Determination of G with time-of-swing method by using high-Q silica fibers

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The Newtonian gravitational constant G is one of the most fundamental and universal constants in nature. Measurement of G has a very long history that dates back to the 18th century. The weakness and nonshieldability of gravity make it very difficult to measure G precisely. The adopted values in recent Committee on Data for Science and Technology adjustment [1] are in poor agreement within the claimed uncertainties. The wide discrepancy suggests that there may be some undiscovered systematic errors existed in measurements taken by different teams.

The aim of the present work at HUST has been to measure G with the time-of-swing method and the angular acceleration feedback method [2] at the same period of time. The two methods, with a different set of systematic errors, are used to measure G at two independent apparatus, so that unknown systematic errors in one method would be unlikely to exist in the other. This may help to evaluate the potential systematic effects between them and get a more reliable result. In this talk, we present the measurement of G with the time-of-swing method.

Our group has devoted to the absolute measurement of G with the time-of-swing method since 1980s, and obtained results including HUST-99 (HUST-05) and HUST-09 [3]. In HUST-09, the largest systematic uncertainty was due to the anelasticity of the tungsten fiber. Aiming to reduce such systematic error, high Q fused silica fibers are used in our new measurement at two independent apparatus [4]. At apparatus 1, three silica fibers with one set of pendulum and source masses are used to check the possible errors caused by the fiber. At apparatus 2, about 150 meters away from the apparatus 1, a silica fiber with another set of pendulum and source masses are utilized to test the possible errors dependent on the apparatus. Some other improvements include the compensation of the background gravity gradient, reduction of the coating layer effect, eliminating of additional effect of the magnetic damper, improving the position stability of the source mass, and other systematic effects are all conducted in the new measurement. Finally, we obtain G value of $6.674184(78) \times 10^{-11}$ $\mathrm{m^3kg^{-1}s^{-2}}$ with relative standard uncertainty of 11.64 ppm [5]. This value agrees with the latest recommended value in CODATA 2014 [1] within one standard deviation.

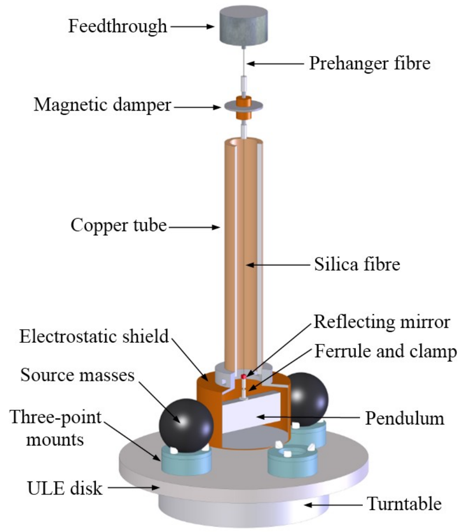

FIG. 1. (color online) Sketch of the experiment.

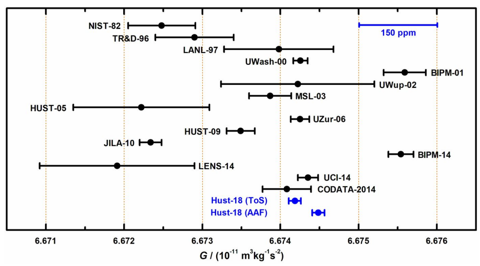

FIG. 2. (color online) Our obtained result, named as Hust-18 (ToS), compared with recent measurements [1, 5].

[1] P. J. Mohr, D. B. Newell, and B. N. Taylor, *Rev. Mod. Phys.* **88**, 035009 (2016).
[2] C. Xue *et al.*, Phil. Trans. R. Soc. A **372**, 20140031 (2014); L. D. Quan *et al.*, Rev. Sci. Instrum. **85**, 014501 (2014).
[3] Z. K. Hu, J. Q. Guo, and J. Luo, *Phys. Rev. D* **71**, 127505 (2005); J. Luo *et al.*, *Phys. Rev. Lett.* **102**, 240801 (2009); L. C. Tu *et al.*, *Phys. Rev. D* **82**, 022001 (2010).
[4] Q. Li *et al.*, Phil. Trans. R. Soc. A **372**, 20140141 (2014).
[5] Q. Li *et al.*, *Nature* **560**, 582 (2018).