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Physics news on the Internet (based on electronic preprints)

1. Electron orbitals

Standard X-ray diffraction techniques yield only the averaged distribution of atoms in a crystal lattice. By combining electron diffraction and electron microscopy, J M Zuo and colleagues at Arizona State University were able to visualize the shape of individual electron orbitals (the electron density distribution around atoms). The 3D map so obtained shows that Cu – Cu bonds in red oxide of copper (Cu_2O) are of covalent character and formed by d-orbital electrons and by holes. The study is likely to provide further insight into high-temperature superconductivity and to speed up the development of new superconductors.

Source: http://www.nature.com
Nature **401** 49 (1999)

2. Optical parametric amplifier

In their experiments on infrared image amplification, P Kumar and his colleagues at the Northwestern University in Evanston, IL used a potassium titanyl phosphate (KTP) crystal to avoid noise problems that typically plague the operation of conventional amplifiers. Green laser photons produce IR photon pairs when passing through a crystal, and if the infrared image of an object is simultaneously projected onto the crystal, the laser beam will stimulate the production of additional IR photon pairs, which will join forces with the initial ones to amplify the image. This 'optical parametric amplification' technique may find useful applications according to its authors, despite the challenge of synchronizing the laser light and IR photons of an image source to obtain the stimulated emission.

Source: http://publish.aps.org/FOCUS/
Phys. Rev. Let. **83** 1938 (1999)

3. Fermi degenerate atomic gas

In the past few years researchers have succeeded in producing a Bose degenerate atomic gas (Bose – Einstein condensate) of some alkali metals and hydrogen atoms by descending to low enough temperatures for the average distance between atoms to be comparable to their de Broglie wavelength. As compared to bosons, fermions are much harder to cool, however, because the Pauli exclusion principle makes atoms in identical states effectively repel one another thus disabling the evaporative cooling method. Researchers at the National Institute of Standards and Technology in Colorado, USA were able, for the first time, to overcome this difficulty and prepare a degenerate Fermi gas of atoms. In their experiment, ^{40}K atoms with opposite spins were first accumulated in a magneto-optical trap and then subjected to an alternating electromagnetic field; as a result, atoms of one spin orientation left the trap thus carrying away energy and cooling to superlow temperatures the opposite-spin atoms still in the trap. With this technique, a degenerate gas of 700,000 atoms at about 300 nK was prepared.

Source: http://www.hep.net/documents/newsletters/pnu/pnu.html#RECENT
Physics News Update, Number 443
Science **285** 1703 (1999)

4. Chandra X-ray Observatory

The Chandra X-ray Space Observatory, so named in honor of the Nobel laureate S Chandrasekhar, has yielded important data while still at its initial testing and tuning stage following the 23 July 1999 launch. Chandra's two X-ray instruments, each a two-in-one device consisting of an imager and a spectrometer, far exceed all previous instruments in sensitivity and resolving power. Directed at the remnants of Cassiopeia A supernova (which exploded about 300 years ago and strangely enough remained undetected by astronomers of the time), Chandra discovered a previously unobserved neutron star left behind by the explosion. Among other findings, a jet from the core of a faraway quasar and a hot stellar corona are noteworthy. As work goes on, many other interesting observations are likely to be made.

Source: http://www.ssl.msfc.nasa.gov/default.html

5. The Hubble constant

The Hubble images of Cepheid variable stars in faraway galaxies have lead to an improved extragalactic distance scale and a more accurate value of the Hubble constant H_0. From the known period – luminosity dependence of long-period Cepheids, their absolute stellar magnitudes and hence photometric distances can be determined. Data on 25 Cepheids within 25 Mpc of the Earth have allowed a number of secondary distance determination methods using the Tully – Fisher relation, type Ia supernovae, etc. to be more accurately calibrated. In adding the velocities of a local galaxy group relative to close clusters and a local supercluster of galaxies, a linear model was employed. The least-mean-squares fitted result is $H_0 = 71 \pm 6\ \text{km s}^{-1}\ \text{Mpc}^{-1}$, the largest contributor to its uncertainty being the distance to the Large Magellanic Cloud, with more than 1000 known Cepheids.

Source: http://xxx.lanl.gov/abs/astro-ph/9909260

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