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Could Electricity be a Gravitational Effect?

Halley's comet, Elenin's comet, Bohr's atom, a free digression throughout gravitation

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ABSTRACT

Although electricity and electrical forces have for a long time been used by mankind as natural resources, it is interesting to notice that in fact no one knows exactly what they are. Some curious-minded people have asked themselves if electric forces could result from gravitational interaction between subatomic particles. The usual argument to avoid such an hypothesis is based on the computation of the gravitational force by means of Newton's equation, to verify that the force between a proton and an electron is nearly 10^{40} times weaker than the electrical force computed by Coulomb's equation. In this article we ponder on such an argument, since we have the impression that Newton's gravitational force does not hold at very small distances, and probably also not in highly eccentric orbits. By analysing the cases of Halley's and Elenin's comets (Elenin is now very close to Earth), and proposing the use of an orbital constant (G_0) alongside the universal constant (G), we will later question if the gravitational force in Bohr's atom could perhaps turn out to be of the same magnitude as that of the electrical force obtained by Coulomb's equation. And this naturally leads us to wonder whether electricity could result from some kind of gravitational effect propagating through certain types of materials, like a pressure wave, for example. If in fact gravitational forces would be much stronger at very small distances than what is usually accepted, the need for a "dark matter" concept to justify the overall cohesion of our universe would perhaps be unnecessary too.

1. Introduction

"Either we have failed to see 99% of the universe, or we are wrong about how the universe began" (Stephen Hawking). When reading this remark for the first time from Hawking, we could not avoid thinking that we have probably failed to see even more than that. Many standard theories are simply crowded with little contradictions, little things people do not want to talk about, and little excuses. But, even so, it is interesting to notice that they are frequently presented as the ultimate models, the very truth of the moment, and the direction to follow. It has forever been confusing to us, that "standard model" scientists insist so much upon the hypothesis of there being "dark matter" crowding the universe, yet they apparently refuse to question the models we use for gravitational force. In order to sustain itself, either the universe needs more mass, hence we have to invent the idea of "dark matter" coexisting, or could it simply be that the forces between masses are much stronger than what has been suggested, thus accounting for this "dark matter"? This case, amongst many others, needs to be considered. Another example is the apparent eternal search for the "graviton", where here it seems that the more negative the results become, the more the scientists seem to believe it is just very difficult to detect it. Couldn't we simply advance in parallel with some other hypothesis?

Maybe our thoughts on these matters will be seen as marginal to those who seriously protect the standard models, but we still believe it is preferable to question any aspects that may seem relevant. Such work we started in the article[1] concerning the

[1] J. Manuel Feliz-Teixeira, "*Deducing Kepler and Newton from Avicenna* (ابن سينا)*, Huygens and Descartes*", first published at http://www.fe.up.pt/~feliz, and YouTube, April 2010

derivation of gravitational forces based on two basic premises: the general validity of the law of conservation of angular momentum; and the fact that bodies fall into their centre of mass. From these, we could deduce that, since *area speed* ($\underline{A} = \underline{r} \times \underline{v}$) is a true *constant for any orbit*, more appropriate than using Newton's universal gravitational constant (G) would perhaps be to express the gravitational force in terms of an *orbital constant* (G_0) given by:

$$G_0 = A^2 / (M+m) \qquad (1)$$

Here, $(M+m)$ is the total mass involved in the process. In this way, a general expression for the gravitational force between masses M and m would be:

$$F_{feliz} = m \,.\, M \,.\, G_0 \,/\, r^3 \qquad (2)$$

Since Newton's force is given by:

$$F_{newton} = m \,.\, M \,.\, G \,/\, r^2 \qquad (3)$$

Therefore, for nearly circular orbits we have:

$$G = G_0 / r \qquad (4)$$

What does this mean? It means that gravitational forces may be viewed as depending on $1/r^3$ along the trajectory of a certain and specific orbit, no matter its shape; and it means that Newton's universal constant (G) should perhaps be used only for nearly circular orbits, as we will see. In other words, F_{feliz} seems to hold for any situation of motion, while F_{newton} seems to make more sense for nearly circular orbits. We will address this issue by comparing data from the most important planets of our solar system along with Halley's and Elenin's comets.

