The gravitational constant G was measured with record precision using two independent methods

With the support of the National Natural Science Foundation of China, the research team directed by Prof. Luo Jun (罗俊) at the MOE Key Laboratory of Fundamental Physical Quantities Measurements & Hubei Key Laboratory of Gravitation and Quantum Physics, School of Physics, Huazhong University of Science and Technology, has measured *G* with record precision up to date by using two independent methods. The relevant research results were published in *Nature* (2018, 560: 582—588).

The gravitational constant *G*, which was introduced to describe the strength of the gravitational interaction between objects, is the first fundamental physical constant proposed by human beings, while it remains the least precisely known among all fundamental constants due to the extreme weakness and unshieldability of gravity. Recently although the values of *G* determined by different groups around the world are considered with relative uncertainties nearing the level of 10^{-5}, a large discrepancy of up to 0.05% between them suggests that there may be some undiscovered systematic errors in the various existing methods.

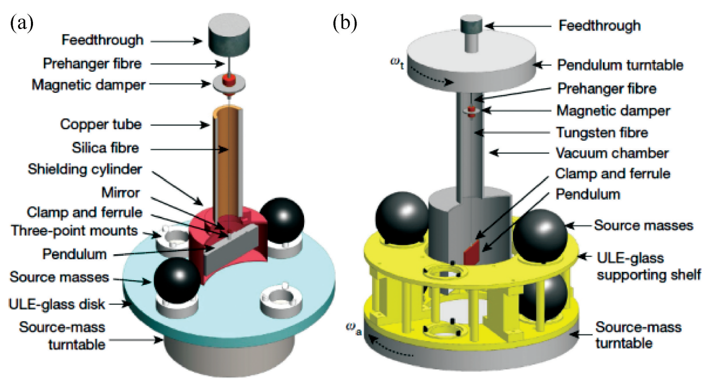

Figure 1 Sketch of the experiment in this work. (a) The time-of-swing method; (b) the angular-acceleration-feedback method.

One way to resolve this issue is to measure *G* using a number of methods that are unlikely to involve the same systematic effects. Prof. Luo and his team reported two independent determinations of *G* using torsion pendulum experiments with the time-of-swing (TOS) method and the angular-acceleration-feedback (AAF) method. A series of improvements were adopted to reduce the impact of various factors in the experiments. Both the methods obtained the results with the smallest uncertainties reported until now, and agreed with the latest CODATA recommended value within a two standard deviations range. This work will provide substantial contribution to nail down the true value of *G*.

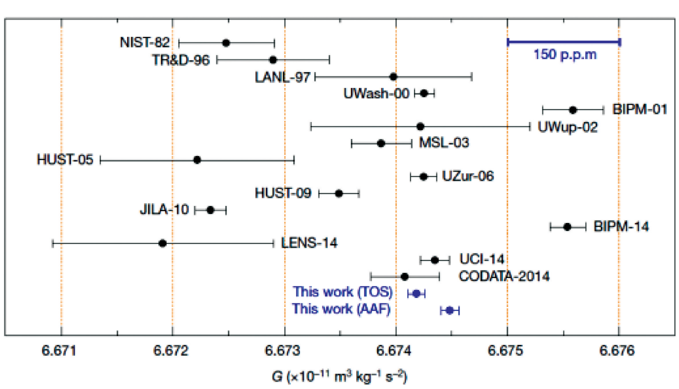

Figure 2 Comparison of this work with previous results. The black dots in the picture represent fourteen measurement results and recommended *G* values relevant to CODATA-2014 adjustment. Two blue points in the bottom represent measurement results of *G* by using two independent methods in this work, with the uncertainties both being about 11.6 ppm.

Beyond that, the team developed a number of precision measurement techniques during the research period, and some of them have already been applied to measurements of gravity field and geological exploration, such as micro-thrust calibration of satellite micro-propellers and the ground calibration of space inertial sensors. These techniques will lay a good foundation for National Precise Gravity Measurement Facility and space gravitational wave detection.