On Kopernicky's Conjecture: Gravity is a Difference Between Electrostatic Attraction and Repulsion

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Some time ago, the editor asked this author to review the manuscript submitted by Jaroslav Kopernicky suggesting that the attractive force between unlike electrical charges may be slightly greater than the repulsive force between like charges. Since all electrically neutral bodies are composed of combinations of positive and negative charges, Kopernicky suggested that this slight difference might account for gravitational forces. This paper seeks to analyze Kopernicky's concept.

Introduction

Kopernicky's argument for slightly different attractive and repulsive electrostatic forces is graphical. He argues that the electric field force vectors are visibly longer (and therefore weaker) in the repulsive case than in the attractive case, as shown in Fig. 1 (as in Kopernicky's paper). He also presents results from an interesting set of experiments he performed involving permanent magnets. In those experiments he reports an almost linear drop-off with distance for both attractive and repulsive forces, with the attractive force being somewhat greater than the repulsive force.

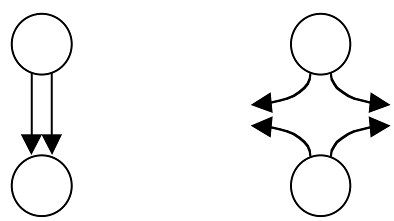

Figure 1. Attraction and repulsion.

Kopernicky's conjecture represents, at the very least, a line of thinking worthy of careful consideration. This discussion will seek to examine three issues:

1) The question of the force vectors being different for attractive and repulsive forces.
2) The order of magnitude of the difference forces that one would expect if they indeed did account for gravitation.
3) Whether or not, if the Kopernicky difference did exist, the inverse-square law would still be obeyed in gravitational systems.

I. Analysis of Electric Field Forces

Because attractive and repulsive forces are inherently assumed to be of equal magnitude by the conventional Coulomb's law, it would seem inappropriate to use that law to make the force calculations. However, there is another scheme that may work better for examining Kopernicky's conjecture. Consider two point charges of equal absolute magnitude, though not necessarily of the same sign, positioned at $x=+s/2$ and $x=-s/2$ with a doubly infinite y-z plane at the origin, as in Fig. 2. If the two charges, q_1 and q_2, are of opposite sign, the electric field is everywhere normal to the y-z plane, as in Fig. 1. If the charges are of the same sign, the electric field is everywhere tangential to the plane, also as in Fig. 1. If the plane is assumed to have an infinitesimal but non-zero thickness Δs, then the following integral represents the energy contained within the planar slab:

$$\mathcal{E} = \frac{1}{2}\varepsilon_0 \Delta s \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \left|\mathbf{E}\right|^2 dydz \tag{1}$$

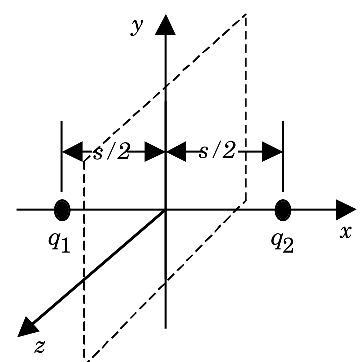

Figure 2. Doubly infinite y-z plane with small but finite thickness Δs.

Dividing the integral (1) by Δs gives the force between the charges. Since we have both multiplied and then divided by the constant Δs, we conclude that for two unlike charges, the attractive force between them is the integral

$$F_{\text{attr}} = \frac{1}{2}\varepsilon_0 \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} E_x^2 dydz \tag{2}$$

and for two like charges, the repulsive force between them is

$$F_{\text{repul}} = \frac{1}{2}\varepsilon_0 \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} E_{\tan}^2 dydz \tag{3}$$

In this case, $E_{\tan}$ is the electric field tangential to the plane.