2. Our planets and Halley's comet

In the following tables we present relevant data about the principal planets of our solar system, most of which orbit the Sun with almost circular orbits (maximum eccentricity is 0,2 for both Mercury and Pluto), and Halley's comet, which orbits the Sun along an ellipse of 0,97 eccentricity, out of the *ecliptic plane* (inclination=162º). Due to the obvious differences in the orbital characteristics, we have chosen this data in order to test the two different concepts of gravitational force previously referred to. Notice that in the case of Halley's comet three rows are presented, in order to distinguish the *perihelion*, the *aphelion*, and the *average* orbit computed by an average radius and the time for an entire circulation around the Sun. This average radius is given by (89+5267)/2 = 2678 (units of table 1); and the average velocity was computed based on the fact that its period is around 74 years (i.e. 2397 x 10^6 s):

$$v = 2\pi \,.\, r \,/\, T \qquad (5)$$

The Sun's mass was considered to be 1989100000 x 10^{21} kg, and G = 6,67 x 10^{-11} SI.

	m x 10e+21 kg	r x 10e+9 m	v x 10e+3 m/s	ω=v/r x 10e-9 rad/s
Mercury	330	58	47.9	825.9
Venus	4869	108	35.0	324.1
Earth	5974	150	29.8	198.7
Mars	642	228	24.1	105.7
Jupiter	1898600	778	13.1	16.8
Saturn	568460	1429	9.6	6.7
Uranus	86832	2871	6.8	2.4
Neptune	102430	4504	5.4	1.2
Pluto	13	5913	4.7	0.8
Halley (perihelion	0	89	54.6	616.9
Halley (aphelion)	0	5267	0.9	0.2
Halley (average)	0	2678	7.0	2.6

Table 1 Some basic astronomical data for the planets of our solar system and Halley's comet. The International System of Units (*SI*) is used. From left to right: mass (m), average distance to Sun (r), orbital velocity (v), and angular speed (ω). Although Halley's comet mass appears null in this table, in all calculations we have used an approximate mass of 10^{14} kg.

	r x v x 10e+12	G0 x 10e+3	[G = G0/r] x 10e-6	[v2/r] x 10e-3
Mercury	2778	0.004	6.6902497566133E-005	39.5588
Venus	3780	0.007	6.6512330292454E-005	11.3426
Earth	4470	0.010	6.6967774350864E-005	5.9203
Mars	5495	0.015	6.6575153219415E-005	2.5474
Jupiter	10192	0.052	6.7058098383394E-005	0.2206
Saturn	13718	0.095	6.6190243574550E-005	0.0645
Uranus	19523	0.192	6.6738346476245E-005	0.0161
Neptune	24322	0.297	6.6024773557109E-005	0.0065
Pluto	27791	0.388	0.000065667	0.0037
Halley (perihelion)	4832	0.012	0.0001326392	33.6854
Halley (aphelion)	4740	0.011	2.1446206827208E-006	0.0002
Halley (average)	18792	0.178	6.6306406189806E-005	0.0184

Table 2 Append to the previous table. From left to right: area speed ($r \times v$), Feliz's orbital constant (G_0), Newton's universal constant ($G = G_0/r$), and Huygens centrifugal acceleration (v^2/r). Notice the similarity between Halley's average orbit with Uranus orbit.

This data[2], and explicitly the data of Table 2, confirms that G can be computed by dividing the

[2] Most of it collected from the Internet sources, mainly Wikipedia.

orbital constant G_0 by the mean orbital radius. The *average* Halley's orbit must obviously be considered a circular orbit too, therefore G can be found the same way. But in this case Halley is being modelled as if it were an asteroid following an orbit very similar to that of Uranus. And this is not the reality. If we consider a more realistic situation, and use Halley's *perihelion* and *aphelion*, such simplifications seem not to be valid.

A demonstration of this naturally arises if we calculate the gravitational acceleration expected at Halley's *aphelion* by Newton's model:

$$a_{a\text{-}newton} = 6{,}67\times10^{-11} \,.\, 1{,}99\times10^{30} \,/\, (5267\times10^{9})^{2} = 4{,}78\times10^{-6}\ \text{m/s}^2 \qquad (6)$$

and compare it with that calculated by Feliz's equation (using an average value for G_0 = 11,5 from Table 2):

$$a_{a\text{-}feliz} = 11{,}5 \,.\, 1{,}99\times10^{30} \,/\, (5267\times10^{9})^{3} = 0.000156624956\times10^{-3} = 0{,}157\times10^{-6}\ \text{m/s}^2 \qquad (7)$$

The results are obviously different, and confirm that equation (7) leads to practically the same value of the *centrifugal acceleration*[3] acting upon Halley at its *aphelion*, as shown in Table 2. Newton's estimation is around 30 times larger than this, making us wonder if there could be a point somewhere in the orbit, *before its aphelion* where Newton's force would exactly match Huygens centrifugal force. And, if this is true, why doesn't the comet start to invert its motion from there? Could there be a force associated with movement itself, which keeps the comet moving in space for some more time? Of course all could be explained in terms of the exchange of kinetic and potential energies, but we would like to use the concept of force.

