A formula for the value of the gravitational constant

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Abstract. A concise and precise formula for 'Big G' has been derived from an electron positron model of vacuum space (the epola model) that regards gravitation as a push force resulting from magnetic spin moments. Extended tests have revealed the significance of the peculiar velocity of the Solar System as a factor within the Fine Structure Constant, by experimentally monitored periodicity of nuclear decay rates. Correlations to gravitational field intensity, indicated by tide heights, also deny a purely random function for nuclear decay. The epola model's definition of EM waves and their spectral characteristics had indicated possible substructure of the electron as a charged hadronic pion. This study resolves anomalies of the electron by identifying Twist in addition to Spin moments that has exposed an epola mechanism for Quantum Entanglement. When free guest particles interact with the bound particles of the lattice, binding energy density reduction induces gravitational forces and reveals the factors comprising the value of Big G, that further indicate pion sub-structure of leptons with a different fine structure.

1. The factors of G are revealed

Revealing the G factors: $G = 6\ BE\ [(c\text{-}Vp) / c]\ [(1 - \alpha) / \alpha] = 6.674 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}$.

This formula, returning the accepted value of G, has resulted from a series of empirical and experimental tests for falsification of a model of vacuum space, as a lattice of strongly bound electrons and positrons, and the gravitational forces acting on two 1 kg masses, their centres of gravity separated by 1m. The 'epola' model of a perfect vacuum dates from 1973. It explains gravitation to result as a push force from mutual short-range forces of repulsion, between all particles of matter, including nuclei and electrons of atomic matter, and the bound ions of the structured epola vacuum lattice. The significance of these factors is overlooked by current textbook physics. This formula bridges the gap between the theories of General Relativity and Quantum Electrodynamics that are evidenced by this result and other tests of the model.

2. An introduction to the epola model

The Electron Positron Lattice (epola) model of Vacuum Space was first published in 1973, by the late emeritus Professor of Physics Menahem Simhony (1922-2015), whilst a researcher in the field of semiconductors, and specialising in Child's Law of charge limitation (later known as the Mott Gurney Law) [1].

The epola model of structured vacuum space is properly described as an elastically bound, polycrystalline interlaced face-centred cubic lattice (FCC) of electrons and positrons as in Figure 1. Known as a solid-state structure because the ions are not free to change stations, as also recognised for

transparent 'rock salt' crystals, formed by ions of metallic sodium and gaseous chlorine. Rock salt can carry six modes of vibrations because of different size and mass of the ions, whilst the electron positron lattice (epola) has only three modes of vibration.

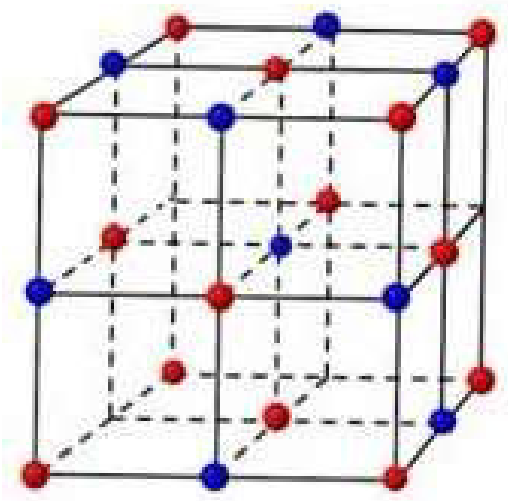

Figure 1. The epola model of structured vacuum space as an elastically bound, polycrystalline interlaced face-centred cubic lattice (FCC) of electrons and positrons.

Real electrons are much smaller than the spherical 'classical' electron. Various electron cross-sections, to as little as 10^{-30}m, are experienced by high-energy colliders that may even indicate a disc-like shape. The epola model assumes that an electron has similar mass density to that of nucleons, giving the electron a small radius of ~0.09 fm (fm the femtometre measures10^{-15}m). The epola lattice size (lattice constant L0) is calculated from the Compton wave of the electron to be 4.572 fm, by the role it plays in electromagnetic waves. This gives plenty of room for a free electron to pass through each cell, that has alternately bound electron or positron at the eight corners. These corner sites are shared with adjacent cells to connect with neighbouring cells and by this means any disturbance spreads radially throughout the lattice at the speed of light. Disturbance of any bound epola particle (epo) is thus shared across the lattice with reducing displacements affecting more epola particles (epos), that increase in number as the volume of a sphere increases with the cube of its radius. Unlike the ionic salts of differently sized molecular ions that are shielded by electron shells and have packing limitations, an epola cell's ions ensure stability and structure by matched mutual short-range repulsions (SRR) due to magnetic spin moments. The epola is very stable by having ions of opposite charge but identical size and so have only three modes of vibration about their equilibrium rest sites. An electron positron (epo) pair of ions can be liberated by a photon of radiant energy of not less than 1.02 MeV, especially where weakened by SRR in proximity to a nearby nucleus. This was demonstrated by C.D. Anderson in 1932. Those electrons and positrons where not created but liberated from the epola.

