# A step closer to an atomic-based kilogram?

Among global standards for length, mass, time, and other fundamental quantities, only the kilogram remains a physical object—a carefully machined cylinder of platinum-iridium alloy at the International Bureau of Weights and Measures at Sèvres, France.

Because the cylinder collects dust and in other ways slightly changes mass with age—and might be lost or stolen—the stewards of the world's measurement system are eagerly seeking a new standard based on a carbon atom's mass or other fixed quantity of the atomic world (SN: 9/24/94, p. 199; 1/28/95, p. 63).

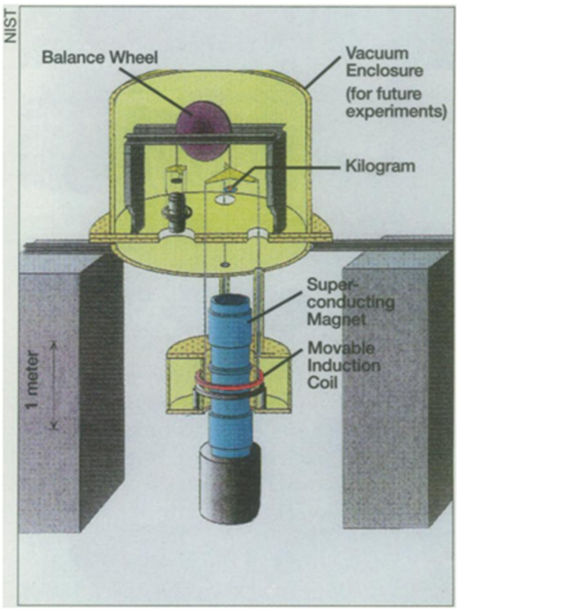
Toward that goal, researchers at the National Institute of Standards and Technology (NIST) in Gaithersburg, Md., report that by weighing the kilogram against an electromagnetic force, they have measured a fundamental physical quantity, known as the Planck constant, with twice the precision of previous experiments. The Planck constant serves numerous roles in quantum mechanics, including setting limits on how much can be simultaneously known about a particle's momentum and position.

Although the new measurement falls short by a factor of 10 of the accuracy needed to redefine the kilogram, it takes an important step in that direction, metrologists say. "We make a connection between the atomic world and the macroscopic world for the property of mass," says Edwin R. Williams, leader of the NIST team. The researchers linked those worlds by balancing an exact copy of the French kilogram against a force already defined by atomic-scale quantities. They used a balance so delicate that it is housed in its own building and operated outside regular office hours to avoid vibrations.

Reporting in the Sept. 21 Physical Review Letters, the NIST group gives a new value for the Planck constant of $6.62606891 \times 10^{-34}$ Joule-seconds, with an uncertainty of 87 parts per billion, less than half the uncertainty of prior measurements. The improvement in the Planck constant—the first in a decade—will also benefit other fundamental scientific constants, whose official values will soon be revised, Williams says. The Planck constant underlies a half-dozen of them and could serve as the basis for redefining the kilogram in terms of absolute physical quantities.

The NIST measurement is "of great importance to basic physics and metrology," says Erich Braun of the German standards institute, the Physikalisch-Technische Bundesanstalt in Braunschweig. A team there is trying to redefine the kilogram by counting the number of atoms in a kilogram of silicon.

So far, their precision cannot match either NIST or the National Physical Laboratory in Teddington, England, where the balance method originated. Improvements already installed at the English balance and expected next year at NIST promise to improve precision to the point that the atomic kilogram could become a reality. —*P. Weiss*




*A kilogram weight on this sophisticated balance exerts a downward force that is countered exactly by the electromagnetic force generated when current flows in the movable coil in the superconducting magnet's field. By measuring the current, researchers link the upward force to ultraprecise constants that could be used to define an atomic-based kilogram.*

# As globe warms, atmosphere may shrink

With tongues nowhere near their cheeks, British scientists report this month that the sky is actually falling. Radar measurements show that the upper atmosphere has contracted since 1958, matching the predictions of greenhouse warming theory.

The atmospheric physicists used radar installations in the Falkland Islands and along the Antarctic coast to probe the thermosphere—the region of the atmosphere above 85 kilometers, where atoms are scarce and the sky blends seamlessly into space. The radar waves shot upward and reflected off a layer of charged atoms, called the ionosphere, at an altitude of about 300 km. By measuring the time it took the radar signal to return to Earth, the researchers could track changes in the height of the ionospheric layer within the thermosphere.

From 1958 through 1995, the average ionosphere height dropped by 8 km, according to the group's report in the Sept. 1 Journal of Geophysical Research. "There does appear to be a global reduction in the altitude of the ionosphere. The best explanation is linked to the increase in greenhouse gases," says Martin J. Jarvis of the British Antarctic Survey in Cambridge, England.

As carbon dioxide and other pollutants trap heat in Earth's lower atmosphere, they conversely cool the middle and upper atmosphere, according to computer climate models. These simple models forecast that the thermosphere will chill by 50°C with a doubling in the atmospheric concentration of carbon dioxide, expected sometime in the next century. That would shrink the thermosphere and cause the height of the ionosphere to drop by 10 to 20 km, according to calculations.

Researchers have previously detected decreases in ionospheric height over Finland and Germany. The Southern Hemisphere data "show that it's a global phenomenon, not just over Europe," says Jarvis.

The British researchers say that although their measurements are consistent with greenhouse warming predictions, there could be other factors causing the thermosphere to contract.

Another recent study, in fact, failed to find a consistent trend in ionospheric height. When Indian scientists analyzed records from 31 stations around the world, they found the ionosphere rising in some regions and falling in others. Their report appears in the Sept. 1 Geophysical Research Letters.

Taken at face value, the Indian study suggests there has been no global shrinking of the thermosphere, says Thomas Ulich of the Geophysical Observatory in Sodankylä, Finland. Ulich cautions, however, that researchers need to check the ionospheric records for changes in instruments and personnel doing the measuring. At Sodankylä, the same technician has conducted measurements since 1957, during which time the ionospheric heights have dropped, he says.

Measurements of the middle atmosphere have been more consistent, with different techniques showing a strong cooling, says Guy P. Brasseur of the National Center for Atmospheric Research in Boulder, Colo.

A more definitive picture of the middle and upper atmosphere could come in 2000, when NASA plans to launch a small satellite to study these regions. —*R. Monastersky*