Let us now make the same calculations for Halley's *perihelion*. By Newton, we have:

$$a_{p\text{-}newton} = 6{,}67\times10^{-11} \,.\, 1{,}99\times10^{30} \,/\, (89\times10^{9})^{2} = 16{,}8\ 10^{-3}\ \text{m/s}^2 \qquad (8)$$

Whilst by Feliz we will get:

$$a_{p\text{-}feliz} = 11{,}5 \,.\, 1{,}99\times10^{30} \,/\, (89\times10^{9})^{3} = 32{,}46\times10^{-3}\ \text{m/s}^2 \qquad (9)$$

Again, our equation gives practically the same result as that expected in Table 2 for the *centrifugal acceleration* at *perihelion*, which, in our opinion, means that the comet is in effect in a stationary orbit. Newton, on the other hand, expects less gravitational pull, meaning that Halley is at *perihelion* with an "excess" of *centrifugal acceleration*, which in effect is responsible for sending it away from the Sun again and in the direction of its external orbit: *aphelion* (r_a). This seems reasonable. In his demonstration of elliptical orbits, Newton considers a radial term for non-circular trajectories, but it seems there are some mysteries here, or at least two different ways of looking at things. By Newton, what moves the comet away from the Sun at *perihelion* is this "excess" of speed compared to that needed to maintain a circular orbit at *perihelion*. In our point of view, it may also be that the comet has a *centrifugal acceleration* exactly matching the *centripetal pull* from the Sun (thus, $1/r^3$ dependency), but it cannot stay in a circular orbit there otherwise the total energy of the system (of the entire orbit) would suddenly jump. This cannot occur, at least naturally, and the system has to continue oscillating between its two extreme states: *aphelion* and *perihelion*. It's as if the comet is continuously jumping from one circular orbit into another, butt always being in orbit in each of these orbits:

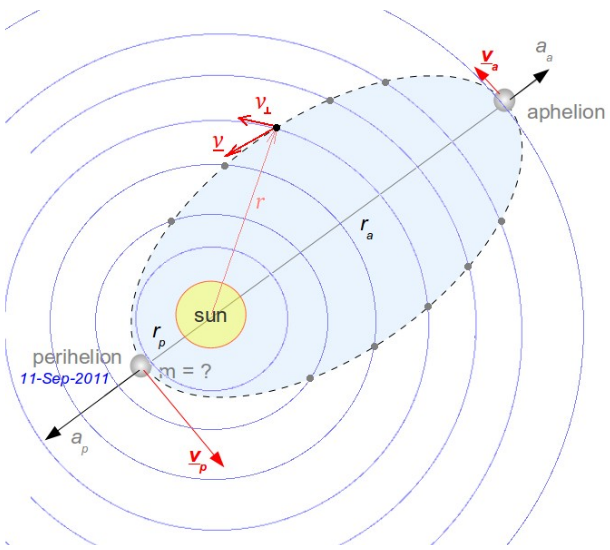

Fig. 1 Ellipse as a continuous jump into different circular orbits.

[3] The term *centrifugal* is usually demonized, but here you may find why we use it again: http://paginas.fe.up.pt/~feliz/e_paper30_in-defense-of-centrifugal-force-revised.pdf

Thus, we may consider that at each point of the trajectory the gravitational *centripetal pull* is always balancing the comet's *centrifugal push*, so we may really think of a $1/r^3$ dependency for gravitational forces[4]. Notice that the *centrifugal push* is only dependent on the *perpendicular* component of the *velocity*, and not on its *radial* component. In other words, the *gravitational pull* needed to maintain the object in each circular orbit, and therefore throughout the whole trajectory, is only that which compensates such a *centrifugal push*. If we consider the fact that *area speed* is conserved along the whole trajectory, no matter its shape, that is:

$$r_a \,.\, v_a = r_p \,.\, v_p = r \,.\, v_\perp = const = A \qquad (10)$$

then we can represent the centrifugal acceleration[5] at *aphelion* in terms of the acceleration at *perihelion* as:

$$a_a = v_a^2 / r_a = (r_p/r_a)^3 \,.\, a_p \qquad (11)$$

Also, for a generic position (r) in the generic orbit, we may in fact expect a cubic dependency:

$$a(r) = (r_p/r)^3 \,.\, a_p = r_p^3 \,.\, a_p / r^3 \qquad (12)$$

$$a(r) = A^2 / r^3 \qquad (13)$$

Of course there is a mechanism of angular acceleration and deceleration along any non-circular orbit, but it's possible that this could be the result of a mix of *centrifugal* and *Coriolis* effects. *Centrifugal* produced by changing $v_\perp$, and *Coriolis* produced by changing r.