The ions stationed at their equilibrium rest sites on each of the eight corners are overall neutral, and each cell has the total binding energy of a single ep, from its share of all eight alternately charged epos at rest sites on the eight cell corners. These impart no nett charge - unless it (or a neighbour) moves from its own corner rest site. We can well imagine that the bound particles vibrate about their corner sites due the local cosmic foreground imparting temperature, momentarily losing some binding energy and emitting some free energy as heat. Simhony pointed out we would be unable to observe lower background temperatures through the foreground, such as are obtained by liquid helium that boils and climbs out of a beaker.

Chemistry, unlike physics, gives binding energy a negative value, because energy must be applied to break bonds, as when lighting a fire. The binding energy density of the epola, with the mass of one electron per cell, due to the small cell size, is a *phenomenal* 9.6 x10^{20} gigajoules per cubic metre, with a mass density of 10^{13} kg/m^3. That is 10^{10} times that of water. The epola is far from aethereal! The calculated melting point of the epola is ~6 GK. This is even hotter than the Sun. The epola passes through the Sun (and vice versa) but those excited epos would not be sitting quietly at that temperature. They would have the advantage of being further away from neighbours, due to increased cell size in the massive Sun. However, if the epos had avoided escape or collisions, but were trapped with atomic fragments in the same cell whilst cooling, on resuming more normal size on exit, might they be crushed together into a bound state? For example, causing hydrogen to become helium or tritium? Atom fragments and freed electrons might be ejected, else caught on epola crystallite grain boundaries, as the epola cooled. Simhony argued that neutrinos are excitons of the lattice, being an unmatched electron or positron [2], partially bound to a vacant site in the distorted lattice, thereby explaining their low mass, transient nature and varying identity.

A full description of the epola model, in Simhony's fine pedagogical style is available in his papers and books, or www.epola.co.uk.

3. The gravitational function of the epola

An empty epola cell is large enough to enclose a copper nucleus, even if ignoring the expansion it would cause by dynamic short-range repulsions of magnetic spin moments. However, a free guest particle passing through the epola, will be surrounded by and expand the faces of 6 epola cells, each with the Binding Energy (BE) of a single electron. Thus, the guest particle will become enclosed in a body centred cell.

Gravitational force was illustrated by Simhony by the case of two neutrons, representing the overall neutral behaviour of atoms. The repulsions of the 6 immediately surrounding epola lattice particles is passed on through successive layers of epos. In the direct line between the two neutrons in body centred cells, these repulsions are self-compensating. Behind each of these two neutrons 6 expanded epola cell in the first two layers, strongly support their neutron and push and guide their guest particle 'from the flanks' in the direction of the other neutron. This applies to any two gravitating bodies of matter, pushed together by the reduction of Binding Energy (BE) from the short-range repulsions, induced in their surrounding epola.

Therefore, the BE of 6 epola cells is a component in the formula for G:

$$G = 6\ BE \times (\text{an unknown factor}) = 6.674 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2} \quad (1)$$

4. Tests of the model

The epola model has been subjected to our extended empirical and experimental tests for falsification since our first proposal in 2008. This was based on Simhony's bold declaration of velocity limits, calculated from the Boltzmann equation (E = kT). The velocity for different categories of material bodies is limited by their own binding energy, relative to the energy required to open and pass through the epola. See Figure 2.

An Experiment was proposed to compare ionisation potentials measured when on rotating Earth and on the International Space Station traveling five times faster. The concept was approved at Rutherford-Appleton-Laboratory (RAL), as the suggested sensitive ZEKE MATI (zero electron kinetic energy mass analysed threshold ionisation) instrumentation required recalibrating every fifteen minutes whilst on Earth. This was not adopted further as a research project.

