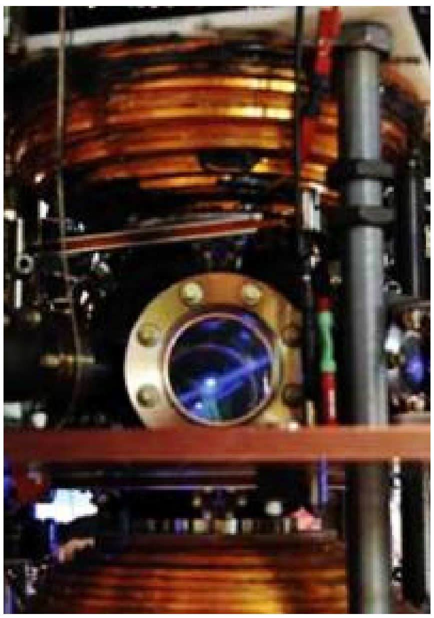
PHYS.ORG

Physicist's research may lead to more precise measurements of time

December 19 2012, by Beth Kwon



A glowing atom cloud, visible as blue light, in Tanya Zelevinsky's lab, cooled to nearly absolute zero or minus 460 Fahrenheit Credit: Chris Osborn

(Phys.org)—Tanya Zelevinsky's Pupin Hall lab is home to a sprawling contraption of gangly wires, metal pipes and chambers, and flashing lights. Inside a container that opens up like a porthole is a glowing blue dot—a cloud of a million atoms cooled to nearly absolute zero, or close to minus 460 degrees Fahrenheit, eight orders of magnitude below room temperature. "I can safely say this is the coldest point in New York City," says Zelevinsky, an assistant professor of physics who may know more about cold than most people—she was born in Siberia.

In a paper in the Sept. 13 issue of Physical Review Letters, Zelevinsky and her team reported the creation of a new type of ultracold strontium molecule, made of pairs of these glowing atoms. Typically physicists couple lasers with magnetic fields to create ultracold molecules; Zelevinsky's breakthrough was in revealing a method to produce large numbers of them in a fraction of a second with just lasers, opening up the possibility of studying complex molecules resistant to magnetic forces. The new techniques will help scientists better understand chemistry and fundamental physics, and could lead to more precise measurements of time.

For most people, hot and cold are simply temperatures. But on a molecular level, the colder something is, the slower the particles are moving. Absolute zero is the absence of thermal energy, the lowest theoretical temperature, colder than any naturally occurring temperature in the universe. "Many people think of lasers as heating things up because lasers carry a lot of energy, but you can also use lasers to take away energy or to refrigerate matter," explains Zelevinsky.

The discovery involved trapping the new molecules in a spider web-like laser scaffold, which allowed Zelevinsky to measure the molecule's spectral frequency at a very high resolution.

Some atoms have a unique frequency—a favorite wavelength of light or a color in the spectrum. Zelevinsky finely tunes lasers to a shade slightly less energetic, or cooler, than the atom's preferred frequency and shines it on the atom.

Every time the atom absorbs a photon from the laser beam, it absorbs a little bit less energy than it wants to, yet it still emits the same amount of energy as usual. In each cycle of absorption and emission it loses a little bit of energy and thus becomes colder.

Zelevinsky's cooling method is compounded by the Doppler effect, familiar to most of us as the phenomenon of a moving ambulance whose siren sounds higher in pitch as it approaches and lower as it moves away.

Lasers have the same effect. When an atom moves toward a laser beam tuned to a lower energy than its preferred color, it perceives the laser as the ideal shade due to the Doppler effect and is drawn to the beam that pushes it back and ultimately stops it.

The cold temperature allows molecules to be trapped and observed, making them useful in metrology, the science of measurement. One application is a molecule clock, a device that measures the vibration frequencies of a molecule extremely precisely and thus is used to set time standards.

Zelevinsky's technique could lead to a more exact measurement of the second. "The second will probably change, but on an everyday scale we wouldn't notice," she says. "One application of atomic and molecular clocks is checking whether certain properties of the universe have been constant since the big bang."

Strontium molecules are good for building quantum clocks because the "time" they tell is not influenced by hard-to-control things like heat in the lab or the Earth's magnetic field.

Zelevinsky was exposed to physics early by her parents, who are also scientists. Her family emigrated to the United States via Denmark in 1992 shortly after the fall of the Soviet Union. Zelevinsky finished high school in the U.S. and entered MIT in 1995, majoring in physics and math. She continued on to Harvard for graduate work and received her Ph.D. there. After a post-doctoral stint at JILA (formerly the Joint

Institute for Laboratory Astrophysics), Zelevinsky arrived at Columbia in 2008.

She cites Nobel laureate I.I. Rabi, who laid the foundation for atomic physics at Columbia, as her inspiration. In 1964, two decades after winning the Nobel in physics, Rabi became Columbia's first University Professor.

"Columbia is the birthplace of modern atomic physics, started by Rabi in the 1930s," she says. "We are excited because ours is the first modern lab in atomic, molecular and optical physics here. Our technique expands the scope of what you can do with molecules in the lab and the possibility for precise measurements in fundamental physics."

Provided by Columbia University

Citation: Physicist's research may lead to more precise measurements of time (2012, December 19) retrieved 23 May 2024 from https://phys.org/news/2012-12-physicist-precise.html