Interestingly, for long distances the gravitational pull from Newton's model seems to be larger than what we propose, while for “short” distances it seems to be lower than that. The two models agree at a distance equal to the average radius of the elliptical orbit. That is, when r = *semi-major-axis*, a condition always true for circular orbits. In that case, G can again be computed from dividing G_0 by r, as Table 2 shows.

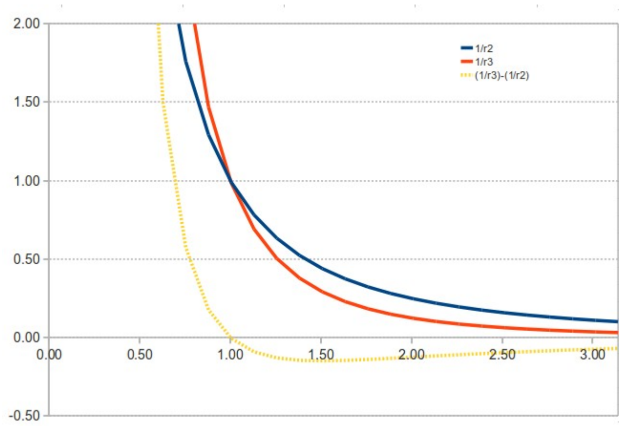

Fig. 2 Comparing the mathematical functions $1/r^2$ and $1/r^3$ and the difference between them. Only at $r = 1$, which corresponds to the case of circular orbits, the two functions coincide. For long distances, $1/r^3$ will be smaller than $1/r^2$, but the difference tends to zero; while for very small distances $1/r^3$ gets much larger than $1/r^2$, and the difference tends to infinity.

3. What do G and G_0 actually mean?

There are many ways for interpreting the meaning of physical constants, depending on the physical quantities we want to enhance. For example, G is usually presented with dimensions [$m^3.kg^{-1}.s^{-2}$], but may also be seen as an *energy per unit of mass* times a *distance per unit of mass*, that is, a *specific energy* times a *specific distance*. In that way, the constant G_0 would be seen as a *specific energy* times a *specific area*, since we can say that $G_0 = G.r$. We prefer, however, to look at the constant G_0 as a sort of a *gravitational index* which gives us the idea of how much a certain orbit is bounded to the gravitational system. It does not depend on the distance, as we can deduce from comparing the data of Halley's *perihelion* and *aphelion*, which have the same value for G_0, but instead on the power of the angular momentum and the total mass involved in the motion. In that sense, we can say that a low value of G_0 means a low degree of freedom within the gravitational system, or highly bounded[6]. By inspecting Table 2 again, not only can we deduce that the planet most bounded to the system is Mercury (G_0 = 4), as we would expect, but that Halley's comet (G_0 = 11) is only slightly less

[4] If we use only the concepts of energy (E) and angular momentum (L), knowing that L will be conserved in all circular orbits: thus, $v_\perp = L/(m.r)$. And $E_\perp = ½\, m.v_\perp^2 = \{L^2/(2.m)\}.1/r^2 = const1 / r^2$. This is the energy of the orbit at radius r.

[5] We mean Huygens centrifugal acceleration projected into the position vector (radial component).

[6] Thus, G_0 means the level of freedom.

bounded than our Earth (G_0 = 10). The least bounded to our solar system is obviously Pluto (G_0 = 388). Such a result means that it would be much easier to force any of the outer planets out of the solar system than Halley itself. In this way, G is simply the linear density of G_0.

4. The surprising visit of comet Elenin

When no one was expecting it, a little known Russian amateur astronomer, named Leonid Elenin, recently discovered in the skies a new visitor to the core of our solar system: the comet C/2010 X1. This happened on the 10th of December 2010, and, on that date, a certain eccentricity (e) was computed for its orbit; which was expected to be either parabolic (e=1) or hyperbolic (e>1), meaning that this asteroid would be an occasional visitor, not some body bounded to us. Analysing data obtained by means of simulation prior to the discovery of the comet, some people have published their calculations on the Internet. There is a case of a chart showing a sudden change on Elenin's orbit eccentricity (previously estimated by NASA to be e=1.000064048145741) which after the *perihelion*, transformed this interesting celestial visitor into something that is bounded to our solar system, now describing an ellipse... The new eccentricity is said to be near e=0,999, therefore the question of the possibility of Elenin being on a return journey to its star arises. Some information is already published in Wikipedia about the event, although most of it seems to be the result of some speculation. The *aphelion* is a rough estimation of ~1037 AU; and the *perihelion* is said to have happened on the 10-Sep-2011, but NASA's dynamic chart obviously shows it occurred precisely on 11-September-2011; mysteriously, since this was the 10th anniversary of the strange 11-September-2001 New York's World Trade Centre attacks that shook our world.

