Atomic, Molecular, and Optical Science

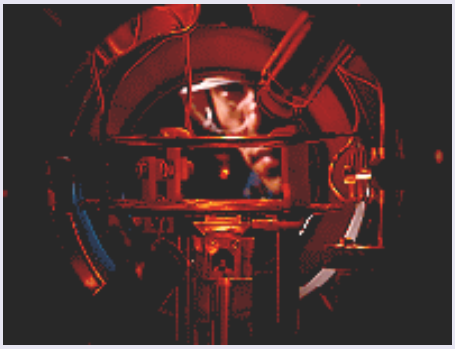
Addressing Fundamental Questions and National Needs

1. Using Light to Cool, Confine, and Position Atoms

- Traditionally, even the tiniest objects are held and moved by mechanical means.
- It is now possible to use light to control microscopic objects without physical contact.
- Manipulation with light permits the cooling, confining, and positioning of atoms with astonishing precision.

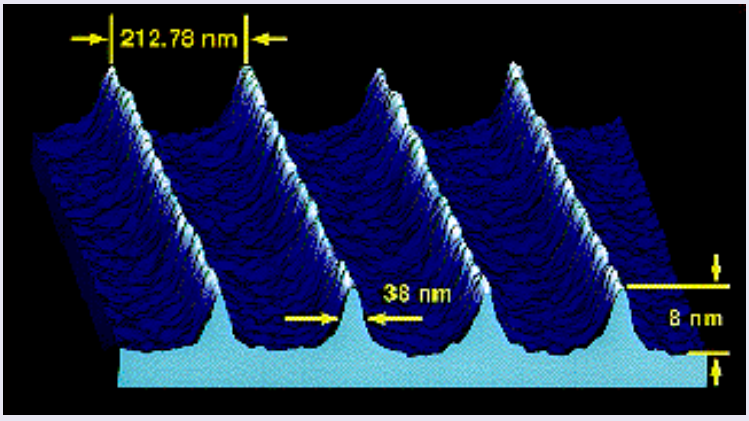
Trapping Atoms with Light

The glowing yellow ball is a gaseous cloud of about 10 million sodium atoms, held in place by light, at a temperature of –474 °F. This temperature is about a thousand times colder than that of superfluid helium and just one-thousandth of a degree above absolute zero.



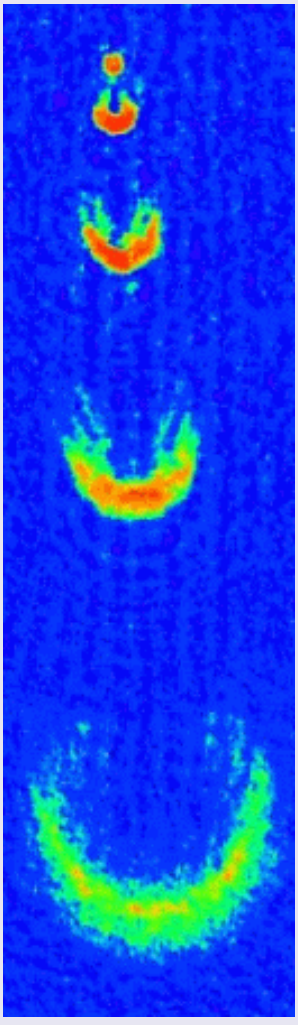
Lithography Using Laser-Guided Atoms

Pictured here are long columns of atoms that are about 100 atoms wide. Such "nanowires" are about ten times smaller than the smallest feature on a typical computer chip. To make this structure, a patterned sheet of laser light just above the surface was used to focus a beam of atoms. The entire image is about a thousand nanometers (nm) across, roughly 1/100 the size of a human hair.



The Coldest Matter in the Universe

This false-color image shows droplets of Bose-Einstein condensate emitted by a recently invented "atom laser". The largest droplet is just over 1 mm in diameter. Bose-Einstein condensates are the coldest matter ever created. They form by evaporation of laser-trapped atoms, much the same process that cools a hot cup of coffee. Ultracold gaseous condensates are of fundamental scientific interest because they are about a thousand times colder than atoms in a typical laser trap (see above left) and exhibit unusual quantum properties similar to those seen in superfluidity.



This is one in a planned series of one-page handouts based on the National Research Council report *Atomic, Molecular, and Optical Science: An Investment in the Future* (National Academy Press, Washington, D.C., 1994). For more information on this report, look on the World Wide Web at http://www.nap.edu/readingroom/books/amo or contact the NRC Board on Physics and Astronomy on the Web at http://www.nas.edu/bpa, by email at bpa@nas.edu, or by telephone at 202-334-3520.