Precision Measurement of the Gravitational Constant G with two independent methods

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The gravitational constant, G, is one of the most fundamental constants of nature. Though more than 200 experiments [1] have been performed to determine G over the past two centuries, the value of G remains the least precisely known among all the fundamental physical constants. A large discrepancy of up to 500 ppm in recent determinations of G suggests that there may be undiscovered systematic errors in the various existing methods. One way to resolve this issue is to measure G using a number of methods which are unlikely to involve the same systematic effects. As a result, two independent determinations of G using torsion pendulum with the time-of-swing (ToS) method and the angular acceleration feedback (AAF) method were performed in the cave laboratory located in the Yujia Mountain at Huazhong University of Science and Technology (HUST) [2].

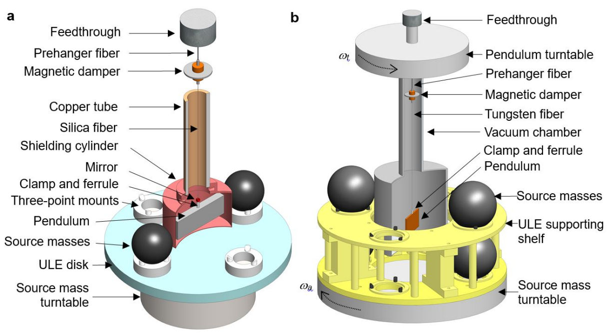

FIG. 1. (color online) Sketch of the experiments with the ToS method (a) and the AAF method (b) [2].

The history of the ToS method in our group can be date back to the 1980s and several phased results were obtained, named as HUST-99/05 and HUST-09 [3] by the CODATA adjustment. In our recent work, we adopted a series of improvements to minimize the large systematic uncertainties encountered in the previous experiment. Especially, fused silica fibres instead of tungsten fibres were used to reduce the anelasticity. On the other hand, a new determination with angular acceleration feedback method has been carried out in our group since 2008. After conducting a proof-of-principle experiment, several improvements were performed to greatly reduce the uncertainties. Great care was exercised in carrying out the experiment and all systematic errors were analyzed to the best of our knowledge. Finally, we obtain G values of $6.674184(78) \times 10^{-11}$ $\mathrm{m^3kg^{-1}s^{-2}}$ for the ToS method and $6.674484(78) \times 10^{-11}$ $\mathrm{m^3kg^{-1}s^{-2}}$ for the AAF method, with the relative standard uncertainties of 11.64 and 11.61 ppm, respectively. These values have the smallest uncertainties reported until now, and both agree with the latest recommended value in CODATA 2014 [4] within two standard deviations. This talk will give a full introduction on our recent work of G measurement with the two methods.

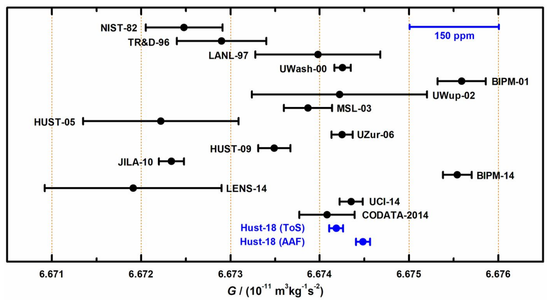

FIG. 2. (color online) G values obtained in this work [2] compared with recent measurements [4].

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