The most accurate data (as it was measured), however, seems to be the *perihelion* distance (r_p), the three-dimensional velocity (v_x, v_y, v_z), and the actual eccentricity (e). To this day, no one seems to have been able to estimate the real mass of Elenin, which is fast approaching Earth[7], and is believed to be around 3-4 Km in diameter. Some people, however, are also relating this visit to the surprising high number of catastrophes of the recent times, including the abnormally strong earthquakes, tornadoes, floods, etc., thus suspecting the comet to have a mass of the order of a planet or more[8]. A scientist who seems to agree with such a perspective is Mr Mensur Omerbashich, as described in his recent article on the "*Astronomical alignments as the cause of ~M6+ seismicity*"[9]. We notice, curiously, at the time when this important event is taking place, no one seems to know what to say. Perhaps fascination is more powerful than science, making us simply astonished. In the scope of this article, however, what matters is to verify if the observed Huygens acceleration of Elenin at its *perihelion* and *aphelion* matches (or not) the gravitational pull imposed by the Sun. That was the condition Newton used in order to deduce his gravitational force equation. Starting with the known parameters[10]:

$$r_p = 0{,}482430958137433 \text{ UA} = 72{,}4 \times 10^9 \text{ m}$$
$$v_{px} = 48027{,}11773370915 \text{ m/s}$$
$$v_{py} = 36972{,}12924493306 \text{ m/s}$$
$$v_{pz} = 1874{,}218585052105 \text{ m/s}$$

and that

$$e = 0{,}999$$

From http://en.wikipedia.org/wiki/File:Elenin_Ecc2011-03-25.gif

We compute the speed at *perihelion*:

$$v_p = \sqrt{\{v_{px}^{\ 2} + v_{px}^{\ 2} + v_{px}^{\ 2}\}} = 60{,}6387 \times 10^3 \text{ m/s} \quad (14)$$

Therefore the orbital constant G_0 for Elenin is:

$$G_0 = (r_p \,.\, v_p)^2 / (M+m) = 0.0096809 \times 10^3 \text{ S.I.} \quad (15)$$

By our previous considerations, this means that Elenin (G_0=9,7) is not only more bounded to our solar system than Halley (G_0=11,5), for example, but, once again curiously, it is practically as bounded as our own Earth (G_0=10,0). It is not surprising then, that many people on the Internet, express the

[7] This text was written before 16-Oct-2011, when Elenin was expected to be at the closest distance to the Earth, at near 0,2 AU from us.

[8] Video showing an example of a curious view on what is happening based on a challenging perspective: http://youtu.be/RnG8Pa0u-4U

[9] Ful text (pdf): http://lanl.arxiv.org/pdf/1104.2036

[10] Based on data from the source: http://ssd.jpl.nasa.gov/horizons.cgi?CGISESSID=f40a36e9863e959034348bb998f81273#results

feeling that this comet may be some sort of a biblical visitor. The real centrifugal acceleration of Elenin at *perihelion* will, nevertheless, be:

$$a_p = v_p^2 / r_p = 50{,}7881\times10^{-3} \text{ m/s}^2 \quad (16)$$

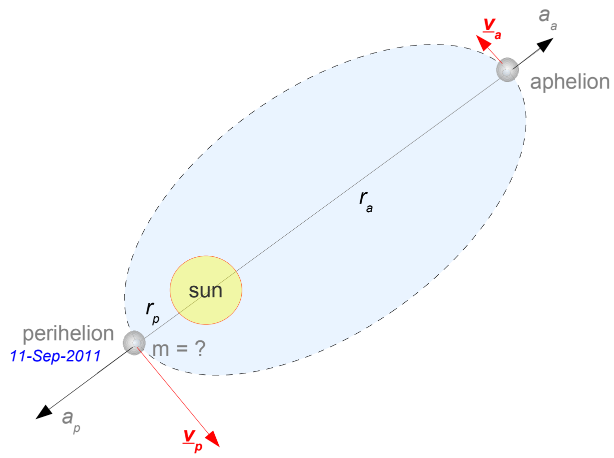

Fig. 3 A simplistic representation of a previously unexpected elliptical orbit for Elenin, showing the centrifugal acceleration (a) and the velocity (v) both at *perihelion* and *aphelion*. The real trajectory will be much more eccentric than the represented here, as r_a is suspected to be around 2000 times larger than r_p.

