FUNDAMENTAL PROBLEMS IN METROLOGY

MICROGRAVIMETRIC BASE SURVEY AT THE GRAVIMETRIC STATION OF THE ALL-UNION SCIENTIFIC–RESEARCH INSTITUTE OF METROLOGY

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The results are presented of a microgravimetric survey of two bases of the gravimetric station of the All-Union Scientific–Research Institute of Metrology (VNIIM) using an E-54 variometer. The measurements form part of preparations for performing comparisons of absolute ballistic gravimeters at the observatory.

The presently achieved accuracy of measuring free-fall acceleration is characterized by an error of 2-3 μGal for absolute measurements and an error of hundredths or thousandths of a microgal for relative measurements (with cryogenic gravimeters). At this level of accuracy, the gravitational field turns out to be dependent on many factors: astronomical (lunar—solar tides, motion of the Earth’s pole, nonuniformity of the Earth’s rotation), meteorological (movement of atmospheric masses, sagging of the surface of the Earth under their action, geophysical (displacement of the inner core of the Earth, a change in the density of the medium before an earthquake), etc. (for more detail, see [1]). A systematic investigation of these factors, necessary in particular in order to maintain the national gravimetric network at the state-of-the-art level in gravimetry is possible only within a framework of gravimetric observatories. One such observatory has been set up in the D. I. Mendeleev All-Union Scientific–Research Institute of Metrology (VNIIM) in an underground laboratory.

The underground laboratory is located at a depth of 45 m in a 150 m long 7.2 m diameter adit. Microtraverse reference points for periodic leveling were laid down in the adit and two gravimetric bases were made in its center. There are bore holes for determining the underground water level in the territory near the laboratory. The work program of the gravitational observatory will comprise regular absolute measurements of the free-fall acceleration g, systematic measurements of tidal changes in g, tilt measurements, observations of the underground water level, understanding of the correlation between meteorological factors and the gravimetric measurements, etc. It is proposed to link the gravimetric station of the observatory to the fundamental national gravimetric network and through it directly to the worldwide gravimetric network.

The most accurate absolute measurements of g are presently made by the ballistic method. Here it is appropriate to remark that the first measurements of g using this method were made in the P. N. Agaletskii All-Union Scientific–Research Institute of Metrology [2] in 1954-1956 even before the creation of laser ballistic gravimeters. The falling body was made in the form of a rod, with a glass photographic plate, located in an 80 cm long evacuated cylindrical chamber. The chamber was dropped from a height of 14 m along two guides. Observations were made of the descent of the chamber relative to the guides and of the rod relative to the chamber. The absolute value of g was determined with an accuracy of 1 mGal and a correction of 14 mGal to the Potsdam system was established. This was later confirmed in the 1960’s by measurements using ballistic gravimeters. The gravimetric station at Potsdam was taken as the international zero-point after absolute measurements of g using a reversible (Kater’s) pendulum had been made there in 1898-1904.

At the present time the role of an international zero-point has actually passed to the International Bureau of Weights and Measures in Sèvres in France where international measurements of the absolute value of g have been regularly made since 1979 using ballistic laser gravimeters. These measurement detected discrepancies in the values of g [3-5] resulting from local...
nonuniformities of the gravitational field [6, 7]. Knowing these nonuniformities, the results of the measurements can be reduced to a single point, and this makes it possible considerably to reduce the overall error. The reduction must be performed not only in height but also in a horizontal plane [8] in which the nonuniformity of the gravitational field can be quite high, as indicated by the measurements reported in [9, 10].

The microgravimetric surveys of bases described in the literature [9, 11] were as a rule carried out with high-precision Sodin gravimeter having a single-reading accuracy of the order of 5 μGal. It is consequently necessary to make 20-30 measurements of one base in order to obtain an error of the order of 1 μGal (0.6-1.0 μGal in [9]). Such measurements are laborious and the Sodin instruments themselves require a high accuracy when working with them [11].