Kilogram Poses Weighty Problem

By Rachel Metz

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If several scientists get their way, a 2.2-pound hunk of metal -- the international prototype of the kilogram -- may soon be out of style.

Like its six basic-units-of-measurement siblings before it -- including the meter -- the kilogram may be moving toward a new definition based on a universal constant. The kilogram has long been understood to equal the mass of its prototype.

Work has been underway for about 25 years to switch the kilogram from being defined by a physical model to corresponding instead to a constant. A paper to be released Monday proposes redefining the unit via fixing the values of one of two well-known universal constants. The choices offered up are Avogadro's constant or Planck's constant; the former measures the amount of carbon-12 atoms in 0.012 kg of that element, while the latter is used to explain the sizes of quanta, which are tiny electromagnetic energy packets.

In 1889, a cylinder of a platinum-iridium alloy was declared the international standard of measurement for the kilogram by the first General Conference on Weights and Measures. It's kept at the International Bureau of Weights and Measures (Bureau International des Poids et Mesures, or BIPM) in France, and several copies were distributed around the world.

Although the main model has only been removed a few times for cleaning, it can pick up deposits from surrounding air. Over time, several copies' masses are generally increasing relative to the model, said Edwin Williams, a paper co-author and research physicist with the quantum electrical metrology division of the United States' National Institute of Standards and Technology, or NIST. It's unclear if the principal cylinder's mass is increasing or decreasing, scientists said, because it is the object used to measure others. Still, this poses a concern. Another worry is the possibility of the main model's destruction, come a natural disaster.

"So the idea is to have some kind of definition to be able to construct the kilogram just given this information, without an object," said Peter Mohr, a physicist with NIST and chairman of the Paris-based Committee on Data for Science and Technology, or CODATA.

Mohr, Williams and fellow scientists Ian Mills, Terry Quinn and Barry Taylor put together the paper, which is titled, "Redefinition of the Kilogram: A Decision Whose Time Has Come." It was initially presented in London in mid-February at a meeting of The Royal Society, a U.K. science organization. It should be available online at the website of the journal Metrologia after its release. The group hopes one of its suggestions gains favor within the metrology community -- metrology being the science of weights and measurements. If accepted, one of the recommended redefinitions would go into effect in October 2007, said Mills, a professor of chemical spectroscopy at England's University of Reading.

The change would mean the kilogram would no longer be known exactly, but would instead be determined by experiments using the chosen defined constant. A definition based on Planck's constant could mean scientists would determine a certain number of photons of light of a certain frequency would correspond to a kilogram. A definition based on Avogadro's constant could mean the kilogram would be determined by a certain number of an element's atoms.

Besides halting current and possible future problems with the kilogram model, scientists think there are several benefits to redefining the unit via a universal invariant. Doing so should make other measurements and scientific results more accurate, Mills said, because lots of other units of measurement are derived from the seven base units. "And precise measurement is very important.... You need to be able to make measurements reliably for the environment, for medical applications, for engineering applications," he said, giving measurements of medications as an example.

In order to augment the kilogram's accuracy, various scientists' experimentally derived values based on Planck's constant and Avogadro's constant were compared to come up with numbers put forth in the paper, Mills said. The values are the most recent ones approved by CODATA, from 2002.
Does the group's current argument represent the final frontier for the definition of the kilogram? Not according to Mohr. As technology improves, new processes develop and people realize the old ways aren't good enough anymore, he said.

"Different types of measurements become better than others," he said.
Mills feels a little differently. If one of the proposed redefinitions is chosen, "I suspect that will be the end -- at least for 100 years. I mean, the last one lasted for 100 years," he said, soon adding, "It's very difficult to say what will happen."

Richard Davis, head of the BIPM's mass and related quantities section, and Quinn, a paper co-author and emeritus director of the BIPM, could not be reached for comment.