Further tests for falsification of the epola model have revealed developments that opened more consequences relevant to modern physics. Our derivation of the factors comprising the Gravitational Constant G result from previous study and tests of the epola model.

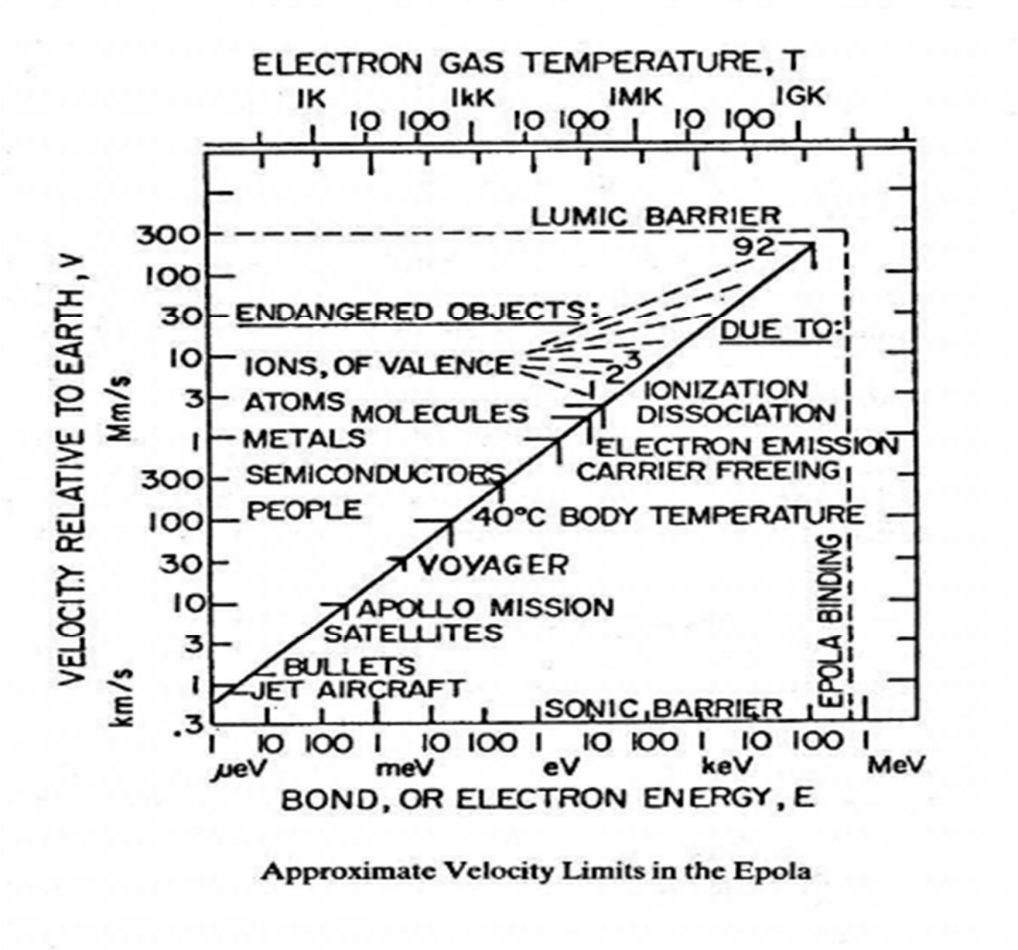

Figure 2. Velocity Limits in the epola. Figure adapted from Simhony p.91 [1].

4.1. The peculiar velocity of the solar system

Arnold Somerfeld's original explanation of 137 passes of the electron around the proton of a hydrogen atom, was developed in our derivation of a formula for the fine structure constant (FSC) in 2010 [3]. It was developed by relating Bohr and deBroglie waves with epola accompanying waves, guiding the electron in an elliptical orbital.

Inspired by improved numerological approximation by J Gilson, we inserted a function for an elliptical orbital and a factor for the unknown velocity of the proton. The value we obtained was identified after some searching, and found to be precisely that of the anisotropy of the Cosmic microwave background, and reported by G H Smoot et al, as the "Peculiar velocity" of the Solar System (Vp), at 392 km per second in the general direction of the fixed star Chertan in the constellation of Leo. Our alignment to the fixed stars changes daily, as the Earth rotates on its axis and seasonally, due to Earth's elliptical orbital. Position of the planets must also be significant, and contribute to periodicity.