For Fig. 2, cylindrical symmetry around the x axis allows simplification. We need only calculate the electric field components on the z axis, square them, multiply the result by $\varepsilon_0/2$, then multiply by $2\pi z dz$ and integrate from 0 to ∞. Eqs. (2) and (3) then become

$$F_{\text{attr}} = \pi\varepsilon_0 \int_0^\infty E_x^2 z dz \tag{4}$$

$$F_{\text{repul}} = \pi\varepsilon_0 \int_0^\infty E_{\tan}^2 z dz \tag{5}$$

The attractive force integral for unlike charges (after simplification) is

$$F_{\text{attr}} = \frac{q^2 s^2}{16\pi\varepsilon_0} \int_0^\infty \frac{z dz}{d^6} \tag{6}$$

Similarly, the repulsive force integral for like charges is

$$F_{\text{repul}} = \frac{q^2}{4\pi\varepsilon_0} \int_0^\infty \frac{z^3 dz}{d^6} \tag{7}$$

where

$$d = \sqrt{(s^2/4) + z^2} \tag{8}$$

As it happens, both can be integrated exactly and have precisely the same absolute value as we might have expected; namely,

$$F = q^2 / 4\pi\varepsilon_0 s^2 \tag{9}$$

At first glance, this result would seem to invalidate Kopernicky's conjecture, and it does lend doubt to the argument about electric field force vectors being longer or shorter. However, perhaps Kopernicky's conjecture should not be rejected quite so easily, for reasons that will be presented later.

II. Order of Magnitude of Difference Between Electrostatic and Gravitational Forces

Before going further it is interesting to present two numbers. The first number is the electrostatic force between two point charges, as computed by Coulomb's law where each charge is the electron (or proton) charge, spaced 1 meter apart. That number, to 50 significant figures, is

$$F_x = 10^{-28} \text{ Newtons} \times 2.3097636000000000000000000000000000000000000000000 \tag{10}$$

In case one wonders how any expression involving π can come out even, remember that the value of the permittivity of free space ε_0 is $10^{-9}/36\pi$, and thus the π's divide out.

The second number is the gravitational force between, say, two protons also spaced 1 meter. The Proton mass m_p is $1.6726231 \times 10^{-27}$ kg. The Newtonian constant of gravitation G is $6.67259 \times 10^{-11} \text{m}^3\text{kg}^{-1}\text{s}^{-2}$. The gravitational force between the protons spaced 1 meter is then

$$f_{grav} = G m_p^2 / d^2 = 1.866769 x 10^{-64} \text{Newtons} \tag{11}$$

Thus the difference between electrostatic and gravitational forces for protons, is about 36 orders of magnitude, and even larger for electrons.

III. The Inverse-Square Law

Any theory that purports to represent gravitation as some offshoot of electrostatic or magnetic forces must account for the fact that gravitation obeys the inverse-square law. This is important because by Coulomb's law, the electrostatic force between two or more electrically neutral bodies, each of which is composed of plus and minus charges, fall off at least as the 4th power of the distance between them. This is the major reason why gravitational forces have not heretofore been considered to be electric or magnetic in any form.

We begin this discussion of the inverse-square law by assuming that the attractive force between unlike charges of equal absolute magnitude spaced a fixed distance, say 1 meter, is represented by the symbol f_{attr}, and has a relative value of 1. We also assume that the repulsive force, f_{repul} between equal charges of the same magnitude but also of the same sign and spaced the same distance is k, where k is a number slightly less than 1. Then the difference between the two forces is $f_{\text{diff}} = 1 - k$. Now let us suppose that we have two hypothetical rigid bodies that are electrically neutral overall, but each consists of a plus charge and a minus charge. Assume the two neutral bodies are arranged as in Fig. 3. The spacing between the + and - charges of each rigid body is a and the spacing between the two bodies is s.

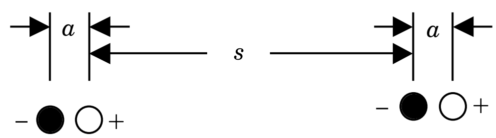

Figure 3.

