Development of a Specialized Hydrostatic Comparator for the Accurate Density Determination of Natural Silicon Spheres: A Novel Method for a Primary Realization of the Unit Kilogram

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A novel method to realize and disseminate the unit of mass, kilogram, as it will be defined in the revised International System of Units (SI) in 2018, is presented. Intrinsically, the Physikalisch-Technische Bundesanstalt (PTB) aims for a primary realization of the kilogram by linking the newly fixed value of the Planck constant, h, to spheres manufactured from monocrystalline silicon (Si) crystals, which are highly enriched in the isotope ²⁸Si. However, since the process for obtaining these crystals is sophisticated and, hence, expensive, a widespread use of these ²⁸Si spheres as a primary realization of the kilogram seems, from an economic standpoint, hardly feasible. To address this issue, we present an alternative method to realize and disseminate the kilogram, which will be established at PTB—the socalled "quasi-primary" realization. This approach allows one to accurately relate h to spheres manufactured from monocrystalline, natural silicon. Therefore, the precisely known isotopical composition of a ²⁸Si sphere will be transferred to spheres manufactured from natural silicon utilizing a newly developed hydrostatic comparator. To enable the dissemination of the unit kilogram with these more favourable silicon spheres, a relative uncertainty of 3×10^{-8} at 1 kg should be achieved. Accordingly, the accuracy of the hydrostatic comparator must exceed that of the well-known apparatuses for precision density measurements of solid materials by one order of magnitude. To this end, we present the concept of a new apparatus, which will be set up at PTB within the next years. As a key feature, the well-known Archimedes (buoyancy) principle will be combined with a magnetic suspension coupling. This allows us to improve one of the major uncertainty contributions of this general type of instrument—the temperature stability in the measuring cell.