Vp contributes to the actual speed or acceleration of any particle of mass passing through the epola (in our part of the universe). The epola itself reacts at the local speed of light, therefore Vp and c are both components of the formula for G:

$$G = 6\ BE\ [\ (c\text{-}Vp) / c]\ \mathbf{x}\ (\text{an unknown factor}) = 6.674\ \mathbf{x}\ 10^{-11}\ m^3\ kg^{-1}\ s^{-2} \qquad (2)$$

4.2. Further evidence of Vp

It was not until 2015 whilst preparing our data for an illustrated lecture, that we spotted further proof of Vp, hidden in the Lyman Alpha wave of hydrogen. Whilst the excited 2s electron falls back to the 1s (or K) shell, with the emission of a 10.2eV photon, the proton nucleus moves by the difference of the two radii at Vp. This fact had been hidden or ignored since Theodore Lyman found the alpha wave of hydrogen in 1906. This implies that the epola does indeed represent the absolute frame of reference for material objects as are listed in Figure 2.

Note in figure 2 that limiting velocities for materials to maintain structure or function are quoted velocities relative to Earth, so must already include Vp in absolute terms/units.

As Vp is a component of the fine structure constant (FSC α) it therefore also imposes periodicity on all the fundamental constants, by ratios of which α is commonly quoted, where the reciprocal of α equals 137.035999174(35).

4.3. Confirmation of elliptical electron orbitals

Our confirmation of elliptical electron orbitals thus explaining Fitzgerald Lorentz contraction, was communicated to a respected researcher Levy [4] of the Michelson-Morley experiments (MMX). These were originally undertaken in the late 19th century, seeking to detect Earth's motion through an aether. His resulting paper was submitted for successful peer review.

4.4. Further test opportunity

We suspect that the subsequent delayed Lamb shift to a 3p orbital also may be triggered by an aspect of orientation to Vp, providing further opportunity for experimental research.

4.5. Evidence for periodicity

The measure of the size of an epola cell is represented by the epola lattice constant L0. The next test was to seek experimental evidence for periodicity in nuclear decay rates after noting that that calculated value of L0, at 4.47fm, is close to the deBroglie wavelengths of the heaviest primordial element on Earth, radioactive uranium, and its heavy daughter products. Natural fission, we presumed, is triggered when large heavy nuclei, especially if misshapen, accidentally interact with the epola, even causing electron capture, whilst passing through epola cells at Vp before their accompanying epola displacement waves can react. The fixed stars move daily across our skies as the Earth rotates on its axis and seasonally, because Earth's orbit of the Sun is elliptical.

The beta/gamma decay rates of samples of Radium (Ra) and/ or Protactinium (Pa) in the luminous paint of an old wristwatch, and data for thorium (Th) on paraffin-lamp mantles, were continuously recorded electronically. Data was collected for counts of 60s plus five counts of 3 seconds, every alternate minute from a Geiger counter, necessarily denied recalibration, as would normally be good lab practice. This was to compare count rates with lattice size changes due to Gravitational intensity, indicated by high/low tide heights in local tide tables and star maps for position of the star Chertan relative to position of Sun and Moon.

Discrete Fourier transform (DFT) in the second year indicated a link to lunar monthly cycle. A second experimental site was opened ~20km distant and using completely different hardware, firmware, clocking and software confirmed coincident trends, as seen in Figure 3. Our progress was summarised in 2017 by a Poster displayed at the RSC Joint Faraday Groups Conference at Warwick in and later presented as an illustrated lecture at the AGM of local RSCl South Umbria Section, where the scientific methodology was approved. The poster is freely available at www.epola.co.uk.

After six years the sensitivity and drift by the small Geiger Muller tube (GMT) became excessive and the experiment ended in January 2018.

Decay rate trends were highlighted by adopting the statistical process control (SPC) technique of CuSum (cumulative sum of difference) plots of difference to a target value, typically the mean of the period for that run, see Figure 4. Details, data and plots available on request.

