Bureau International des Poids et Mesures

Redefinition of the kelvin

SI – a universal language of measurements

The International System of Units (SI) constitutes a coherent set of units by which any measurable quantity of interest in research, industry, trade or society can be quantified. The signatory states of the Metre Convention represent about 98% of the world's economy, so the SI is the very basis of international trade and supports the global measurement quality infrastructure through national metrology institutes.

The international measurement community, through the International Committee for Weights and Measures, is presently working on updating the SI. This update, which will most probably take place in 2018, will redefine the kilogram, the ampere, the mole, and the kelvin in terms of fundamental physical constants.

The kelvin – the SI unit of temperature

The kelvin, presently defined by the triple point of water, will be defined by assigning an exact numerical value to the Boltzmann constant. This redefinition will ensure a long-term stability and traceability of the unit for temperature by making it independent of any material substance. For example, this is essential for measuring climate trends. This modification will make the kelvin directly accessible to different measurement techniques applied in temperature ranges far from the triple point of water.

For most people the redefinition will pass unnoticed; water will still freeze at 0 °C, and thermometers calibrated before the change will continue to indicate valid temperatures. The immediate benefits of the redefinition will be the access to direct measurement of thermodynamic temperature in parallel with the methods associated with the International Temperature Scale of 1990 (ITS-90) and its extension to lower temperatures, the Provisional Low Temperature Scale of 2000 (PLTS-2000).

Facilitate universality of access to the agreed basis for worldwide measurements

Redefining the SI by fixing the numerical values of fundamental physical constants — as suggested by Max Planck in 1900 — will have far-reaching benefits for innovations in industry, serving society and fostering science and research. In Planck's visionary words, these units will "necessarily retain their validity for all times and cultures, even extra-terrestrial and nonhuman," meaning that they are stable and realizable everywhere.

The redefinition of the kelvin will allow the accuracy of temperature measurements to gradually improve without the limitations associated with the manufacture and use of water triple point cells, nor with the limitations of the present temperature scales. Laboratories can realize a temperature standard by choosing, within a variety of alternatives, the experimental method which is best suited to their available facilities, experience, and knowledge. For some temperature ranges at least, thermometry methods that directly realize thermodynamic temperature are expected to eventually replace the International Temperature Scale as practical temperature realization and dissemination methods.

Changes will underpin future requirements for increases in accuracy

There is no doubt that this redefinition will open the door to continuous technical developments towards ever-decreasing uncertainties in the realization of the kelvin, without the need for further redefinition. New primary methods are already emerging for direct realization and dissemination of thermodynamic temperature. For example, at high temperatures, absolute radiation thermometers have been developed that could measure thermodynamic temperature without the need to refer to the triple point of water, the exclusive defining point in the present definition.

Changes to the SI will provide a springboard for future innovation

A redefinition of the kelvin will create more opportunities for improvements to technology and technique. In particular, this redefinition does not require the replacement of the International Temperature Scale of 1990 or of the Provisional Low Temperature Scale of 2000 with an improved temperature scale nor does it prevent such a replacement. Rather, the guidelines on the realization of the kelvin, the *Mise en Pratique* (*MeP*), will describe recognized primary methods for reliable measurement of thermodynamic temperature, as well as the approved approximations to thermodynamic temperature: currently the ITS-90 and PLTS-2000 defined scales. The *MeP* will be updated periodically as methods improve. Although the ITS-90 and PLTS-2000 will not change with the redefinition of the kelvin, future revisions of the *MeP* may include improved approximations consistent with the best thermodynamic measurements.

For further information contact the National Metrology Institute of your country.

See also

http://iopscience.iop.org/journal/0026-1394/page/Focus_on_the_Boltzmann_Constant