A5-7 Invited

SESSION CODE A5

A Determination of the Avogadro Constant using Silicon Crystal Spheres

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Abstract; The Avogadro Constant is related both to the Unit of Mass and to various Fundamental Physical and Electrical Constants and is necessary to be known for the accurate standard of the Mol. Owing to the recent success in semiconductor technology, the element silicon acquired the position of the possible candidate for the universal reference material for accurate measurement because of its nearly perfect atomic structure in the crystal. The project determining the Avogadro constant using silicon crystals is a historical consequence as the subject of standard organizations in the world. The group in NRLM has just started the last phase of the long project using the silicon perfect sphere of 1 kg. It measures the diameters of the sphere using optical interferometer together with its mass using national kilogram standard, providing the macroscopic density of it. It also measures the lattice spacing of the X-ray interferometer manufactured from the identical silicon ingot. The latter is to be combined with the averaged atomic mass, determined by the cooperation with CBNM, Geel, Belgium, yielding the microscopic density. Equivalence between these two densities provides the Avogadro Constant. Claimed precisions of the measurements at present are 0.3ppm in the volume, 0.05ppm in the mass, 1ppm in the lattice spacing. Target accuracies of the project for the respective measurements will provide the Avogadro constant with a total uncertainty less than 0.3ppm . The last revision on the instrumentation in X-ray interferometry promises far better precision and the introduction of vacuum enviroment to the volume measurement stabilizes the reading of optical fringe fraction in diameter measurements. The pans for weighing are designed to allow both the sphere and the 1kg standard weight for direct comparison without auxiliary pans. The details of these revisons are presented together with the reviews on the work by other institutes.

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A5: Quantum Metrology and Fundamental Constants

Monitoring and Replacing of the Kilogram using an SI Watt Experiment

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By International agreement, the Josephson frequency to voltage quotient or Josephson constant and the quantum Hall resistance or von Klitzing constant are fixed in value [1]. These two stable sources provide highly reproducible laboratory units of voltage and resistance which can be converted into a highly reproducible unit of electrical power. Through the use of a watt balance, the stability of the mass of the kilogram can be evaluated at the accuracy of the watt determinations. It has been reported that the mass of the kilogram is thought to be stable to at least 0.03 ppm/year. Thus the measurement uncertainty of the watt balance experiment would have to be of the order of 0.01 ppm to be of significance in the monitoring of the stability of the international standard of mass, the SI kilogram.

The theory [2] and apparatus of the NIST watt balance have been fully discussed elsewhere [3]. Simply put, one can consider the heart of the apparatus as being a linear motor-generator, a coil in a radial magnetic field whose axes are coincident and parallel with respect to local vertical. The required measurements are:

1. the ratio of the voltage V induced in the coil when that coil moves at some velocity v parallel to the axis of the radial magnetic field (V/v); and
2. the ratio of the static force F that the coil will exert parallel to the axis of the radial magnetic field to the dc current I in that coil (F/I).

The ratio of the electrical watt to the SI watt is the result of measurement 2 divided by the result of measurement 1. The overall uncertainty in monitoring the stability of the kilogram mass rests in how well one can do measurements 1 and 2. Presently we are measuring these quantities near the 0.1 ppm level with expectations of further improvements.

References

[1] B. N. Taylor and T. J. Witt, Metrologia 26, 47, 1989
[2] B. P. Kibble, Atomic Masses and Fundamental Constants. J. H. Sanders and A. H. Wapstra, Eds. New York: Plenum Press, 1976
[3] P. T. Olsen, W. L. Tew, Jr., E. R. Williams, R. E. Elmquist, and H. Sasaki, IEEE Transaction on Instrumentation and Measurement, 40, 115, 1991

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