Implications of an electron-positron-lattice model of space for EM waves and a possible reconciliation of QM with RT.

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Abstract The spectrum of electromagnetic waves in vacuum space is discussed as a function of the vibrations of an elastic electron-positron-lattice (the epola model of 1973 by M. Simhony). It is shown how wave propagation is subject to a finite velocity by an extension to the model for quantum substructure of the electron responsible for spin interactions stabilising the lattice in a frustrated magnetic system. An implicit cut-off frequency for EM waves leads to the structure of mesons and potential reconciliation of Quantum Mechanics with Relativity Theory.

1. The epola model

A total vacuum is devoid of atomic matter but, as implied by all models of an 'active vacuum', it is not an empty space.

The electron positron lattice (or e-po-la) model[1] of M. Simhony contends that the vacuum is occupied by a bound aggregation state of matter, of different mass and energy densities to the aggregation states of atomic matter or of nuclei. The unobservable poly-crystalline epola has a mass density 10^{10} times greater than water but $\sim 10^5$ times less dense than nuclear matter[2]. The epola structure is analogous to the lattice structure of sodium chloride, with elastic binding energy of 1.02MeV per electron-positron pair yielding a finite velocity of bulk deformation waves corresponding to the square root of {binding energy per unit volume / mass per unit volume} from which the well-known formula $E = mc^2$ results. The velocity of electromagnetic waves in vacuum equates to the velocity of vibrational waves in the empty epola at the bulk deformation velocity of the epola.

The lattice constant of the epola was calculated to measure 4.4 +/-0.5fm whilst the electrons and positrons at the nodes of the resulting simple cubic unit cells were estimated to have radius of less than 0.1fm radius with similar mass density to the ~1836 times heavier neutrons and protons, as disclosed by high energy scattering experiments,. The lattice constant represents both the dimensions of the unit cube with shared leptons at the nodes and the separation of leptons at the centre of similar cubes of the *reciprocal* lattice (Fig. 1).

Mutual short range repulsion (SRR), that is considered to be a result of the intrinsic spin moments between epola nodes, counters electrostatic attraction, analogously to the repulsions of overlapping atomic orbitals in ionic lattices and gives stability to the lattice, as required by Earnshaw's Theorem[3].

Where an epola cell is occupied by a guest particle, e.g. a nucleon, lepton or nucleus, then the cell is enlarged by SRR with the guest and additionally distorted by any EM forces. The cell size is gradually restored in successive layers of unoccupied neighbouring cells in accord with Gauss's surface area law, as the effect is shared out by increased numbers of cells. The bond length and bond strength are proportionately restored with the square root of increasing radial distance.

Multiple guest particles in the lattice are pushed together toward their centre of mass at a saddle point with an emergent force identified as the 'gravitational' effect. This is because the expansion of cells cannot be restored as fully in the line between adjacent guest particles as in all other surrounding directions. Gravitation is not a fundamental force but a result of SRR in the lattice.

Acceleration of a guest particle causes accompanying

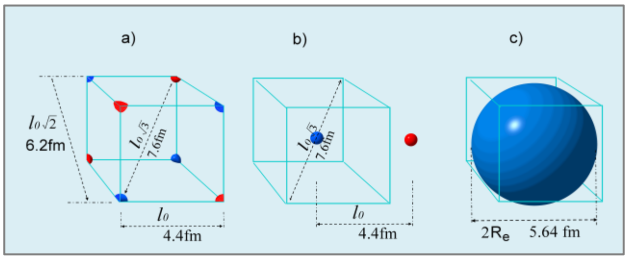


Figure 1 The epola structure

a. Unit lattice cell taking a 1/8th share of the nodal particles
b. One bound epola particle per *reciprocal lattice* unit cell
c. Classical electron compared to an empty epola unit cell

waves (AWs) to become established in the line of motion when the bound epola particles are caused to vibrate by successive enlargement and reduction of sequentially occupied cells. This process gives inertia to the guest particle by requiring energy change in the epola bonds for acceleration or deceleration yet sustaining constant velocity without further energy input and recognised as conservation of momentum. The de Broglie waves of particles are a derivative of their accompanying waves.