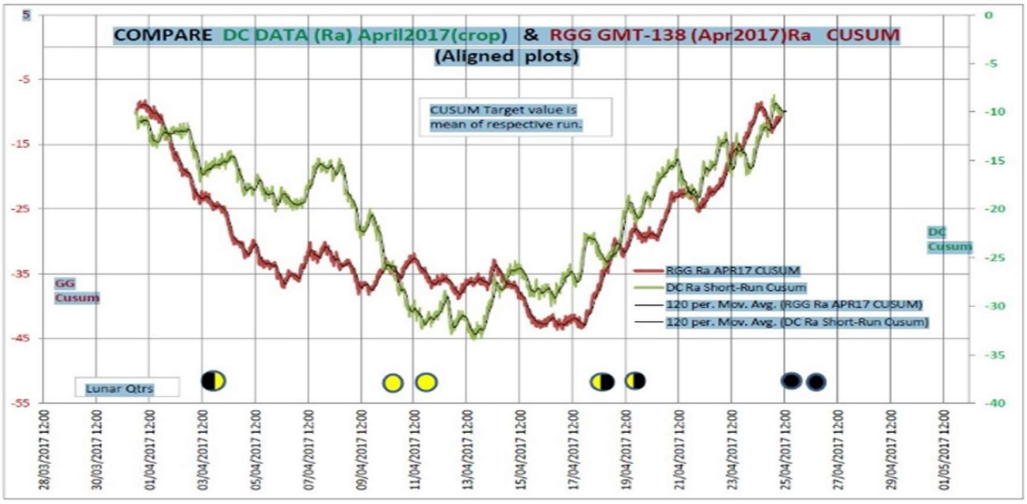

Figure 3 Coincident trends of radioactive decay of radium with lunar cycles at 2 sites.

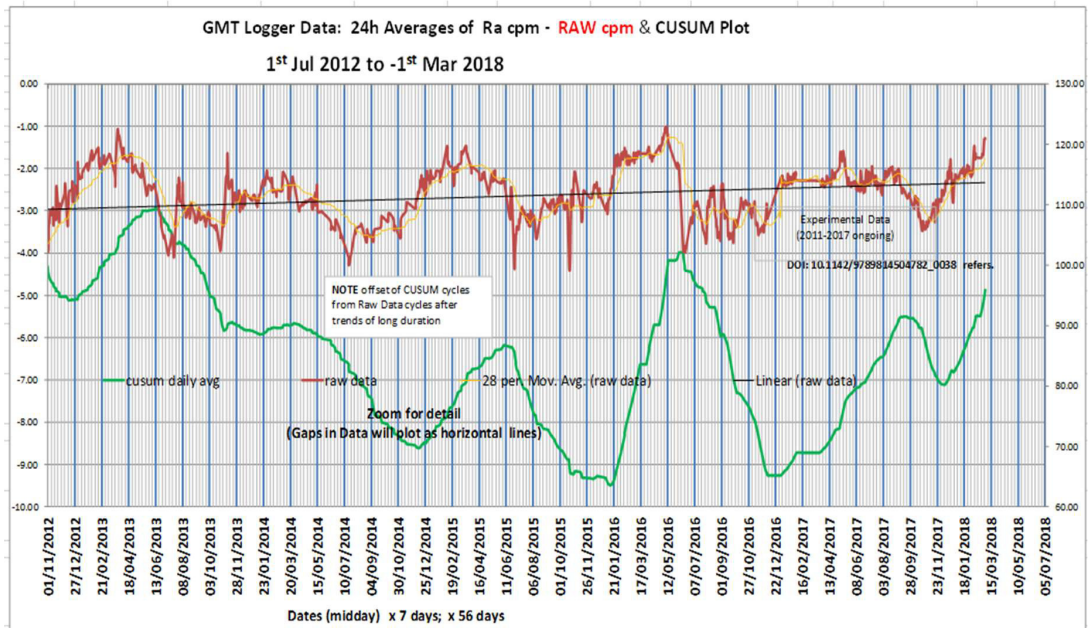

Figure 4 Periodicity of Ra CPM decay throughout 6 years. Upper line raw data, lower line CuSum.

5. Electron sub-structure

The epola spectrum of Electromagnetic (EM) waves in Figure 5 is defined by spherical half-wave clusters of epola particles vibrating on their rest sites, due to the frequency of the causative action (Action, symbol S, energy-time). These clusters, each of 10^7 epos, are alternately rich/deficient in either electrons or positrons, in comparison with the balanced state of empty epola. These EM waves propagate at the velocity of light as determined by the ratio of the Binding Energy density to mass density (as used by Isaac Newton for the speed of sound in air) and reordered by Albert Einstein as E=m.c2 , where c is the speed of light through the epola.