But let us compute the gravitational acceleration at *perihelion*, due to the Sun. By Newton's method we have:

$$a_{p\text{-}newton} = 6{,}67\times10^{-11} \,.\, 1{,}99\times10^{30} / (72{,}4\times10^{9})^2$$
$$= 25{,}3\times10^{-3} \text{ m/s}^2 \quad (17)$$

Again, it is obviously not enough to keep Elenin in a circular orbit at that point, being only <u>half</u> of that required to do so. From the point of view of Newton, Elenin would stay in a circular orbit[11] at *perihelion* if it would have a speed $v_p = \sqrt{\{G.M/r_p\}} = 42{,}8\times10^3$ m/s, but in reality its speed is much higher: $v_p = 60{,}6\times10^3$ m/s. At that same point, the speed needed to escape from the Sun (*escape velocity*) will be $v_{esc} = \sqrt{\{2.G.M/r_p\}} = 60{,}528\times 10^{-3}$ m/s, which suggests that Elenin is not bounded to the Sun.

Using our method, however, we get:

$$a_{p\text{-}feliz} = 0.0096809\times10^{3} \,.\, 1{,}99\times10^{30} / (72{,}4\times10^{9})^3$$
$$= 50{,}76\times10^{-3} \text{ m/s}^2 \quad (18)$$

which is the same as the centrifugal acceleration, of course, since G_0 was computed by means of the *perihelion* data. In order to do the same calculation for the *aphelion*, let us start by estimating r_a by means of the eccentricity relation:

$$(1 - e)/(1+e) = r_p/r_a \quad (19)$$

Which leads to:

$$r_a = 1999 \,.\, r_p$$
$$= 144656{,}96\times10^{9} \text{ m} = 964.38 \text{ AU} \quad (20)$$

Wikipedia presently gives an estimation of r_a of around ~1037 AU. In any case, these are really astronomical distances, around 24 times the distance to Pluto! Light would need 5,6 days to travel such a distance. It is therefore expectable that the influence of our Sun will be practically null there. The predictions are:

$$a_{a\text{-}newton} = 0{,}000006\times10^{-3} \text{ m/s}^2 \quad (21)$$
$$a_{a\text{-}feliz} = 0{,}000000006\times10^{-3} \text{ m/s}^2 \quad (22)$$

This suggests that Newton's gravitational acceleration at *perihelion* is roughly 1000 times stronger than the comet's centrifugal acceleration. Thereby, once again, making us wonder why... Would not a point much *before aphelion* where such a strong gravitational attraction would match Huygens force, make the trajectory start to deviate towards the Sun again? One also wonders if this may be due to the inertia of the motion, but, could it also be that this is tending towards the idea of a gravitational field that is dependent on $1/r^3$?

<u>Elenin's orbital period:</u>

In order to estimate the period of Elenin we must first imagine it travelling in a *circular orbit* with a radius given by the *average radius* of the real orbit. That is:

$$r_{avr} = (r_p + r_a) / 2 = 1000 \,.\, r_p = 72400\times10^{9} \text{ m}$$

Since we are now dealing with a circular orbit, we will use Newton's equation again. And, by imposing that the now *imaginary* centrifugal force equals the *imaginary* gravitational pull, we find the average orbital speed:

$$v_{avr} = \sqrt{\{G.M / r_{avr}\}} \quad (23)$$

[11] Notice that Newton derives all his theory of gravitation from proposing a central force of the same magnitude of the Huygens force (centrifugal).

$v_{avr} = 1{,}3540047 \times 10^3$ m/s

Thus, we expect Elenin to have a period of:

$$T = 2\pi \,.\, r_{avr} / v_{avr} = 335970221566 \text{ s} = 10645 \text{ yr} \quad (24)$$

If this is correct, the last time Elenin would have visited the Earth would have been around 8600 BC, when humans were in the early neolithic period of their collective history, and starting to develop agriculture and a sedentary civilization, in the way of a superior being based upon intellect.

5. Bohr's atom

The previous results make us wonder if the gravitational force between two masses, if in fact it exists, can be correctly estimated in all these cases by means of the equation proposed by Newton. It seems not. Perhaps either *G* is not a universal constant or there are other forces "adding" up to Newton's centripetal force. It makes us also wonder on the possibility of movement itself being the source of some kind of force, which may send comets into longer *aphelion* distances than those expected by Newton's gravitational force. Curiously, in our article on the Geometric Law of Motion[12] we have proposed that a kind of *Coriolis* acceleration may also exist in the case of non-circular orbits, which may also be responsible for part of the *acceleration* while moving into *perihelion* and the *deceleration* when heading to *aphelion*. Could such a non-gravitational interference justify what seem to be some deviations from Newton's expectations? Perhaps we will address this issue another time.

