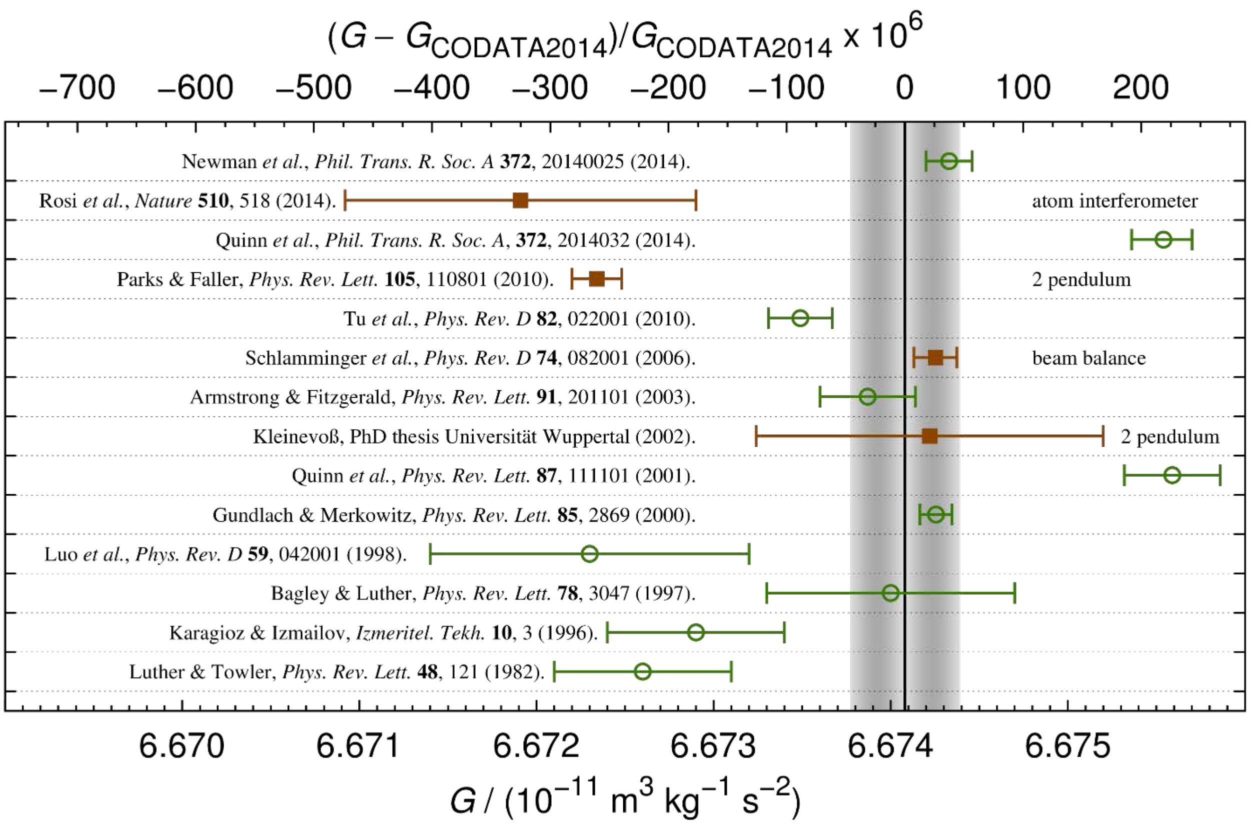
Motivation

The gravitational constant *G* is a measure of the strength of the gravitational interaction. A first laboratory determination of *G* was performed in 1798 by Henry Cavendish. Since that time hundreds of measurements were performed worldwide. Despite that long history, our current knowledge of the gravitational constant is comparatively poor. The recent recommended value by the Committee on Data for Science and Technology (CODATA) has a relative uncertainty of 47 x 10 ^-6. Compare this with the relative uncertainties of the Planck constant (0.012x 10^-6) or the Boltzmann constant (0.57x 10^-6).

The figure below shows the most precise measurements that were conducted in the past 30 years. While the relative uncertainties of some measurements are below 20x10^-6 the scatter between the experiments is 6 times as large. In fact, the relative difference between the largest and smallest number exceeds 500 x 10^-6.



As shown above, we do not understand either the physics behind gravitation, or the physics used in the instruments used to perform these measurements, or both. New Ideas for new measurements can illuminate both of these aspects, which are very important for science and technology.

Our understanding of gravitation, as described by general relativity may not be complete. Attempts to unify gravitation with quantum mechanics, even though an active area of research, have not yielded a satisfying theory. Could the scatter in the big G data be an indication of a richer field of gravity having hidden variables, that the researchers were not aware of? It would be a shame if new physics is lying before our eyes in the scatter plot above there and we did not fully comprehend it, because we deemed the constant as unimportant. Let's see if we can measure this constant with uncertainties below 10^-5.

The experiments measure, depending on their detailed mechanics, small forces, torques, or accelerations. Typically, the gravitational force modulated in these experiments corresponds to the weight of a red blood cell and it has to be measured absolutely with a relative uncertainty of about 10^-5. Is the scatter in the data a tell-tale of underestimated biases in small force metrology? Many fields of physics, biology, and chemistry, rely on precise determination of the absolute values of small forces, including the Casimir effect, spring constants of atomic force microscopy (AFM) cantilever, and intermolecular forces in DNA.