

THE POSSIBLE EXISTENCE OF A ‘GRAVITO-ELECTRIC’ CURRENT.

By

Richard M. Blaber.

Abstract.

The unification of gravitation and electromagnetism requires the existence of a gravito-electric current, however small, and an equation for the velocity of gravitation taking the existence of such a current into account enables us to quantify this current in ampères, and to relate the value of the Newtonian gravitational constant to the values of the magnetic and electric constants.

Keywords: gravitation; electromagnetism; velocity of gravity; velocity of light; electric current; Newtonian gravitational constant; electric constant; magnetic constant.

Conflict of interest: The author asserts that he has no conflict of interest and has received no funding for his research from any source or sources, public, private or voluntary sector.

Nine equations, all numbered; no tables or diagrams.

The classical works on the unification of gravitation and electromagnetism are those of Nordström (1914 [1]), Kaluza (1921 [2]) and Klein (1926 [3]). None of these, however, make any mention of the possibility of a gravito-electric current, which would appear to be a natural concomitant of gravitational propagation, given that electric current is simply moving electric charge or charges.

Laplace attempted, using Newtonian theory (Newton, 1687 [4]), and the assumption that gravity behaves similarly to a fluid, to calculate

the speed of gravity in Laplace (1776 [5]), and arrived at the conclusion that it travelled at a speed of 7.45 million times that of light. Einstein, in the early part of the twentieth century, corrected this idea, demonstrating that the speed of light is universal, and that gravitation propagates, in wave form, at light speed (Einstein, 1905 [6]; 1918 [7]).

If we combine these two ideas, we find that:

$$v_G = c = |\sqrt[4]{G\mu_0 I_G^2}| = |(\epsilon_0\mu_0)^{-1/2}| \quad (1)$$

Here, v_G is the speed of gravitation, c that of light or electromagnetic radiation in vacuum, ϵ_0 and μ_0 the electric and magnetic constants, G the Newtonian gravitational constant, and I_G the purported ‘gravito-electric’ current.

If the above is correct, then:

$$G\mu_0 I_G^2 = (\epsilon_0\mu_0)^{-2} = c^4 \quad (2)$$

From this straightforward algebra, we can conclude that:

$$I_G = c^2(G\mu_0)^{-1/2} \quad (3)$$

and also:

$$G = c^4/\mu_0 I_G^2 \quad (4)$$

A quick dimensional analysis confirms that these formulae are correct, as may readily be seen. Equation (3) enables us to obtain a value for the gravito-electric current, I_G , of 9.81372×10^{24} A, which is far from being ‘small’, in any sense!

This would seem absurd and unphysical – but is the simplest obtainable relation, nevertheless, and we find that:

$$e/t_P = 2.9718 \times 10^{24} \text{ A} \quad (5)$$

where e is the fundamental electric charge and t_P is the Planck time. $I_G \simeq 3.3 e/t_P$. It is possible that the equation:

$$t_G = /(\sqrt[4]{G\mu_0 e^2/c^4})| = 1.2777279 \times 10^{-22} \text{ s} \quad (6)$$

gives what would seem a more realistic value to the fundamental, and indivisible, unit of time, in which case, $e/t_G = 1,253.926 \text{ A}$, which is still large, obviously, but seemingly not so unfeasibly large as either of the results given above. The fundamental (smallest measurable) unit of length would then be $\ell_G = ct_G = 3.830532 \times 10^{-14} \text{ m}$. Given the collision energies, E , of the protons at the Large Hadron Collider (LHC) at CERNⁱ, however, which routinely reach $13.6 \times 10^{12} \text{ eV} = 2.17896 \times 10^{-6} \text{ J}$, these yield measurable length distances equal to $9.1164861 \times 10^{20} \text{ m}$ by the equation:

$$\Delta x = hc/E \quad (7)$$

Here h is Planck's constant and c is the speed of light in vacuum, as above. Then $x/c = 3.0409 \times 10^{-28} \text{ s}$. It would seem we must retain the Planck distance and time scales, and the very much larger figure for the gravito-electric current we derived earlier.

Any electric current must, however, by the terms of classical electromagnetic theory (Maxwell, 1865 [8]), produce a magnetic field, and thus a magnetic force. It is thus quite easy to determine what the magnetic force between the 'gravito-electric' current, given its value in (3), and another current of – say – one ampère, running through a conductor in free space, would be:

$$F_m = \mu_0 I_G I \simeq 1.23323 \times 10^{19} \text{ N} . \quad (8)$$

It is perfectly plain that no such force is experienced, and that therefore no ‘gravito-electric’ current *of such magnitude* exists. It can only be saved, as it were, with the introduction into Equation (1) and consequent equations of a dimensionless constant of such numerical value as to render I_G a considerably smaller quantity, howsoever measured.

