New scales for the new kilogram

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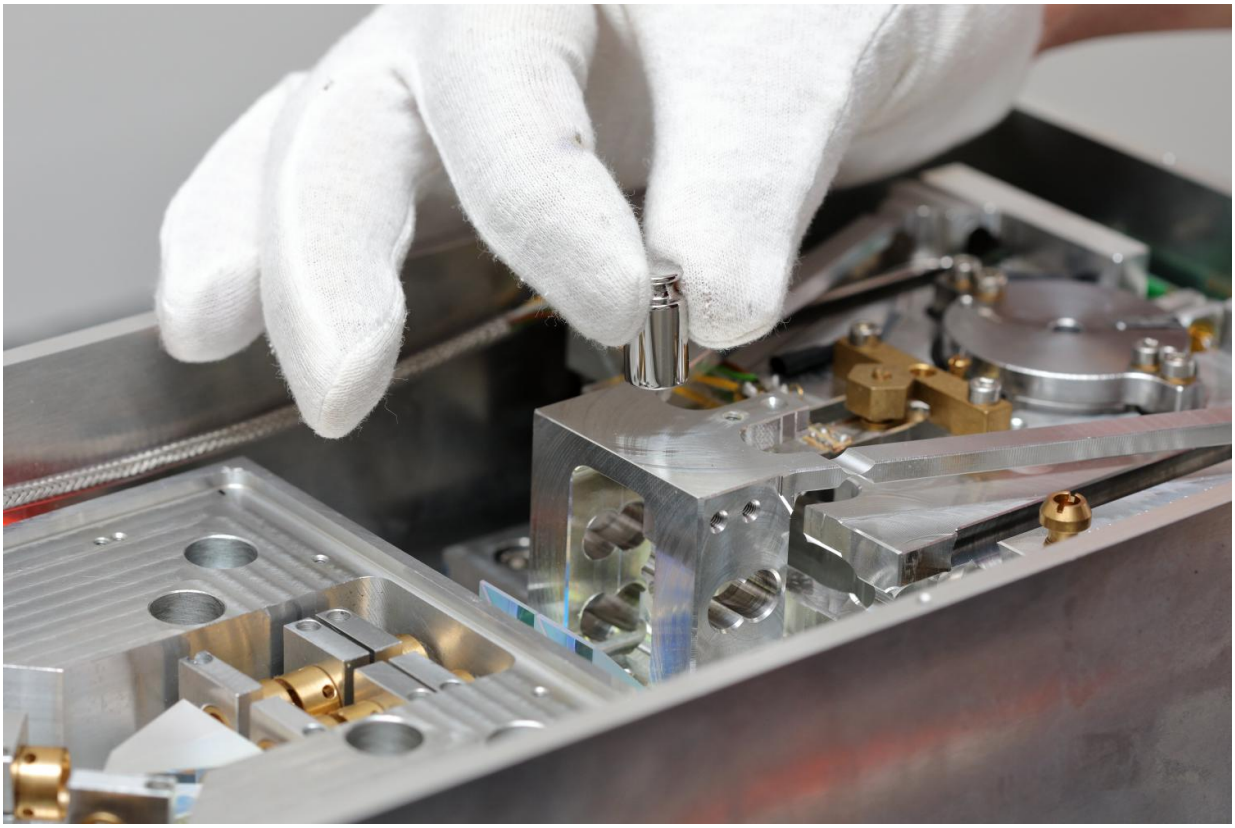

By the end of this year, scientists will have access to an initial prototype of the Planck scale. Credit: TU Ilmenau

The Planck scale works according to the principle of electromagnetic force compensation: A weight force on one side of the scale is balanced by an electromagnetic force on the other side. This means that weights (so-called mass standards) will no longer be needed. This could be the

beginning of the development of a completely new generation of scales that are suitable for industry.

Together with the Technische Universität Ilmenau, the Physikalisch-Technische Bundesanstalt (PTB) is developing a so-called Planck scale. This scale works according to the principle of electromagnetic force compensation: A weight force on one side of the scale is balanced by an electromagnetic force on the other side. This means that weights (so-called mass standards) will no longer be needed; to date, weights have "told" scales how large the mass on the scale actually is (for example, 1 kg). By the end of this year, scientists will have access to an initial prototype of the Planck scale. In this way, a review can be carried out of the steps that are still necessary to develop the scale to the point that it is suitable for industrial use. This could be the beginning of the development of a completely new generation of scales that are suitable for industry.

The development of the Planck scale was lent momentum by the approaching redefinition of the kilogram: In the near future, the international prototype of the kilogram, a small metal cylinder in a safe near Paris, will become obsolete. In its place, a kilogram definition will be used that is based on an indestructible and unchanging natural constant: Planck's constant h. The name "Planck scale" alludes to this very constant. Once the value of h is established internationally, masses will be determined solely by measuring electrical quantities.

An additional advantage of the Planck scale is its continuous measuring range. Although the initial prototype will only achieve a measuring range from 1 mg to 100 g, its successor, which has already been planned, will have a range from 1 mg to 1000 g. Comparable scales could be used for industrial weighing operations as so-called primary standards, since no calibration using standard weights will take place. In the long term, however, the Planck scale could also be used to achieve higher accuracy

(even for small masses) than has been possible to date using standard weights in industrial applications. In this way, the expertise gained at PTB during the development of the Planck scale will benefit the economy in general and strengthen the leading position of the German scale industry throughout the world.

While PTB is considering the practical outcomes and opportunities of the redefinition of the kilogram, the redefinition itself is not yet complete. As one of the world's leading metrology institutes, PTB is playing a major role in this redefinition as well. Two experiments are being pursued internationally in order to achieve the goal of defining the kilogram in such a way that it is based on of natural constants: the Avogadro experiment, which will determine the number of atoms in an almost perfectly spherical crystal made of isotopically pure silicon; and the Kibble balance (or watt balance), in which the gravitational force of a mass in the Earth's gravitational field is compensated by an electromagnetic force. Because both experiments determine the value of Planck's constant, both approaches fulfill the goal mentioned above. Whereas PTB's approach is primarily via the silicon sphere, the Kibble balance is favored by NIST in the United States and NRC in Canada. However, in order to be able to offer both approaches for the future dissemination of mass units to industry, PTB - together with TU Ilmenau - has initiated prototype development for a Planck scale (as a version of the Kibble balance that is suited for industry).

The Institute of Process Measurement and Sensor Technology at TU Ilmenau, which is jointly contributing to the development of the Planck scale under the scientific direction of Professor Thomas Fröhlich, is an internationally leading institution in the fields of industrial force-measurement technology, weighing technology and nanometer-precision laser metrology. Over the past ten years, measuring instruments were developed at TU Ilmenau that were considered the "most accurate scale in the world". The knowledge gained from the development of a so-

called 1-kg prototype comparator was directly incorporated into the research on the Planck scale. This highly accurate mass comparator is already being used at national metrology institutes throughout the world to compare kilogram prototypes.

Provided by Physikalisch-Technische Bundesanstalt