Problems with the Gravitational Constant

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In their article, "Experimental Evidence that the Gravitational Constant Varies with Orientation" (*IE* #55), Mikhail Gershteyn *et al.* report on their observation of *G* anisotropy.[1] They have detected a change of about 0.054% in the value of *G* occurring every 23.89 hours corresponding to about the period of one sidereal day. These experiments were carried out using a torsion balance with two small masses of about 0.9 g and one large mass of about 4.3 kg. The masses were not covered with an insulating material. D. Sarkadi and L. Bodonyi of the Research Center of Fundamental Physics in Hungary have used a pendulum to measure *G* between equal and nearly equal masses.[2] They have observed significant discrepancies from the theoretical value based on Newton's Universal Law of Gravitation. Measurements of *G* below the surface of the earth, in mine shafts,[3,4] boreholes,[5,6] the deep ocean,[7,8] and a hole down the Greenland ice cap[9] have consistently shown deviations from predictions based on Newton's law, which assumes a correlation of gravity with the density of the inert matter.

In a "News Focus on Fundamental Constants," published in *Science* (Vol. 287, February 25, 2000, p. 1391), Andrew Watson points out, "But Mohr and Taylor and their Task Group colleagues have an even bigger thorn in their sides: big *G*, the gravitational constant. The new value has a factor of 10 greater uncertainties than the 1986 figure. . ." The 1986 CODATA recommended value of *G* was[10]

$$6.67259 \pm 0.00085 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$$

The 1998 value is[11]

$$6.673 \pm 0.010 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$$

The fundamental question regarding the big *G* has not been answered. Is the very small angle of deflection (or the very small change in the period) of the torsion balance due to electrostatic attraction of the heavy metals or is it due to the inert mass of the spheres or cylinders? A simple experiment to measure and compare the attraction when the metallic balls are covered with a thin layer of an insulating material with that of the uncoated masses would provide very significant information. In an experiment reported by Heyl in 1930,[12] the small mass of platinum was coated with a thin layer of lacquer. Consistently smaller values of *G* were obtained compared to the experiments using the uncoated gold and glass masses, with no overlap in the spread of the data. The large masses were steel cylinders of about 66 kg; they were not covered with a thin layer of lacquer or other insulating materials. The small masses were spheres of gold, platinum, and optical glass weighing about 50 g. Only the platinum balls were coated with lacquer. There were six experiments with the uncoated gold balls, five experiments with the coated platinum balls, and five experiments with the uncoated glass balls. The arithmetic mean and the sample standard deviation, σ_{n-1}, (x 10^{-8} in the cgs units) are

Uncoated Gold Balls	Coated Platinum Balls	Uncoated Glass Balls
6.6782 ± 0.00387	6.664 ± 0.003	6.674 ± 0.00274

The difference between the coated platinum and uncoated glass balls is significant at the 95% confidence level; the difference between the coated platinum and the uncoated gold balls is highly significant at the 99% confidence level. No measurement of the electrical conductivity of the materials used is reported in Heyl's article. We do not know how effective the thin layer of lacquer was in completely insulating the platinum balls and the large masses were not covered by any insulating material. This experiment was not designed to test the effect of electrostatic attraction. To my knowledge no experiment has yet been performed to rule out this possibility.

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