It is possible this constant might be the square of the reciprocal of the gravitational fine-structure constant, $\alpha_G = (Gm_p^2/\hbar c)$, where m_p is the rest-mass of the proton and \hbar is Dirac’s constant ($h/2\pi$). It has the value 5.906149×10^{-39} , its reciprocal is 1.6931506×10^{38} , and its square, $(\hbar c/Gm_p^2)^2 = 2.866759 \times 10^{76}$, is Eddington’s number, the total number of protons in the observable Universe (Eddington, 1939 [9]).

If this is then inserted into (1), the value we obtain for I_G is then given by:

$$I_G = (m_p^2 c/\hbar) \cdot |(G/\mu_0)^{1/2}| = (m_p^2/\mu_0 \hbar) \cdot |(G/\epsilon_0)^{1/2}| = 5.79613 \times 10^{-14} \text{ A} . \quad (9)$$

This is not only a smaller value, it is far more realistic, and is related to the fundamental electric charge, e , by the relation $e/I_G = 2.76422 \times 10^6 \text{ s}$.

ⁱ CERN (*Conseil Européen pour la Recherche Nucléaire*; European Council for Nuclear Research), ‘Large Hadron Collider [LHC] restarts,’ 22nd April 2022, <https://home.cern/news/news/accelerators/large-hadron-collider-restarts>.

REFERENCES.

[1] Nordström, G., ‘Über die Möglichkeit, das elektromagnetische Feld und das Gravitationsfeld zu vereinigen (On the possibility of uniting the electromagnetic and gravitational fields),’ *Physikalische Zeitschrift (Physical Journal)*, **15:504-506**, 1914.

[2] Kaluza, T., ‘*Zum Unitätsproblem der Physik (On the Unity Problem in Physics)*,’ *Sitzungsberichte der Königlich Preußischen Akademie der Wissenschaften (Berlin) (Physikalisch-Mathematische Klasse)* [*Reports of the Meetings of the Royal Prussian Academy of Sciences, Berlin (Physical-Mathematical Class)*], [pages] **966-972**, 1921, BibCode 1921SPAW.....966K.

[3] Klein, O., ‘*Quantentheorie und fünfdimensionale Relativitätstheorie (Quantum theory and five-dimensional Relativity theory)*,’ *Zeitschrift für Physik (Journal of Physics)*, **37:895-906**, December 1926, DOI: 10.1007/BF01397481.

[4] Newton, I. (1687), *Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy)*, London: Joseph Streater.

[5] Laplace, P.-S., ‘*Sur le principe de la gravitation universelle, et sur les inégalités seculaires des planètes qui en dépendent (On the principle of universal gravitation, and the secular inequalities of the planets which depend on it)*,’ 1776, in *Œuvres complètes de Laplace*, Tome 8,

<https://gallica.bnf.fr/ark:/12148/bpt6k77596b/f206.item>

(French text).

[6] Einstein, A., ‘*On the Electrodynamics of Moving Bodies (Zur Elektrodynamik bewegeter Körper)*,’ *Annalen der Physik (Annals of Physics)* **17:891-921**, 30th June 1905,

<https://einsteinpapers.press.princeton.edu/vol2-trans/154>.

[7] Einstein, A., ‘*Über Gravitationswellen (On Gravitation Waves)*,’ *Sitzungsberichte der Königlich Preußischen Akademie der Wissenschaften (Berlin) (Physikalisch-Mathematische Klasse)* [*Reports of the Meetings of the Royal Prussian Academy of Sciences (Berlin) (Physical-Mathematical Class)*], **154-167**, 1918,

<https://articles.adsabs.harvard.edu/pdf/1918SPAW.....154E> (German text).

[8] Maxwell, J.C., ‘*A Dynamical Theory of the Electromagnetic Field*,’ *Philosophical Transactions of the Royal Society of London* **155(155):459-512**, 1st January 1865, issue date 31st December 1865, DOI: 10.1098/rstl.1865.0008,

<https://royalsocietypublishing.org/doi/epdf/10.1098/rstl.1865.0008>.

[9] Eddington, A.S. (1939), *The Philosophy of Physical Science. Tarner Lectures, University of Cambridge, 1938*, London: Cambridge University Press, Chapter XI, 'The Physical Universe', pp.170-186, ISBN: 978-1-107-63034-5, pbk. (2012).

ⁱ Centre Européen de Recherche Nucléaire (European Centre for Nuclear Research); see: <https://home.cern/news/news/accelerators/large-hadron-collider-restarts>.