Trapping cold atoms in microwave webs

Dramatic progress in the use of laser light along with various combinations of magnetic and electric fields to cool and trap neutral atoms has opened the possibility of studying exotic forms of matter.

For example, theorists have postulated that a gas of hydrogen atoms at high enough densities and low enough temperatures may undergo a transition known as Bose-Einstein condensation. The result would be a peculiar substance – unlike any known form of matter – in which a large fraction of the atoms are in the same quantum state.

Now, researchers have demonstrated that microwave radiation can trap neutral cesium atoms. The success of this particular type of atomic trap offers the possibility of capturing sufficiently large numbers of hydrogen atoms at temperatures near 1 microkelvin to achieve Bose-Einstein condensation.

Physicists Isaac F. Silvera and M.W. Reynolds of Harvard University and their collaborators at the National Institute of Standards and Technology in Gaithersburg, Md., report their results in the May 16 PHYSICAL REVIEW LETTERS.

According to quantum mechanics, particles come in two varieties. Fermions – which include electrons, protons, and neutrons – have spins measured in fractions of a quantum unit. Bosons, which include photons and certain atoms such as hydrogen, have whole-number spins.

Whereas no two interacting fermions can occupy the same quantum state, no such restriction limits bosons. Therefore, a sufficiently cold, dense collection of bosons, losing their individual identities, should undergo Bose-Einstein condensation to a single quantum state.

For more than a decade, physicists have struggled to create this state, and various groups throughout the world have tried different methods of chilling and capturing hydrogen atoms. These efforts have so far proved inadequate for achieving Bose-Einstein condensation.

In a test of a new approach, Silvera and his coworkers load neutral cesium atoms cooled to approximately 4 microkelvins into a small spherical cavity machined from steel. The slowly moving cesium atoms fill a trap defined by a web of laser light and magnetic fields at the cavity's center. This trap is then switched off and replaced by a new magnetic field and microwaves of a certain frequency, which keep the atoms in their lowest-energy spin state.

"You find that the atoms don't escape," Silvera says. "We've demonstrated that the microwaves can actually confine atoms and work as a new type of trap. We want to do it for atomic hydrogen now."

– *I. Peterson*

The social brain: New clues from old skull

Phineas Gage died in 1861, about a dozen years after surviving a horrifying accident in which an iron rod hurtled through his face, skull, and brain. More than 130 years later, brain imaging techniques have provided a new look at Gage's wounds that adds to emerging evidence on how the brain's frontal lobes facilitate social decision making and a sense of responsibility toward others.

"The damage involved left and right prefrontal [areas] in a pattern that, as confirmed in Gage's modern [brain-damaged] counterparts, causes a defect in rational decision making and the processing of emotion," argue Hanna Damasio, a neurologist at the University of Iowa Hospitals & Clinics in Iowa City, and her colleagues.

The 25-year-old Gage envisioned no such contributions to science in 1848 as he directed the controlled blasting of uneven terrain in Vermont prior to the laying of new railroad tracks. He mistakenly triggered one explosion before an assistant had covered the strategically placed explosive powder with a buffer of sand; the force of the blast threw a 3½-foot-long tamping iron through his head.

Remarkably, Gage regained consciousness almost immediately and walked away from the site with the help of his work crew. Although he remained as able-bodied and intelligent as before the accident, his personality changed irrevocably. Formerly a top-flight worker and popular with peers, Gage began to behave in irresponsible ways. He refused to honor commitments on the job and with friends. He offended others with his sudden tendency to sprinkle profanities throughout his conversation and to otherwise depart from social conventions of the time.

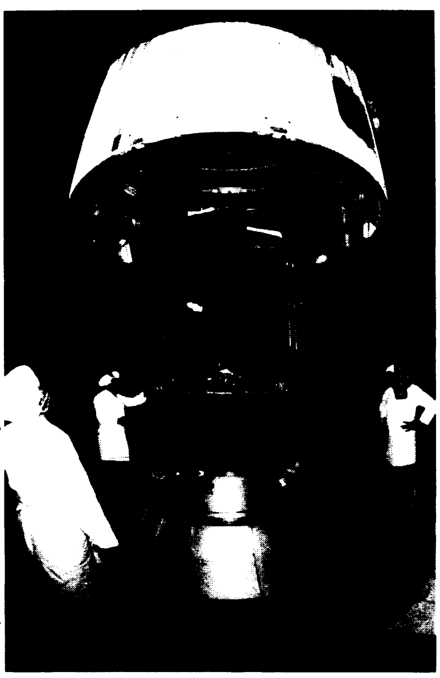
Gage lost his job soon after the accident

Clementine's spin may cancel asteroid visit

Lost and gone forever? Not quite, but the Clementine spacecraft isn't likely to keep an August date with the near-Earth asteroid 1620 Geographos.

A computer problem 2 weeks ago set the craft spinning at 80 revolutions per minute (rpm), says mission manager Lt. Col. Pedro L. Rustan of the Defense Department's Ballistic Missile Defense Organization in Arlington, Va. Engineers can probably slow the spin to 30 rpm, but that would still be too fast to image the asteroid clearly, Rustan says.

Clementine, originally scheduled to pass within 100 kilometers of Geographos on Aug. 31, would have been the first craft to photograph a near-Earth asteroid.



BMDO/Naval Research Laboratory

Clementine spacecraft before launch.

Ironically, the glitch occurred just after the joint military-NASA mission got a last-minute reprieve. Acting under congressional pressure, the Pentagon came up with the $3.2 million needed for the craft to continue on to Geographos after its just-completed moon-mapping mission.

DOD didn't want to pay for the asteroid visit because the flyby deals more with astronomy than military testing, Rustan says. He notes that the department has given less attention to the astronomical parts of the mission. "I feel a lot like a neglected stepchild."

NASA has given little publicity to the low-cost project – in part, apparently, because of the perceived taint of a project that has its origins in the Stars Wars program.

Though Clementine carries 23 new devices, the malfunction occurred in the flight-proven main computer. During a brief communication loss with the ground, the computer accidentally directed four attitude control thrusters, which help steer Clementine, to fire. This emptied the propellant from one of two fuel tanks and set the craft spinning.

Plenty of fuel remains in the other tank, which powers the main engine. But even if scientists can use this engine to slow the spinning to 30 rpm, the probe could take only blurry images of the asteroid and would have trouble even pointing at the rocky body. Clementine may not get any closer to Geographos than several thousand kilometers.

Rustan says his team will try instead to steer Clementine toward Earth's radiation belts. If they succeed, this should further test the durability of the craft's miniaturized detectors. – *R. Cowen*