Physics 'Holy Grail' Finally Captured

A team of physicists in Colorado has done something really cool.

The scientists chilled rubidium-87 atoms to a temperature of 170 nanokelvins, then watched them coalesce into a Bose-Einstein condensate—a state of matter predicted over 70 years ago but never observed until now.

For 15 years, groups around the country have been striving to create such a condensate. The team that finally succeeded included Eric A. Cornell of the National Institute of Standards and Technology, Carl Wieman of the University of Colorado, and their colleagues at the Joint Institute for Laboratory Astrophysics (JILA), all in Boulder. They report their finding in the July 14 SCIENCE.

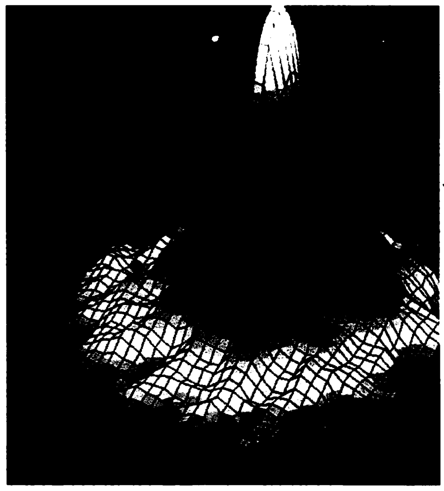
In 1924, Albert Einstein and Indian physicist Satyendra Nath Bose independently predicted that at sufficiently low temperatures, atoms in a dilute, noninteracting gas would condense to the point where they fall into the same quantum state, essentially behaving like a single atom.

Similar conditions prevail in a laser, where photons travel in a coordinated way, generating a coherent light beam. The existence of the atomic condensate opens up the possibility of creating the "atom equivalent of a laser" one day, says Steven Chu of Stanford University, a pioneer in the field.

Cornell's group coaxed the atoms into forming the condensate with a kind of tag-team approach, using two proven techniques. First, by trapping the atoms in a pattern of interfering light waves woven by a system of six lasers, they dropped the temperature to a frigid 20 microkelvins.

Then, with the laser trap switched off, they turned on a magnetic trap that allowed the warmer atoms to escape, taking their excess energy with them.

Along the way, the group developed a magnetic trap that reined the atoms in for a longer time.



Mike Matthews/University of Colorado

Three-dimensional image of the atomic velocity distribution just after the appearance of the Bose-Einstein condensate.

The condensate eventually reached a record low of 20 nanokelvins. Images displaying the atoms' velocities began to show a clear peak around zero, indicating a stationary cluster of atoms. When the team removed the magnetic trap, Cornell says, the condensate fraction retained its original elliptical shape, while the uncondensed atoms spread out.

"It wasn't some sort of thermal effect," Cornell says. "It was very consistent with it having a single wave function that has particular properties."

Although many people have been trying to create a Bose-Einstein condensate, no one was sure what they would see once they achieved it.

"When I saw the results, they were breathtaking," said Daniel Kleppner of the Massachusetts Institute of Technology, whose group first developed magnetic cooling techniques. "It's rare that one finds an important new phenomenon which is really so vivid. When you saw it, you just had to believe it—like someone came out ringing a loud bell."

The JILA group plans next to perform spectroscopy on the condensate to see which wavelengths of light it absorbs. "There are six or seven recent theoretical papers about how light should interact with the condensate, and they don't all agree," Cornell says. "We're going to go in and sort that out experimentally."

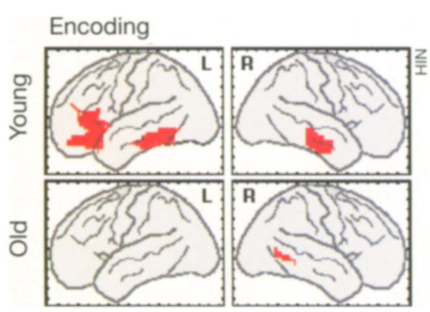
The race may be won, but the work is far from over. — *C. Wu*

Brain scans hint why elderly forget faces

As we age, phone numbers elude us, details of that unforgettable summer dim, and new faces don't leave a lasting imprint. Researchers aren't sure whether this age-related forgetfulness results from difficulty in creating memories, retrieving them, or both.

Now, a study examining which areas of the brain bustle with activity during the memorization of faces indicates that older brains may indeed have trouble building, or encoding, memories. During encoding, the study revealed, a number of memory-associated brain regions that jump into action in young people lie dormant in older ones.

"I think these data provide a lot of support for the encoding deficit hypothesis of aging. It seems like the information never gets in to begin with," says Cheryl L. Grady of the National Institute on Aging in Bethesda, Md. Grady, along with NIA colleagues and researchers from the National Institute of Mental Health, also in Bethesda, report their data in the July 14 SCIENCE.



Younger people show more intense brain activity (red) than the elderly when trying to memorize a face.

Grady's group conducted the study with a scanning technique called positron emission tomography (PET). PET can pinpoint brain regions to which large amounts of blood are flowing—an indication that those areas are active.

Grady and her colleagues worked with two groups of 10 volunteers each, one group with an average age of 25 years, the other 69 years. The researchers took PET scans as the subjects viewed 32 unfamiliar faces for 4 seconds each. After 15 minutes or so, the researchers obtained PET scans while each volunteer looked at faces from the earlier session paired with "distracter" faces and chose the ones he or she recognized.

The young group recognized significantly more faces than the elderly group. PET scans of the younger subjects showed that several regions in the brain flared into activity during memorization. Among those areas was the hippocampus, which some investigators suggest plays a crucial role in encoding. In contrast, PET scans of the elderly participants showed no elevated activity in areas linked to the encoding process, says Grady.

The images of the older brains resemble PET scans of people trying to memorize something while occupied with another task, notes Fergus I. M. Craik of the University of Toronto. Both groups of people may "lay down records of things they want to learn in a less effective way," he says. — *J. Travis*