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A Proposed Experiment on the Shielding of Variations in a Gravitational Field

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Summary

Stationary electric, magnetic and gravitational fields follow the same force laws with the exception of the constant, so we might expect the three to have similar shielding properties. Varying gravitational fields, like varying magnetic fields might be easier to shield than stationary fields. A simple experiment could be performed, utilizing the daily variation of the earth's gravitational field due to the sun. The experiment would only involve the accurate determination of the value of the acceleration of gravity at noon and at midnight at some point near the equator. The measuring device could be surrounded by different shielding materials.

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Stationary magnetic, electric and gravitational fields are similar in some ways. They all obey the inverse square law of attraction. $F = q_1 X q_2 / d^2$ is the law for electostatics, where F is the force of attraction, q_1 and q_2 are the charges and d is the distance between the charges. The law differs only by a constant and notation for the other two fields. One important difference between gravitational fields and electric and magnetic fields is that there is no repelling force due to mass in gravitational fields. This is true at least at macroscopic distances. Because of the similarity in fields, similar problems might arise in shielding the different fields. Complete shielding of stationary fields is not easily accomplished. Stationary magnetic fields are shielded by using materials which are better conductors of magnetic fields than the region to be shielded. This allows the magnetic field to follow the path of the better conductor and to some extent shield the desired region. Stationary electric fields are shielded by placing around the region to be shielded a metal container and placing this material at zero electrical potential. This prevents the electric field from affecting the inside of the container.

Gravitational fields could be shielded by either of the above methods if materials of the desired character could be obtained. To date, no material has been found that would conduct a gravitational field any differently from any other material, and no material has been found that could be held at a gravitational zero potential in a gravitational field.

Varying magnetic fields are more readily shielded than stationary fields. The varying magnetic field induces a current in the shielding material, and the current flowing uses power that must be supplied by the varying field. This helps prevent the varying field from penetrating the material because the energy in that part of the field is used up and appears as heat in the shielding material.

I propose that a variation in a gravitational field might be more easily shielded than a stationary field. This is not to indicate that the entire field is to be shielded, but only that the variation might be easily shielded. In a parallel with magnetic fields, the more rapid the variation in the field, the more easily it might be shielded.

Since no outside energy can be used in the proposed experiment, a rapidly varying gravitational field of even small magnitude would be very difficult to produce. I propose that the gravitational field variations already present on the surface of the earth be utilized to conduct shielding experiments. The earth's rotation causes a variation in the earth's gravitational field because it places the sun during the hours of darkness so that the gravitational field is added to the earth's gravitational field and at midnight an object should experience a maximum force to the center of the earth. At midday the sun's gravitational field is in such a direction so as to decrease the gravitational field at the surface of the earth. The variation in the gravitational field at the surface of the earth at the equator due to the sun should be about .118 per cent.* This variation occurs in 12 hours. The variation due to the moon is much less than this and little variation should occur at the poles in either case. The variation calculated is not a rapid one, but some shielding effects might be noticed even with this slowly varying field.

My proposal is that this variation in the gravitational field might be shielded. This could be tried by accurately measuring the variation and comparing with the calculated value.

If a variation too low is obtained, part of the variation of the field is probably being shielded by the earth when the earth is between the measuring device and the sun. Different materials could be placed between the measuring device and the sun to determine the ability of the materials to shield the variation in the gravitational field. Just as in varying magnetic fields, low resistance metals might best shield this gravitational field variation.

Additional information might be obtained by making measurements of the variation of gravitational attraction when the sun and the moon are on the same side of the earth. The effect of the sun and moon would be additive and a slightly larger variation would be expected.

The problem of shielding stationary fields is so closely related to the mass of materials used that even for large masses of shielding materials, any shielding of a stationary gravitational field would be extremely small. This is probably true because of the small size of the gravitational constant. A variation in the gravitational field might be more readily shielded.

* The variation in the gravitational field on the earth was calculated using the formula $F = G M_1 X M_e/d_1^2 \pm G M_1 X M_s/ d_2^2$, where M_1 is the mass of any object used and M_e is the mass of the earth. M_s is the mass of the sun, and is equal to 332,000 times the mass of the earth. d_1 is the radius of the earth and d_2 is the distance from the sun to the earth. G is the universal gravitational constant. This should be a vector sum, but we are interested only in the maximum and minimum values, or the percentage variation. Substituting the values in the equation we have:

$$\text{Force equals} \quad G \frac{M_1 X M_e}{(3,960)^2} \pm \frac{G M_1 X M_e X 3.3 X 10^5}{(9.3 X 107)^2}$$

The variation is equal to: $$2 \frac{G M_1 X M_e X 3.3 X 10^5}{(9.3 X 10^7)^2} X \frac{(3,964)^2}{G M_1 X M_e},$$

and is equal to $1.18 X 10^{-3}$ or .118 per cent.

For the variation due to the moon, the mass of the moon is equal to .012 M_e and the distance to the moon is 237,000 miles. The variation is equal to $5.9 X 10^{-6}$ or .00059 per cent.