2. Inertia

Inertia and momentum are explained satisfactorily by gift of the epola particle bonds to guest particles within the lattice cells yet, to be so, the epola particles must themselves exhibit an intrinsic inertia. Huygens' waves in the elastic vibrations of epola particles are limited to a finite velocity by the primary inertia of those bound particles. Every epola particle transferring wave energy by Huygens' Principle to the next particle in line exhibits a holding time. The epola ions are bound electrostatically to their lattice sites but are subject to interactions of their intrinsic magnetic dipole spin moments in a three dimensional arrangement that, we propose, must behave as a frustrated magnetic system. The magnetic spin moments of any bound electron or positron cannot satisfy the neighbouring moments of all six nearest anti-particles at the same time. Vibrations in the lattice prevent any static alignment of spin moments that must therefore perpetually realign within a (holding) time, dependent upon some functionality or internal structure within the leptons.

Zero point motion and cosmic microwave background temperature (CMB) may be both a cause and a consequence of the non-zero entropy of the lattice in such a frustrated magnetic state.

The epola model, other models of physics (e.g. QED, SED), and high energy scattering experiments accept that the electron has a radius less than 0.1fm and perhaps as small as 10^{-22} m. However, this may indicate the measure of a quark-like particle in the internal structure of the 'real-world' relativistic electron. The 'Classical' electron defines an electrostatic model but fails to represent fully its magnetic moment(s). Loop models of the electron[4] have been suggested that, perhaps, better represent it as a spinning or a gyrating torus, with overall diameter similar to the classical electron model yet with both a toroidal magnetic moment and a poloidal dipole moment (Fig. 2). Alignment of a gyrating torus of small cross section, together with the velocity of the probing particle, would determine the scattering dimension. The two rotational aspects, sweeping a spherical (or ellipsoidal) volume of space would resolve the conundrum of the 4pi rotation of the classical electron and its large effective size with small mass compared to a proton.

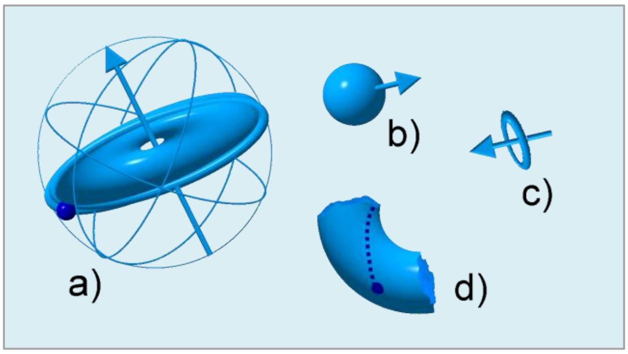


Figure 2. Loop electron.....a) gyrating torus with spiralling point charge; b) shown as a sphere with magnetic moment c) as ring with magnetic moment d) portion of toroidal path with point charge.

3. Electromagnetic Waves

Electromagnetic (EM) waves in the epola are not the same as vibrational waves but are the consequential moving electrostatic (E) and magnetic (H) fields resulting from the vibrations of bound lattice particles, caused to deflect from and to rotate in their rest positions, as physically disturbed bulk deformation waves. The EM signature waves are both the result of disturbed epola particles and the cause of the disturbance during their self-propagation through the active epola vacuum. Epola particles vibrate in all directions but the transverseness of EM waves is assured because in the direction of the wave motion electrical neutrality is maintained by the bound particles, with as many vibrating one way as the other. However, in perpendicular directions to this line, the deviation from charge neutrality and the coupled magnetic vector are at maximum[5].

The spectrum of epola waves and EM waves was summarised by Simhony in a nomogram[1B, p64] and a revised version is appended in Section 6. The wave characteristics were compared to and derived from the known attributes of the Compton wave having the energy of the rest mass of the electron, as a single photon of 511keV with wavelength 2426fm. At this wavelength there are 11 million epola particles in the volume of the half-wave cluster, 275 epola particles (lattice constant 4.4fm) on the diameter of the half-wave cluster and thus ~137 epola cells in the radius of the cluster.

It was shown by Simhony that the energy and alternating charge carrying function of sequential spherical half-wave clusters of vibrating epola particles depended upon the surface area and the number of excess electrons or positrons at that envelope surface, whilst the number of energy quanta (photons) was proportional to the number of epola particles in the volume of the cluster. (The reader is referred to Ref 1B, chapters 6 & 7 for a full derivation). The number of epola particles on the diameter of a half-wave cluster Nd, each with holding time of l_o/c, determines the periodicity and frequency of the wave.

