Creating, cooling, trapping francium atoms

At number 87 in the periodic table, francium is the least stable of the first 103 elements. Typically found in trace amounts in uranium deposits, francium atoms decay rapidly into lighter elements.

Now, researchers have not only created but also, for the first time, slowed down and captured francium atoms in a glass bulb, holding them in place with a web of magnetic fields and beams of precisely tuned laser light. Such accumulations of francium set the stage for detailed studies of the atomic characteristics of this rare radioactive element.

Luis A. Orozco, Gene D. Sprouse, and their coworkers at the State University of New York at Stony Brook reported the team's findings at an American Physical Society meeting held last week in Indianapolis.

"We're very excited about what we have achieved," Orozco says.

Francium atoms can serve as miniature laboratories for probing interactions between electrons and quarks, which make up the protons and neutrons of the nucleus. These subtle effects are enhanced in the heavy nuclei of atoms such as francium.

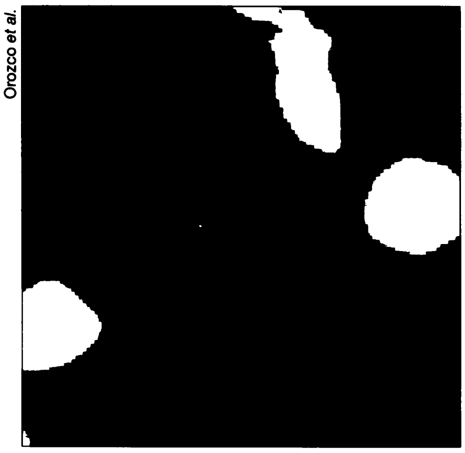
Applying techniques similar to those used earlier to capture radioactive rubidium atoms (SN: 5/7/94, p. 303), the researchers produced francium by hurling oxygen-18 atoms at a gold target heated almost to its melting point. Collisions between gold and oxygen nuclei created atoms of francium-210, which has 87 protons and 123 neutrons.

Diffusing to the surface, these newly generated nuclei escaped from the gold target as ions and were then focused electrically into a beam (see diagram). Later neutralized, the atoms were sent into a glass bulb, where they bounced back and forth between the container's specially coated walls, losing energy with each bounce. An array of six laser beams at a wavelength of 718 nanometers, together with a magnetic field, captured slowly moving atoms to form a cluster at the trap's center.

Orozco and his team generated about 1 million francium-210 ions per second and held 1,000 or more atoms at a time in their trap. Although the atoms remained in the trap for only about 20 seconds before decaying or escaping, a steady stream of fresh atoms replaced those lost, keeping the number of trapped atoms roughly constant for minutes or longer.

Enough francium was trapped that a video camera could capture the light given off by the atoms as they fluoresced (see image). The atoms appeared as a glowing sphere about 1 millimeter in diameter. "This was the very first time that anyone had ever seen the fluorescence from francium," Orozco says.

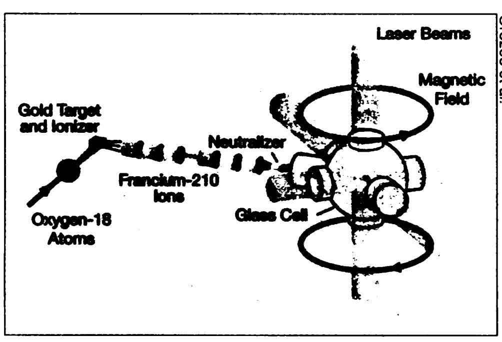
The researchers can now make extremely sensitive measurements of the light emitted and absorbed by the trapped atoms, providing the first experimental results on various transitions between atomic energy levels in francium. Initial measurements show very good agreement between experimental values and calculations based on quantum theory, Sprouse says.



Orozco et al.

False-color image of light emitted by a blob of about 10,000 francium atoms (middle) in a laser trap. Large colored features surrounding the small central blob represent reflections from surfaces of the glass apparatus containing the atoms.

Such high-precision atomic data are necessary for later detecting the tiny influence of the weak nuclear force on the behavior of electrons bound to an atom. *— I. Peterson*



Orozco et al.

Schematic diagram illustrating how francium ions are created, then focused, neutralized, slowed down, and trapped in a glass bulb.

DNA from dinosaurs: Impossible dream?

Molecular biologists have been tripping over each other in recent years in the race to retrieve samples of DNA from dinosaur bones and other fossils. Now, new research challenges these claims of finding ancient DNA.

Molecules of DNA fall apart after a few thousand years and are unlikely to have survived from the time of the dinosaurs, more than 65 million years ago, report Hendrik N. Poinar of the University of Munich and his colleagues. "The prospects of retrieving DNA sequences from dinosaur fossils seem bleak," the scientists report in the May 10 SCIENCE.

Poinar and his coworkers describe a quick, simple test that reveals whether DNA in old samples has degraded or been contaminated by modern genetic material. Their technique focuses on amino acids—the building blocks of proteins—which come in right-handed and left-handed forms.

Most organisms build proteins using only left-handed amino acids, known as L-enantiomers. After death, a chemical reaction called racemization changes L-enantiomers into right-handed D-enantiomers until a balance is reached.

The racemization reaction for one amino acid—aspartic acid—proceeds at about the same rate as DNA degradation. Scientists can therefore use aspartic acid's ratio of D- to L-enantiomers as an independent means of authenticating DNA extracted from old samples, proposes Poinar's group. If extensive racemization has occurred, the original DNA will have deteriorated. In such cases, any DNA extracted from a sample must come from a modern contaminant, say the scientists.

To test their idea, Poinar and his colleagues examined 26 archaeological remains, including a 27,000-year-old horse from Alaska and a 4,500-year-old human leg from Egypt. In all specimens known to contain ancient DNA, less than 10 percent of the aspartic acid had shifted from the L form to the D form. Researchers could not obtain reliable DNA samples from remains in which the D-enantiomer reached more than 10 percent.

Poinar's group then used the technique to assess fossils that had purportedly yielded ancient DNA. In the much-publicized case of a dinosaur from Utah, they found that D-enantiomers in aspartic acid had reached 21 percent, casting further doubt on the authenticity of DNA from this sample (SN: 12/2/95, p. 373).

Laboratory tests suggest that DNA should break up within a few thousand years in warm climates and 100,000 years in cold regions. Poinar's group found one environment that may preserve DNA for millions of years, however. Insects encased in amber showed almost no racemization, apparently because amber keeps out water, which is necessary for this chemical reaction.

"That made us much more enthusiastic about retrieving DNA sequences [from amber]," says Svante Pääbo, a coauthor of the SCIENCE paper. Poinar and others have previously reported DNA sequences from insects trapped in amber, but they have yet to replicate these findings. *— R. Monastersky*