Nevertheless, we have verified in this article that considering gravitational forces to be dependent on $1/r^3$ could perhaps be an interesting possibility. So, we have decided also to test such an idea for very small distances in the atomic world. As Bohr's atom (Hydrogen) is such a classical academical example for atomic mechanics, we will make use of it here. In this instance, however, we will consider that the electron is describing a circular orbit around the proton, therefore Newton's universal constant should also hold. Knowing the proton mass (M=1,7×10^{-27} kg), the electron mass (m=9,1×10^{-31} kg), and the radius of Bohr (r=5,3×10^{-11} m), the gravitational acceleration expected by Newton is:

$$a_{bohr\text{-}n} = 6{,}67 \times 10^{-11} \,.\, 1{,}7 \times 10^{-27} / (5 \times 10^{-11})^2 = 0{,}45 \times 10^{-16} \text{ m/s}^2 \quad (25)$$

This produces a centripetal force on the electron of the order of 4,1×10^{-47} N. This is an extremely weak force, usually said not to be enough to explain the atomic robustness observed in nature. This is also the standard argument used for rejecting any hypothesis proposing that matter could perhaps be maintained in cohesion in the atomic world due to gravitational interactions, instead of electrical forces. In effect, for such an hypothesis to be valid it should be demonstrated that gravitational forces could be as strong as the actual electrical forces observed in practice, which are well predicted by means of the Coulomb equation, as we know:

$$F_{coulomb} = q_p \,.\, q_e \,.\, K_e / r^2 \quad (26)$$

where the electric constant K_e = 8,99×10^9 SI, the proton electric charge q_p = 1,6×10^{-19} C and the electron charge $q_e = q_p$. The electrical force acting on the electron will therefore be:

$$F_{coulomb} = (1{,}6 \times 10^{-19})^2 \,.\, 8{,}99 \times 10^9 / (5 \times 10^{-11})^2 = 9{,}2 \times 10^{-8} \text{ N} \quad (27)$$

which in fact is 2,24×10^{39} times (!) stronger than the gravitational force previously estimated by Newton. Coulomb's force, however, is computed based on the concept of *charge* and some other electrical parameters. It is not based on *masses* and the usual concepts of gravitation. It is another paradigm, thus another type of force.

Let us, nevertheless, try to apply our gravitational equation of force:

$$F_{feliz} = G_0 \,.\, m \,.\, M / r^3 \quad (28)$$

where G_0 in this case is given by:

$$G_0 = (r_b \,.\, v_b)^2 / (M+m) \quad (29)$$

[12] J. Manuel Feliz-Teixeira, "*The Geometric Law of Motion*", first published at http://www.fe.up.pt/~feliz, and YouTube, 25 July 2011

r_b and v_b being Bohr's radius and electron speed respectively. Or, in terms of angular momentum:

$$G_0 = (L_b/m)^2 / (M+m) \quad (30)$$

But, since we now may use Bohr's proposal for the quantification of angular momentum in atomic physics, which must always be an integer (n) related to Planck's constant ($h = 6{,}62606957\times 10^{-34}$ J.s):

$$L_b = n \,.\, h/(2\pi) \quad (31)$$

Then we may generalise our G_0 expression for the subatomic world, for the n^{th} electronic orbital:

$$G_{0\text{-}n} = \{n \,.\, h/(2\pi.m)\}^2 / (M+m) \quad (32)$$

And now we may compute the gravitational force by means of equation (28), considering only masses and the usual gravitational concepts.

$$F_{feliz} = (1/4\pi^2) \,.\{(n.h/m)^2/(M+m)\} \,.m.M/r_n^{\,3} \quad (33)$$

Or, using the reduced mass ($\mu = m.M/(M+m)$):

$$F_{feliz} = (1/4\pi^2) \,.\, \{n \,.\, h/m\}^2 \,.\, \mu \,/\, r_n^{\,3} \quad (34)$$