Let us assume that attractive and repulsive forces between charges, albeit different, both obey the inverse-square law. Then the net electrostatic force of attraction between the two rigid bodies is

$$F_{net} = \frac{q^2}{4\pi\varepsilon_0}\left[-\frac{1}{s^2} - \frac{1}{(s+2a)^2} + \frac{2k}{(s+a)^2}\right] \tag{12}$$

The distance s, the spacing of the rigid bodies, is assumed to be many orders of magnitude larger than a, which would be the inter-atomic spacing since we are considering only gravitational forces, not intermolecular forces. Under those circumstances, a power series expansion of Eq. (12) yields

$$F_{net} = \frac{q^2}{4\pi\varepsilon_0 s^2}\left[-2(1-k) + \frac{4a}{s}(1-k) - \frac{12a^2}{s^2} + \frac{6ka^2}{s^2} - \ldots\right] \tag{13}$$

Since a/s and all higher-order terms would be very small, we can reasonably conclude that

$$F_{\text{net}} \cong -\frac{q^2}{4\pi\varepsilon_0 s^2}(2-2k) \tag{14}$$

and thus the inverse-square-law requirement of gravitational forces is reasonably met in Kopernicky's conjecture unless k is unity, in which case the usual Coulomb's law result occurs and the force drops off as the 4th power of distance.

Other Considerations

It is interesting to examine the question when the physical structure of a charge is distributed over a small but finite region. Since Heisenberg won't even let us know where a charge is for sure, let alone what one looks like, some assumptions that are completely arbitrary must be made about the physical size and shape of charges. Further the force integrals for the shapes we choose will not be of closed form, and numerical methods will be required. Since the differences we are looking for are very small, large numbers of significant figures will have to be carried.

The first case examined was for spherical charges of very small but finite dimensions. An appropriate numerical integration program using Mathematica software and carrying 50 significant figures was written and debugged. The program runs, but the angle and distance increments necessary for numerical integrations are so small that accuracy of thirty or forty significant figures would take years, even for the 1 Ghz pentium computer available to the author. Therefore, a simpler expedient was used: charge distributions were assumed to be simple rings. If there is a slight but finite difference between the attractive and repulsive forces for rings, it can be assumed that the same could also hold for charges of other shapes. Since opposite charges may not be of the same physical size, cases will be examined where charges are both of the same size and also of different sizes.

Consider Fig. 4, in which two charged rings of different radii are illustrated. The absolute value of the total charge on each ring is assumed to equal the electron (or proton) charge. It can be shown that the electric field on the z axis at the point $0,0,z$ due to each ring has components in the x and z direction only. For the left and right rings they are, respectively:

$$E_{x1} = \frac{\sigma s}{8\pi\varepsilon_0}\int_0^{2\pi}\frac{d\phi}{d_1^{\,3}}, \quad E_{z1} = \frac{\sigma z}{4\pi\varepsilon_0}\int_0^{2\pi}\frac{d\phi}{d_1^{\,3}} - \frac{\sigma r_1}{4\pi\varepsilon}\int_0^{2\pi}\frac{\sin\phi\, d\phi}{d_1^{\,3}} \tag{15}$$

$$E_{x2} = -\frac{\sigma s}{8\pi\varepsilon_0}\int_0^{2\pi}\frac{d\phi}{d_2^{\,3}}, \quad E_{z2} = \frac{\sigma z}{4\pi\varepsilon_0}\int_0^{2\pi}\frac{d\phi}{d_2^{\,3}} - \frac{\sigma r_2}{4\pi\varepsilon}\int_0^{2\pi}\frac{\sin\phi\, d\phi}{d_2^{\,3}} \tag{16}$$

where $\sigma = q/2\pi$ is the charge density on the ring, with q being the total charge on each ring, and

$$\begin{aligned} d_1 &= [(s/2)^2 + r_1^{\,2} + z^2 - 2r_1 z\sin\phi]^{1/2} \\ d_2 &= [(s/2)^2 + r_2^{\,2} + z^2 - 2r_2 z\sin\phi]^{1/2} \end{aligned} \tag{17}$$