The epola spectrum of electromagnetic waves, by having a high frequency cut off, shortest wavelength at 140MeV, indicates sub-structure, because that is the mass energy of a charged pion, a meson, not a second generation leptonic muon, as might have been expected at 105MeV to succeed an electron or positron.

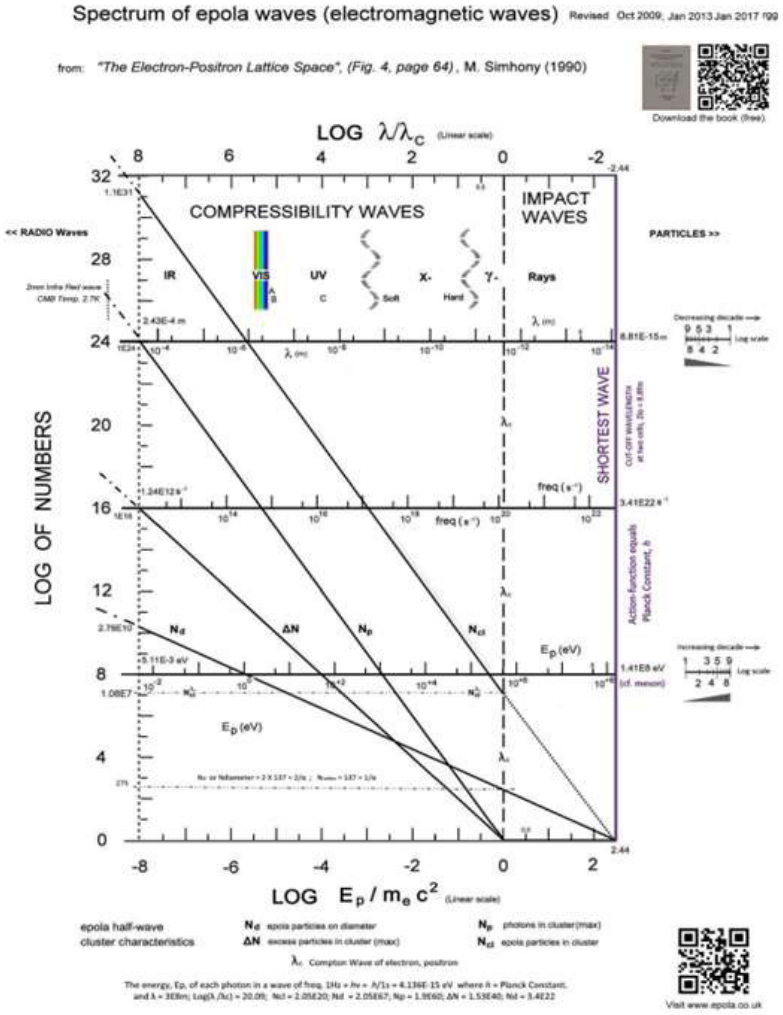

Figure 5. Spectrum of epola electromagnetic waves. Note: the lower dashed horizontal line crosses at a value $2\alpha^{-1}$, and shows the number of epos on the diameter of a half-wave cluster at the Compton wavelength of electron. This enables the calculation of L0 = Compton wavelength/$4\alpha^{-1}$

The +/- charged pion is comprised of an Up and Down quark pair, either one being an antiquark, according to QED/QCD. We had suggested in a conference presentation during 2010, that the electron and positron may have the toroidal substructure of a hubius helix Figure 6, described as an loop electron concept as early as 1897 by J J Thomson, and subsequently detailed as a hubius helix in the work of others [5,6]. If this be so, we recognise that an electron's magnetic Spin moment is accompanied by an S or Z Twist magnetic moment, as seen in Figure 6. Twist differs from Spin by not inverting (S clockwise or Z anticlockwise). This can be likened to a right-hand threaded bolt which will take its nut either way up, but never accepts a left-handed nut.

Figure 6 Examples of toroidal hubius helices and S and Z twists.

