Atoms looser than expected

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All the atoms in the universe just got looser, at least in the eyes of humans. No, the laws of physics didn't change overnight, but our knowledge of how strong atoms are held together did have to be readjusted a bit in light of a new experiment conducted at Harvard University.

By studying how a single electron behaves inside an electronic bottle, Gerald Gabrielse and his colleagues at Harvard were able to calculate a new value for a number six times more precise than the previous measurements called the fine structure constant, which specifies the strength of the electromagnetic force, which holds electrons inside atoms, governs the nature of light and provides all electric and magnetic effects we know, from a flash of lightning to a magnet on a refrigerator. Knowledge of these fundamentals helps scientists and engineers design new kinds of electronic devices–and obtain more profound details on the workings of the universe.

Gabrielse sums up the experiment this way: "Little did we know that the binding energies of all the atoms in the universe were smaller by a millionth of a percent--a lot of energy given the huge number of atoms in the universe."

Electrons are the outermost part of every atom. When detached from their home atoms, electrons constitute the electricity that flows through all powered machines.

By studying an individual electron in isolation from any other particle, scientists can eliminate complications of measuring a single object too small to see with even the most powerful microscopes. The Harvard scientists achieved extraordinary conditions of isolation for their individual electron. First of all, the inside of their trap apparatus is pumped free of almost all other particles, establishing a vacuum comparable to that in interplanetary space. And it's ultra-frigid inside: the apparatus is chilled to millionths of a degree above absolute zero, a temperature far colder than the surface of Pluto.

The lone electron and its surrounding cage constitute a sort of gigantic atom. Combined electric and magnetic forces in the trap keep the electron in its circular orbit. In addition to this circular motion, the electron wobbles up and down in the vertical direction, the direction of the magnetic field. It's like a giant merry-go-round, with an electromagnetic trap as the carousel and the electron as the lone horse.

The circuitry used to activate the electrodes keeping the electron pretty much centered in the trap is so sensitive that the system knows when the electron is bobbing upwards and approaching one of the electrodes. A feedback effect using the combined electric and magnetic forces, supplied by electrodes and coils, restricts the motion of the electron. This allows the electron's energy to be measured with great precision.

By measuring the electron's properties so meticulously, physicists could improve their calculation of the fine structure constant, the number that determines the strength of the electromagnetic forces that hold all atoms together. The new value for the constant is slightly smaller than the best previous value (revealing atoms to be just a tiny bit looser) and six times more accurate.

The Harvard work with the special electron trap has taken more than twenty years and has produced more than a half dozen PhD theses, all centering on a single electron.

Source: American Physical Society