A Space Probe Designed to Improve the Accuracy of all Gravitational Calculations

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Commentary

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ABOUT THE STUDY

The empirical Gravitational constant G is of fundamental interest in metrology, Newtonian physics, and the field equations in General Relativity, particle physics, geophysics, and astrophysics. A paper pursuing a more accurate G is Space Gravity Constant G Probe. The precise value of G is unknown with the desired level of accuracy. Specifically, The National Institute of Standards and Technology, Co-operative Orbital Dynamics Analysis (CODA), gives the value of $G=6.67430 \times 10^{-11}$ Nm^2/kg^2 with six significant figures. In comparison, the mass of a proton is 1.67262192369 10^{-27} Kg with 12 significant figures.

The English scientist Henry Cavendish in the years 1797-17980, was the first to measure G by observing the mutual gravitational attraction between a pair of 2-inch (51 mm) lead spheres and two 12'(300 mm) lead spheres and came up with $G=6.74x10^{-11}$ Nm^2/kg^2. Cavendish was also able to determine the average density of the Earth to be 5448 kilograms per cubic meter. Hundreds of experiments since then sought more precise determinations of G but produced inconsistent results. Although they have had much more advanced supporting technology, past experiments have mostly used the same as the Cavendish approach.

The paper shows that a different approach is feasible to enhance the accuracy of G. A sphere made of metal with a large uniform mass density with a channel through the centre would be used. If no significant gravitational fields are present except for the self-generated gravitational field produced by the sphere itself and no frictional forces are present, a small bead in the channel will oscillate back and forth in a simple harmonic like fashion from one end to the other. Oscillation happens because the field is strong at both ends of the channel, pulling the bead toward the center with no net force at the center. Since an experiment to demonstrate this requires an absence of significant ambient gravity, it cannot be shown on Earth, where the gravitational field is many orders of magnitude greater than any field produced by any finite metallic sphere.

A space probe dedicated to refining gravitational calculations promises ground breaking accuracy. By observing distant celestial bodies and mapping their gravitational fields, scientists can recalibrate existing models. This will enhance our understanding of the universe's fundamental forces, lead to more precise space missions, and potentially unveil new discoveries about the cosmos. By positioning a probe beyond Earth's gravitational influences, scientists could meticulously measure gravitational forces with unprecedented accuracy. This data could refine our understanding of planetary orbits, celestial body masses, and even the elusive nature of dark matter. The probe's ability to escape Earth's atmosphere and potential interference would yield highly precise measurements, contributing to breakthroughs in fundamental physics and cosmology. Such a probe could revolutionize our grasp of gravitational interactions, ultimately enriching our knowledge of the universe's intricate fabric.

The motion of the bead is different from a proper simple harmonic motion. It is quasi simple motion because of the removal of matter in the channel. The paper develops a gravitational force function for the bead in a channeled sphere to better predict the bead's motion. The period of the bead oscillation and its frequency are easily measured and compared with calculations based on the current G. Monitoring the positions of the bead experimentally and comparing the predictions of the channel model will allow refining the value of G.

The study determines that the best place to perform future gravitation constant experiments is in space far away from interfering gravitational effects. A near-perfect place is likely in outer space at the Sun-Earth Lagrange point L1, about 1.5 million kilometers from the Earth on a line toward the Sun where other probes reside. According to the preliminary results of an example done, the accuracy of G is increased by four significant figures, but more significant numbers are achievable by extending trial durations.