The bound epola particles ensure that twist orientation of a 'guest' electron is conserved, but random sampling of an individual lepton may show enhanced or decreased total magnetic moment. Quantum entanglement, the EPR dilemma and an enigma of the electron properties are thus resolved by the epola model.

The logic of the epola model can be summarised so far as:

$$G = 6BE\ ((c\text{-}Vp)/c) \times (\text{an unknown factor}) = 6.674 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2} \quad (3)$$

By comparison with the measured value for G, the unknown factor is revealed as 136.03599917. This is one less than the reciprocal value of the Fine Structure Constant, alpha-1 equal to 137.03599917; this is too precise to be random.

We propose that the functioning of electrons, by toroidal substructure in the phase-space realm of hadrons as a charged pion is the explanation for the necessary correction to the value of the fine structure constant that completes our formula for G in such a precise manner. This substantiates the epola model and further indicates pion sub-structure of leptons with a different fine structure.

Thus, the formula for G, derived from the epola model, can be written as:

$$G = 6BE\ ((c\text{-}Vp)/c)\ ((1-\alpha)/\alpha) = 6.674 \times 10\text{-}11\ m\ 3\ kg\text{-}1\ s\text{-}2 \quad (4)$$

Where:
G is the gravitational constant
BE is the binding energy of an epola cell with the mass energy of an electron in Joules
c is the speed of light in km/s
Vp is the peculiar velocity of the solar system km/s
and alpha is the Fine Structure Constant, 0.00729735257

6. Consequences and opportunities

6.1. Influence over bodies buoyant in the epola

Reducing epola binding energy between masses produces a differential pressure to increase acceleration. If Binding energy were to be reduced by other than the presence of matter, some degree of influence could be imposed on the bodies buoyant in the epola.

This was demonstrated unknowingly by Professor Louis Rancourt who had reported how the *attractive* force of gravity was enhanced (i.e. *repulsion* reduced) when a light or laser beam was shone between two heavy masses, even when the lamp was covered.

The epola explanation is that the epos excited by the light waves to vibrate about their rest sites were less strongly bound, reducing binding energy thus increasing differential pressure for the push effect.

6.2. Reducing epola binding energy

One might excite the epola by a mixture of short and long wavelengths to reduce epola Binding energy, as the equivalent of white noise by sound waves.

6.3. Reducing epola binding energy

What occurs to gravity in proximity to a nuclear reactor? Neutrinos emitted as excitons of the lattice may be a signal that epola grain boundaries proliferate where binding energy is reduced.

6.4. What occurs to gravity near a nuclear reactor?

What occurs to gravity in proximity to a nuclear reactor? Neutrinos emitted as excitons of the lattice may be a signal that epola grain boundaries proliferate where binding energy is reduced.

6.5. Dark matter and dark energy?

We have previously suggested REF that the epola is too dense to be mistaken for Dark Matter (DM) or Dark Energy (DE) but polycrystalline epola will exhibit grain boundaries with substituted ions, that maybe mistaken for DM DE that can propagate.

6.6. Challenging the big bang theory

The Big bang theory can be challenged if the epola vacuum can condense from originating from quark and antiquark pairs via pions if their original partners become separated. See “What is vacuum?” by P Rowlands.

6.7. Impact on the Hubble universe?

Hubble universe might still be growing rather than expanding? Light from far away/long ago will have suffered tired light syndrome by scattering and frequency changes. Where the epola is holed the thinned epola increases the differential pressure and can eventually exhibit as a Black Hole. Is the swallowed matter still inside, or did it turn back to nothing where no light can propagate?

In the proceedings of the Royal Society, ‘A Dynamical Theory of the Electromagnetic Field by Prof. J Clerk Maxwell FRS, October 1864 wrote “….if we look for the explanation of the force of gravitation in the action of a surrounding medium, the constitution of the medium must be such that, when far from presence of gross matter, it has an immense intrinsic energy, part of which is removed from it wherever we find the signs of gravitating force.” Maxwell nor the scientists of that time could conceive of the function of the performed by the epola and he went on to say “This result does not encourage us to look in this direction for the explanation of the force of gravity.”

Acknowledgements

We wish to acknowledge the Management team and Members of Lincoln Astronomical Society (UK) for support and encouragement. In particular P Hellen for DFT analysis, D Castledine for building and operating the second decay-rate site, and ad hoc data visualisation.

And K Lambert for invaluable support producing this document.

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