precision measuring devices known as SQUIDs. In 1997, J C Davis and his colleagues at the University of California observed an analogue of the Josephson effect in their liquid helium experiments in which a 50-nm-thick membrane with thousands of 100-nm-diameter holes in it played the role of a Josephson junction. When subjected to pressure (the analogue of voltage), the helium atoms oscillated rapidly through the membrane. In the team's recent experiments, not only the oscillations but also the dc component of the atomic current through the membrane was studied. As is the case with superconductors, for each value of pressure (voltage) there is a corresponding Josephson frequency. As the Josephson frequency approaches a resonant mechanical frequency of the liquid helium chamber, a large increase in the constant component of the flow is observed. The work shows that liquid helium analogues of squids are in principle possible, which may be useful in detecting very weak vibrations, among other things.

Source: http://publish.aps.org/FOCUS/

3. X-ray laser

The possibility of creating a superpower x-ray laser was demonstrated both experimentally and theoretically in the collaborative work of SLAC and a number of other institutes, including the Russian Research Centre 'Kurchatov Institute'. As of now, the SLAC prototype of such a laser can only function at infrared frequencies. The radiation is produced in a 2-m ondulator through which a 18-MeV electron beam is passed. The laser gain reaches a value of 300,000, a record high in the IR. Although experiments are limited to IR, in the x-ray case the same physical principles and design approaches are expected to be valid. The only difference will be in the scale of the device, in which a 100-m-long ondulator and a SLAC-produced 15-GeV electron beam will be involved. The x-ray laser, expected to be completed by 2005, will have a pulse duration of 100 fs and a peak intensity 10^{10} times that of currently available x-rays sources. A coherent x-ray source of such power holds vast promise for material structure and atomic process studies.

Source: http://www-leland.stanford.edu/dept/news/newsfs.html

4. Galaxy clusters

MS1054-0321, an unusual, very massive cluster of galaxies has been investigated by American scientist M Donahue using data from space x-ray and ground-based optical telescopes. The cluster, consisting of several thousands of galaxies, is 8×10^9 light years from Earth and contains a large amount of very hot intergalactic gas. That such massive and well structured galaxy clusters existed as early as 8×10^9 years ago is an unexpected result because in the plane universe models popular with cosmologists, the large-scale structure forms rather slowly and such clusters should therefore appear much later in time. Thus, Donahue's investigation favours the open model of the universe, in which the density of matter is below the 'critical value' and no change from extension to compression can occur.

Source: http://www.stsci.edu/

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Uspekhi Fizicheskikh Nauk **168** (9) 1036 (1998)
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