Measurement of geometric distance between silicon spheres with laser interferometry in determination of G

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The time-of-swing method and the angular acceleration feedback method were used in our last measurement of G in 2018, both of which gave the values of G with an uncertainty of 12 ppm. In the two methods, the distances between the geometric centers of the source masses are the main error sources. For example, in the time-of-swing method, a 0.36 μm uncertainty of geometric distance introduces 9.3 ppm to the G value. If the measurement precision of the geometric distance can be reduced to 0.1 μm, its contribution to the G value is less than 1 ppm, so that it is no longer the main error source in the experiment.

In the on-going G measurement, the silicon spheres with more uniform density will be used. The roundness of the silicon spheres is expected to be 0.1 μm. The laser interferometry is used to measure the geometric distances between the spheres, which is a non-contact measurement method, has a very high precision, and can be carried out on the site to improve the reliability of measurement result. So far, the apparatus of measuring the geometric distances has been built. The measurement principle is analyzed, and the error sources, such as the laser, the sphere, the alignment of optical path, and the environment are evaluated. The measurement uncertainties of the horizontal and vertical geometric distances reach 11 nm and 9 nm, respectively. In the next step, the silicon spheres will be processed with great care, and the on-going G measurement is expected to give a new result in a few years.

References

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