REDEFINITION OF THE SI UNIT KELVIN AND ITS REALIZATION

Wolfgang Buck, Bernd Fellmuth, and Christof Gaiser
Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany

e-mail: christof.gaiser@ptb.de

The International System of Units, the SI, is a coherent system of units for use through-out science and technology which is, as we could say, historically founded on seven base units: kilogram, second, meter, kelvin, ampere, mole and candela. In the past these units have partly already been based on atomic properties (second) and fundamental constants (meter), partly, however, they referred to artefacts like the kilogram prototype, the triple point of water, and the current through infinite parallel wires. Due to the unsolved problems e. g. with the changing weight of the kilogram prototype and other difficulties the CIPM started a project for the redefinition of the SI at the beginning of the century aiming the following properties: The result should be universal, stable in time and space, coherent, and suitable for real-world needs.

Already in 1900 Max Planck suggested to use fundamental constants, e. g. the speed of light in vacuum c, the Boltzmann constant k, the gravitational constant G and a constant h in his equations, which later was called Planck's constant, in order to define units of mass, length, time and temperature. For this purpose, however, these constants had to be determined to the same accuracy as the known artefacts could be actually measured. This great challenge has now been successfully finished by a large international effort ending up in new definitions for the base units which were put into internationally binding force at May 20th, this year, i. e. a few days ago. For practical and mainly economic reasons the seven base units were kept for future, although they are not strictly independent from each other.

The new definitions will be based on fixed numerical values of the Planck constant h for the kilogram, the elementary charge e for the ampere, the Avogadro constant N_A for the mole, and the Boltzmann constant k for the kelvin. The effect of the new definition of the kelvin is that one kelvin now is equal to the change of thermodynamic temperature T resulting in a change of thermal energy kT by 1.380649×10^{-23} J. It implies the equivalence of mechanical and thermal energy. Thus, k is simply the conversion factor between energy and temperature. As basis for fixing the value of k, since almost two decades projects have been underway to measure k using independent methods like acoustic and dielectric-constant gas thermometry, Doppler-broadening spectroscopy, and Johnson noise thermometry [1]. The result achieved and the consequences of the new definition of the kelvin will be discussed. Special emphasis will be given to dielectric-constant gas thermometry, since performed at PTB.

References

[1] B. Fellmuth, C.Gaiser, J.Fischer., Meas. Sci. Technol. **17,** R145 (2006)