Following the derivation philosophy of Eqs. (1) through (9), if the rings are of the same radius and of opposite sign, then because $E_{x1} = E_{x2}$ and the E_z fields cancel, the net attractive force between the rings is

$$f_{\text{attr}} = \pi\varepsilon_0\int_0^{\infty}(2E_{x1})^2 z dz \tag{18}$$

If the two rings are of the same radius and the same sign, then the net repulsive force between the rings is (because $E_{z1} = E_{z2}$ and the E_x fields cancel)

$$f_{\text{repul}} = \pi\varepsilon_0\int_0^{\infty}(2E_{z1})^2 z dz \tag{19}$$

If the two rings are of different radii and opposite signs, then the attractive force is

$$f_{\text{attr}} = \pi\varepsilon_0\int_0^{\infty}[(E_{x1}+E_{x2})^2 - (E_{z2}-E_{z1})^2] z dz \tag{20}$$

Because we assume all protons are of the same size and all electrons are also of the same size, we will not consider the case where the rings are of different radii but the same sign.

Computer programs using Mathematica software have been written using an increment of the angle ϕ of $\pi/50$ and carrying 50 significant figures. It was found that smaller increments of the angle ϕ made no difference until beyond 50 significant figures. Increments of z equal to $s/1000$ were used, and the z axis was integrated out to $1000s$. The spacing of the rings s is taken as 1 meter in all calculations.

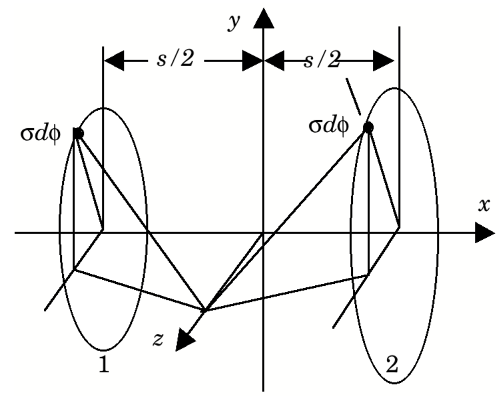

Figure 4. Two rings, one with radius r_1 and the other with radius r_2.

The next question is what radius to use for the charges. Unfortunately, we don't really know how large protons and electrons are, so we will have to guess. Let's assume that the diameter of one is about 10^{-15} m. That is the same order of magnitude as the classical radius of an electron, which is derived from special relativistic considerations, so it is probably as good a number as any.

The first case studied was if the rings were of equal radii equal to 10^{-15} m. The attractive force in Newtons for rings of unlike charge was [to 50 significant figures using Eq. (18)]

$$f_{attr} = 10^{-28}\ \text{Newtons} \times 2.3097651398454893225258821010107671993238938331409 \tag{21}$$

whereas the repulsive force for rings of like charge was [also to 50 significant figures using Eq. (19)]

$$f_{\text{repul}} = 10^{-28}\ \text{Newtons} \times 2.3097624451175551843199991833515113300185815317 07 \tag{22}$$

The attractive force is greater than the repulsive force by

$$f_{\text{diff}} = 10^{-34}\ \text{Newtons} \times 2.694727934138205882917725206632203567997 02 \tag{23}$$

The next problem analyzed was assuming the left ring had a radius of 10^{-18}m and the right ring remained at a radius of 10^{-15}m. The left number was chosen arbitrarily simply to make the two rings have different radii approximating the difference of the classically calculated radii. In this case, when the charges were equal and opposite, the attractive force was [to 50 significant figures using Eq. (20)]

$$f_{\text{attr}} = 10^{-28} \text{ Newtons} \times 2.3097651398454893225258821010801845835638251130 0 \tag{24}$$

This is greater than the attractive force force between two rings of radii 10^{-15}m by

$$f_{\text{diff}} = 10^{-56} \text{ Newtons} \times 0.69417384239931279 96 \tag{25}$$

Finally, for comparison, let us compute the attractive, repulsive, and difference forces for two rings both of radii 10^{-18} m, spaced 1 m apart, and of like charge [again using Eqs. (18) and (19)]. Those numbers are:

$$f_{\text{attr}} = 10^{-28} \text{ Newtons} \times 2.30976513984548932252588210108364923733675789123 \tag{26}$$

$$f_{\text{repul}} = 10^{-28} \text{ Newtons} \times 2.30976244511755518431999918335844260253460831359 \tag{27}$$

$$f_{\text{diff}} = 10^{-34} \text{ Newtons} \times 2.6947279341382058829177252066348021495776 4 \tag{28}$$

As the radii get smaller, the forces approach the point charge forces, as would be expected. We note that this repulsive force is actually slightly greater than the attractive force between the two rings of different radii beginning in the 30th decimal place.

