Laser Displacement Interferometers with Subnanometre Resolution in Absolute Ballistic Gravimeters

L.Vitushkin

Bureau International des Poids et Mesures, Pavillon de Breteuil, 92312 Sèvres Cedex, France, e-mail: LVitushkin@bipm.org

O.Orlov

D.I.Mendeleyev Institute for Metrology, Moskovsky pr. 19, 198005, St Petersburg, Russian Federation, e-mail: orl@mail333.ru

A.Germak, G.D'Agostino

I.N.RI.M, (IMGC-CNR), strada delle cacce 73, I-10135 Torino, Italy, specially organized
e-mail: A.Germak@imgc.cnr.it, G.Dagostino@inrim.it

Abstract

The absolute ballistic gravimeter (ABG) realizes the free motion (free fall or rise-and-fall) of the test body in the gravity field and the free-fall acceleration *g* is obtained from the measurement of the length and time intervals using the motion equation of the falling body. Laser displacement interferometers (LDI) and precise clocks are used in such measurements.

To obtain a relative uncertainty of a few parts of 10^9 (or a few units of 10^{-8} ms^{-2}) in a *g*-measurement on the Earth the uncertainty in the length measurement should be less than 1 nm. In addition, the rate of interference fringe counting achieves more than 5 MHz. The required uncertainty in the displacement measurement in the ABG is from 0.025 nm to 0.5 nm for the path length of the free-falling body in existing gravimeters of 2.5 cm and 50 cm, respectively. Such LDIs operate in vacuum. An additional requirement to the laser used in the LDIs of an ABG is the low frequency noise (or the short-time interval frequency instability at time intervals from 1 ms) because the free fall lasts less than 1 s and hundreds of length intervals are counted over this time.

A high accuracy in the measurements length and time is crucial for the ABG but a direct calibration of its LDI in terms of the length unit is not possible due to the design of the absolute gravimeter and because the required uncertainty in the calibration is difficult to reach. Currently, the only way to determine, indirectly, the accuracy of the LDIs of absolute gravimeters is by comparison of the results of specially organized *g*-measurements using the ABGs.

The design of the LDI for an ABG represents a practically task for length metrology with the subnanometre uncertainty in the dynamical measurement mode.