Scientists work to squeeze atoms

January 4 2006

Like bakers measuring the exact same amount of flour every time they made bread, physicists at The University of Texas at Austin have used a laser trap to consistently capture and measure the same small number of atoms.

Dr. Mark Raizen, Sid W. Richardson Foundation Regents Chair in Physics, and his colleagues at the Center for Nonlinear Dynamics have been able to repeatedly capture as few as sixty atoms in a box made of lasers.

They report their work in the Dec. 30, 2005 issue of *Physical Review Letters*.

Raizen's ability to measure atoms with great accuracy places scientists one step closer to assessing and controlling single atoms and realizing quantum computing. Quantum computers will use the power of atoms to store information and make ultra-fast calculations.

Raizen's work is also the beginning of a new field--quantum atom statistics.

"Some work closes a chapter on a problem in science, and some work opens a new chapter," says Raizen. "I view this as opening a new chapter because the study of quantum statistics of atoms has enormous potential for future discoveries."

Raizen and his colleagues created what's called a squeezed number state, where the number of atoms captured in a laser trap was held nearly constant. To reach the atomic number squeezing, the physicists made a box out of sheets of laser light. The laser box had no top--just four sides and a bottom--and held a fixed number of atoms like a cup holding ping-pong balls.

"Suppose we have a trap that works like a cup," explains Raizen, "and I start putting ping-pong balls in the cup. I reach a point where I can't put any more balls in without them spilling over. So there's a hard cut-off on the number that can fit in the cup. That's the mechanism we use, only our cup is made out of light."

The other difference, of course, is that Raizen and his colleagues used atoms instead of balls.

In the reported set of experiments, a cloud of Rubidium-87 atoms was trapped and super-cooled into a Bose-Einstein condensate so that they would occupy the ground state of the trap. A Bose-Einstein condensate is a new state of matter that is reached near the absolute zero of temperature, -459.67 Fahrenheit, and typically holds about one million atoms.

To decrease the atom number to as few as sixty atoms, the researchers very slowly lowered the sides of their laser box, which was about two micrometers (two millionths of a meter) across, and the atoms fell out over the lip.

"Every time we lowered the lip a little more, some atoms left the box until finally we reached the level we were happy with and we counted," says Raizen.

The researchers were able to repeatedly trap and count close to the same number of atoms each time with great accuracy, and Raizen says these are "the first measurements of quantum atom statistics by counting atoms." The small remaining fluctuations in number could be accounted for by taking into account small changes in the laser box's dimensions.

Raizen has dubbed the new concept of the Bose-Einstein condensate leaking out over the top of the trap "quantum evaporation," because the atoms escaped the laser trap like water molecules evaporating out of a glass.

Since the publication of the paper, Raizen says that he and his colleagues have been able to accurately measure and trap as few as twenty atoms. They are aiming for one or two by making the box even smaller.

Source: University of Texas at Austin