Gravitational constant calculation methodologies

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We consider the gravitational constant calculation methodologies for a rectangular block of the torsion balance body presented in the papers Phys. Rev. Lett. **102**, 240801 (2009) and Phys.Rev. D. **82**, 022001 (2010). We have established the influence of non-equilibrium gas flows on the obtained values of G.

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The methodologies of calculating G are described in [1]. In methodology 1, the periods of anharmonic oscillations are determined by the Runge-Kutta method. In methodology 2, calculations are carried out by analytic formulas after expanding the attraction torques in series in odd powers of the balance deflection angles φ. Complicated shapes of the bodies prevent obtaining an analytic representation of the attraction torques. In [2-4], the attracting bodies have a spherical shape while the working body is fabricated as a rectangular quartz block coated with two thin metal layers. In the model system, the block is changed for a thin rod of the same mass. Increasing the distance between the rotation axis and the attracting bodies provided an adequacy of the model and real systems at small φ. A three-position scheme of measurements has been considered. In position 1, the attracting bodies are placed at the ends of the block, in position 2 they are absent, and in position 3 they are rotated by $\pi/2$. The positions, oscillation periods and values of G_{ij} according to methodologies 2 [1] and 3 [2-4] for one inverse measurement run (positions 3, 2, 1) and one direct run (positions 1, 2, 3) in the first experiment as well as one direct and one inverse run in the second experiment are given in the table. The results are actually indistinguishable. Methodology 3 understates the values of G in combinations 1-3 and 3-1 by 6 ppm, while in combinations 2-3 and 3-2 it slightly overstates them by a small nonlinearity persistence in the equations of motion. A correction of 212 ppm for inelasticity of the suspension thread was not taken into account. It contradicts the dislocation theory of inner friction [5]. After removing a calculation error made in [1] and using the actual values attraction torgue data from [4], average value of G as compared with [2] in first experiment was overstated by 192 ppm and in second experiment was understated by 206 ppm. In this case the first five values of G_{ij} understate the average value of G at 1120 ppm, and overstate its last eight to 386 ppm. Only this eight have to be taken into account, since they reduced the standard deviation of 24 times. The difference in values of G for direct and inverse runs was in the first experiment 1016 ppm, and the second one 472 ppm. A monotone drift of the oscillation period, the differences in G_{ij} in direct and inverse runs, appreciable deflections of G_{ij} from the normal values when taking into account position 2 indicate the existence of slowly decaying non-equilibrium gas flows in the chamber. An unlucky choice of the material and shape of the working body has strengthened their effect. It could be weakened by increasing the density of the block and the attracting masses. The equality of all combinations of G_{ij} was provided by an oscillation period diminished by 15 ms in the first experiment and increased by nearly 5 ms in the second experiment. One also cannot exclude the influence of a magnetic interaction [1], which is hard to single out against a more powerful factor.

n_i	n_j	T_i, s	T_j, s	$10^{11}G_{ij}$, Nm/kg^2	$10^{11}G_{ij}$, Nm/kg^2
3	2	535.80980	535.17246	5.4845575	5.4845579
2	1	535.17246	532.56028	7.0498664	7.0498083
3	1	535.80980	532.56028	6.6787451	6.6787032
1	2	532.56028	535.17048	7.0445617	7.0445037
2	3	535.17048	535.80557	5.4652905	5.4652908
1	3	532.56028	535.80557	6.6701301	6.6700882
1	2	532.84127	535.25129	6.5380552	6.5380042
2	3	535.25129	536.07102	7.0682555	7.0682579
1	3	532.84127	536.07102	6.6640717	6.6640326
3	2	536.07102	535.24705	7.1049000	7.1049024
2	1	535.24705	532.83246	6.5506933	6.5506422
3	1	536.07102	532.83246	6.6824157	6.6823764

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