Actually, many combinations of these programs have been run with similar general results with the differences generally in the 5 to 10th place. However, as the numerical integration increments become smaller, and the range of integration greater, the differences between attractive and repulsive forces become smaller, although they have never equaled zero. Of course we are looking for differences in perhaps the thirtieth or greater decimal place. To carry enough significant figures and to use small enough integration increments to achieve that result would take literally years of computation on the 1 Ghz pentium computer. The computations presented here all took more than 24 hours each. It may be an issue worthy of study on a supercomputer to see if the differences ever converge to some small but finite value or simply disappear altogether.

One must also report a negative note. When a similar program was written involving four rings, two plus and two minus, the inverse-square law was not obeyed, the forces varying as the 4th power of distance. When the repulsive components were multiplied by a number k slightly less than unity (actually 0.99999), the inverse-square law was obeyed as predicted by Eqs. (13) and (14).

This reviewer would be happy to provide copies of any of the computer programs to any seriously interested persons.

Conclusions

A first conclusion is that, since the inverse-square law was not obeyed for four rings unless the constant k was inserted, if Kopernicky's conjecture is true, it probably represents some microscopic phenomenon not inherent in the conventionally accepted field equations. If such a phenomenon exists, it is not unreasonable that it has not been discovered before, because the differences are so miniscule that they would not be detectable in the normal physical experiments performed historically as the basis for the formulation of the conventional field equations. Further, the simple models used for the calculations presented here must certainly be naive compared to the actual case. For example, besides electrostatic field forces between charged particles, there are other forces such as those caused by magnetic moments, which have not been taken into account.

Thus it is important not to read too much into this analysis. It merely gives some small credence to the postulate that perhaps attractive forces between charges of equal magnitude but different sign may be very slightly greater (perhaps due to geometric size) than the repulsive forces between charges of equal magnitude, sign, and size. If that is so, the implication is that gravity might really be a subtle electromagnetic manifestation after all. That is the importance of the Kopernicky conjecture. In this reviewer's opinion, whether its probability of being correct is high or low, the conjecture is worthy of further serious study. This reviewer has spent several hundred hours examining various aspects of Kopernicky's idea, and will continue to do so.

The Black Hills historian Watson Parker says "Some things that may or may not be true really ought to be." Kopernicky's conjecture may be one of them. Already several papers in Galilean Electrodynamics have suggested that inertial mass may have electromagnetic roots, one written by this reviewer. If gravitational mass also has electromagnetic roots of some kind, we must then contemplate the implication that the macroscopic nature of the Universe may be essentially determined by the microscopic nature of matter. Perhaps the resemblance of Kopernicky's name to that of a former scientific pioneer, Nicolaus Copernicus, is prophetic. The late Petr Beckman, in his book *Einstein Plus Two*, obviously had a gut-level suspicion that there is a relationship between electromagnetic phenomenon and gravitation, although he clearly pointed out the inconsistencies. This reviewer has shared that suspicion for many years, and he admits that fact may have colored this review. Petr would be cheering the study on.

Editor's Update

The original Kopernicky submission came to us in November of 2001. For review we sent it to Bill Hughes, who took an immediate interest in the idea. Indeed, he investigated so thoroughly that he produced the above paper. Kopernicky and Hughes have continued their interaction ever since then, and as a result there will be more publications in GED in the future. But as always, publication takes a long time. Readers are invited to get more current updates on the investigations at the website that Kopernicky and Hughes have set up: www.electmag.com. Your Editor is delighted to see so much activity stimulated! *C.K.W.*