This will give a gravitational force between the proton and Bohr's electron ($n=1$) of the order:

$$F_{feliz} = (1/4\pi^2) \,.(6{,}63\times 10^{-34}/9{,}1\times 10^{-31})^2 \,.\, 9{,}095\times 10^{-31} /(5{,}3\times 10^{-11})^3 = (1/4\pi^2) \,.\, (7{,}29\times 10^{-4})^2 \,.\, 6{,}109$$

$$F_{feliz} = 8{,}22\times 10^{-8} \text{ N} \quad (35)$$

That is, a gravitational force of the same order as Coulomb's electric force. But this was expected, since this deduction is based on an indirect circular computation. Interesting would be to test it with elongated types of orbitals (*p-type*, for example). In any case, it is interesting to notice that Planck's constant lets us compute the force between an electron and a proton based on an equation involving gravitating *masses*, instead of gravitating *charges*. Could this mean something else? The first reaction is to ask ourselves if electricity could somehow be a kind of gravitational pressure which propagates in certain materials (conductors) through its valence electrons. The second reaction is to wonder if all forces, including nuclear forces, could simply turn out to be different realisations, or states, of a single source of power: the gravitational interaction? It seems that, between protons ($2{,}3\times 10^{-28}$ m), nuclear forces are also 10^{39} times stronger than gravitational forces. Then they seem to remain constant along a quark distance. Could it be that there is *another constant* similar to that of Planck's constant for the nuclear world? It would be nice to dedicate some time to these questions, if possible, in the future.

Notice that our gravitational force can also be expressed as a function of the angular speed (ω) of the electron (or orbiting mass, in general), and the mass relation $\eta = M/(M+m)$ and be written in a form that brings to mind harmonic motion, but with an *elastic constant* (κ) dependent upon r, if ω depends on r:

$$F_{feliz} = -\, m \,.\, \eta \,.\, \omega^2 \,.\, r \quad (36)$$

$$F_{feliz} = -\, \kappa \,.\, r \quad (37)$$

6. A naturally unstable universe?

So, in our perspective, for orbital motion to be perfectly "stable" it would be necessary that the *centripetal* force matches the *centrifugal* force in any point of the trajectory. This means that equation (36) must be equal to Huygens centrifugal force $m.v^2/r = m.\omega^2.r$ acting upon the orbiting mass. That is, for any position on the trajectory:

$$F_{feliz} + F_{centrifugal} = 0 \quad (38)$$

$$m \,.\, \eta \,.\, \omega^2 \,.\, r = m \,.\, \omega^2 \,.\, r \quad (39)$$

$$\eta = M/(M+m) = 1 \quad (40)$$

Would this be the condition for ensuring an 100% stable orbit? It may eventually also be seen as the *probability* that mass m establishes an orbit around mass M. If that is true, it means our universe is naturally unstable, since $\eta = 1$ is not possible in practice. It also may explain why masses of the same order (η=0,5) are rarely observed rotating about each other. From equation (38) we should expect that their capacity of attraction is only half of that required for an orbit, therefore equal masses rotating would tend to repel due to centrifugal forces, instead of attracting each other. A proton would repel a proton, an electron would repel an electron, galaxies would not easily collapse into each other… since they have a low probability of orbiting each other. Sufficiently stable systems seem to have $\eta > 0{,}95$, as is the case of electrons orbiting protons, for example, moons orbiting planets, planets orbiting stars, a star orbiting a galaxy, etc.

7. Curiosity about *G, h* and Avogadro's number

Another interesting exercise is to try to connect atomic mechanics with our world's macroscopic and planetary mechanics, by somehow comparing the two fundamental constants of these worlds: Planck's constant (h) in the atomic world, and the universal constant of gravitation (G) in the macroscopic world. From that we will find out that multiplying the minimum angular momentum allowed by Planck in the atomic world $L_0 = h/(2\pi)$ by Avogadro's number $Av = 6{,}022\text{x}10^{23}\ \text{mol}^{-1}$ will result in a number very near Newton's universal constant of gravitation, even if not with the same units:

$$L_0 \,.\, Av = 6{,}354 \times 10^{-11}\ \text{S.I.} \tag{41}$$

While,

$$G = 6{,}67 \times 10^{-11}\ \text{S.I.} \tag{42}$$

Could somehow Newton and Planck be talking about the same thing, but at very different spatial scales and units?

8. Conclusion

Sometimes a simple digression around a subject may result in some interesting questions and ideas. That was the aim of this article. It is not a publication of results in order to confirm a theory, or even the presentation of a complete theory; it is more a sequence of thoughts taken by the natural curiosity on these subjects that from now on will be open to discussion. We hope it may at least contribute for a better collective reasoning in what concerns the origins of all those forces we daily experiment and use, but we don't really know where they are coming from. A theory is a way to approach an objective, therefore several theories can lead to the same objective, just as *all roads lead to Rome*. We like these questions, so we are even planning to question the so called *Big-Bang* in the next article dedicated to these matters.

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