Activities of the Working Group on the Newtonian Constant of Gravitation

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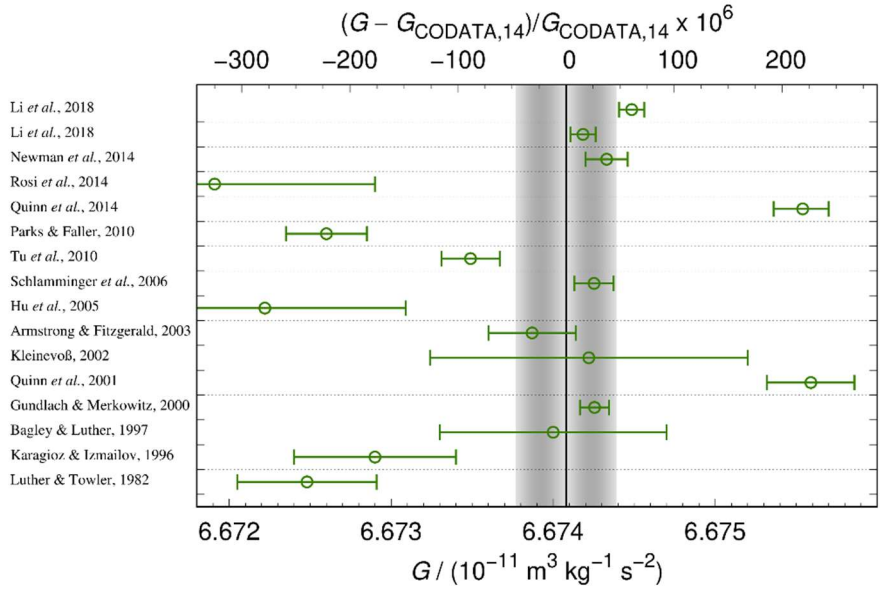
Introduction

The working group on the Newtonian Constant of Gravitation was created at the 28th General Assembly of IUPAP in November 2014. The purpose of the working group is to coordinate experimental efforts to measure the Newtonian constant of gravitation, G. This fundamental constant of nature describes the strength of gravity, the weakest of the four known fundamental interactions. The first laboratory measurement of the gravitational constant was carried out by Henry Cavendish at the end of the 18th century. In modern times, more than a dozen measurements have been described in the literature in the last 30 years. However, the agreement between the results is poor. The best results report relative standard uncertainties of about 20 parts in a million, but the relative difference between the largest and smallest value exceeds 500 parts per million. Clearly, something is amiss. One task of the working group is to understand this problem.

Status

In 2018 two new G results were published with record-setting uncertainties. Previously the experiment with the smallest uncertainty, measured at the University of Washington, had a relative uncertainty of 13.6 x 10^{-6}. Two new results were published by researchers from the Huazhong University of Science and Technology, Wuhan, China. To both results, relative uncertainties of 11.6 x 10^{-6} were assigned. The new situation of the G data is as follows:



The new data are close to the average put forward by the committee on data for science and technology (CODATA). However, the data set has not become much more consistent. The χ^2 marginally increase, and the numbers of degrees of freedom increase from 13 to 15. Overall the likelihood for the data to be consistent is minimal.

Activities

The activities of the working group in the reporting period can be sorted in two broad categories: Support of experimental work and outreach.

Support of Experimental Work

The working group encourages reproducing existing experiments. Two experiments are currently repeated at locations different than where the experiments were conducted initially. One experiment that is presently repeated is given by the data point labeled Quinn et al., 2014 in the above figure. The other experiment is the one marked Faller & Parks, 2010. Both experiments are repeated at the National Institute of Standards and Technology.

The Quinn experiment is already taking data, and it is possible that a conclusion can be reached by December 31st, 2018. The last day of 2018 is the deadline put forward by CODATA for data to be considered for the new least squares adjustment of the available data to produce a new recommended value for G.

The Faller experiment has been set up at NIST, and preliminary measurements have been performed. Data taking will begin in earnest in 2019.

The working group encourages the gravity group at HUST to look at the difference between their new values and the numbers reported in 2005 (Hu et al. 2005) and 2010 (Tu et al. 2010).

Communication and Outreach

The chair of the working group has written a News and Views article for Nature, where the two new G values were published. Two members of the working group have written a review article in the Review of Scientific Instruments. Another review article is in preparation.

The working group is thinking about compiling a review of different numerical and analytical methods for mass integration. A necessary part of every G experiment.

Future work

The working group is planning a face to face meeting at the joint meeting of General Relativity (GR22) and Amaldi (13) in Valencia from July 7th to July 12th. The GR conferences are organized by the International Society of General Relativity, an affiliated commission of IUPAP. A session on recent measurements of the gravitational constant is in planning.