NMIJ/AIST Succeeded in Increasing the Accuracy of the Avogadro Constant

- Contribution to the fundamental physical constants and opening a way for replacing the kilogram -

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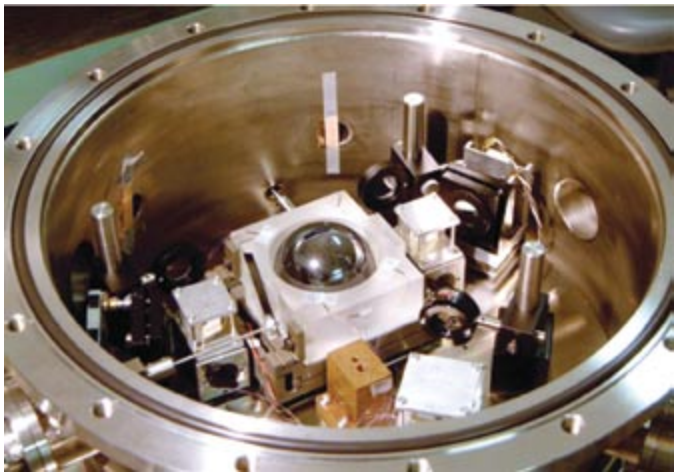
A more accurate value of the Avogadro constant is of primary importance because fundamental physical constants, such as the Planck constant, Boltzman constant, elementary charge, and Josephson constant, are so closely related to the Avogadro constant that its accurate value is indispensable for determining the fundamental physical constants used in physics and chemistry. In the field of metrology, the kilogram is the only SI base unit still defined by a material artifact made of a platinum/iridium alloy. For replacing the present definition of the kilogram by defining the number of atoms, a more accurate value of the Avogadro constant is needed. A determination of the Avogadro constant by the x-ray crystal density (XRCD) method has therefore been conducted at the National Metrology Institute of Japan (NMIJ), AIST, where the lattice constant, density, and molar mass of a silicon crystal are measured in conformity with the definition of the SI units. The photograph shows an optical interferometer used to measure the diameter of a single-crystal silicon sphere. This interferometer determines the volume of the 1 kg silicon sphere with an uncertainty of better than 0.1 ppm. From the known value of the lattice constant, it determines the number of atoms in this sphere. By combining this number with the mass data for the silicon sphere, it leads to an accurate value of the mass of a single Si atom. Recently, a research group led by K. Fujii succeeded in increasing the accuracy of the Avogadro constant; NMIJ measured the density and lattice spacing, and an European Joint Research Center, the Institute for Reference Materials and Measurement (IRMM), measured the molar mass of the silicon crystal. The Aogadro constant was thus determined to be $6.022\ 1375 \times 10^{23}$ mol^{-1} with a standard uncertainty of 0.2 ppm, the best accuracy ever achieved by the XRCD method (see *IEEE Trans. Instrum. Meas.*, 52-2, 2003, 646-651). The data was reported to the CODATA Task Group on Fundamental Constants as one of input data for finding a best set of the fundamental physical constants, and the new set of the constants was issued in December 2003. This research is now organized as an international project with the PTB (Germany), IMGC (Italy), IRMM (EU), CSIRO (Australia), NPL (UK), NIST (USA), and BIPM (France) for replacing the kilogram. This project, scheduled to continue till 2010, uses an isotopically enriched silicon crystal ^{28}Si to further increase the accuracy of the Avogadro constant by a factor of ten, and will realize the dream of the Metrologist in the near future.



Optical interferometer to measure the diameter of a 1 kg silicon sphere