At longer wavelengths than the Compton wavelength λc the bulk deformation waves (carrying E and H fields) correspond to compressibility waves whilst at and below λ_c, where there is only one photon per cluster then the waves take the nature of impact or shock waves.

Propagating waves preserve the frequency of sequential half-wave clusters as the active wave front is regenerated merely over the distance of one half-wavelength irrespective of the distance from the source. Waves are however subject to simple Doppler shifts by motion of source or receptor relative to the epola medium of propagation, complying with interferometry experiments.

There is no theoretical upper limit to wavelength, other than eventual fade-out imposed by loss of integrity due to non-linear energy absorption in large volumes of 'impure' cosmological epola vacuum containing the half-wave clusters at extremely low frequency. Significantly however, the epola implicitly sets a high frequency cut-off at a wavelength of two epola lattice constants (2 x 4.4fm), each half-wave cluster at this wavelength comprising, or carrying, a single electron or positron.

The Compton wave with the rest mass energy of an electron has only one excess particle in its half-wave compression cluster. It carries only one quantum (photon) of energy represented by the 511keV binding energy of that single excess electron or positron inserted or rejected from the surface of the spherical cluster by the positions of the bound epola particles in their vibrations during the half-period of the wave.

EM radiation within the bands recognised as gamma-rays or X-rays, with cluster diameter smaller than typical intra-atomic and inter-atomic distances can readily penetrate ordinary molecular materials.

At longer wavelengths, the number of excess particles is increased in proportion to the surface area of the half-wave cluster whilst the number of photons increases with the volume of the cluster and total number of bound vibrating particles in the cluster so that the photon energy, or amount of energy transferred particle to particle, is reduced as wavelength increases in accord with Planck's postulate (1900). The clusters of these epola compression waves expand easily in all directions, pass around atoms of insulating materials by gentle vibrations, are slowed by interactions with electrons but still must be regarded as single rays else as beams of multiple rays.

Conduction electrons roving freely in a metal prevent penetration by absorbing and re-emitting some or all photons as reflected wave(s).

Energy remaining in a half-wave cluster, with less excess particles on the surface of the cluster, continues to propagate at the same frequency carried by the elastic vibrations of the epola particles maintained by their individual transfers of kinetic energy although the EM energy in the wave is not defined by the total kinetic energy of those multi-tasking particles.

The common concept of a single wave spreading spherically in all directions as a 3D version of ripples on water is misguided; those shells of wave-fronts represent the group behaviour of the sibling waves, enhanced or cancelled by mutual interference.

The Compton Effect (1923) demonstrates the particle nature of the wave in the epola, whereby an X-ray scattered by a resting electron at an angle of 90°, causes the wavelength of the photon to be reduced by λ_c and its energy to be reduced by $m_e c^2$ irrespective of the incident frequency. Wavelengths at and shorter than the Compton wavelength λ_c of a resting electron, carry all the energy in each half-wave cluster as one photon of 511keV plus the kinetic energy of the single excess particle (either electron or positron) at the surface of the half-wave cluster.

The photon at wavelength λ_c is carried by 11 million vibrating epola particles within the body of the cluster but at shorter wavelength this number reduces as the major diameter and period of the cluster is reduced and the frequency is increased, causing the wave to behave with pronounced shockwave or impact wave characteristics. The time available for vibrations to spread sideways in the epola to form spherical clusters by Huygens' Principle is inadequate. The clusters become more and more ellipsoidal with disproportionately reduced minor radius and surface area as the half-wavelength on the major axis is progressively reduced to the limiting size of one lattice cell.

Cosmic ray energies are experienced up to the order of 10^{20}eV, however, this cannot be as a single electromagnetic wave but as the kinetic energy of luminal or subluminal particle(s) plus accompanying gamma rays in the epola. Claims have been made[6] for expected maximum gamma wave energy up to 10^9 to10^{15}eV (10^{24}-10^{30}Hz) but such immeasurably high 'wave' or ray energies are inevitably deduced from their secondary effects and would be more properly defined by the sum of their energy as gamma rays plus particles with kinetic energy.

4. Discussion and Summary

The concept of a frustrated magnetic system proposed for the short range repulsions responsible for the fundamental functioning of inertia calls upon the magnetic moments of the electrons and positrons bound in the vibrating poly-crystalline lattice. An ionic lattice rarely occurs naturally as one large crystal and the epola, stirred by waves and sheared by moving charged particles, is unlikely to provide an exception. It is possible that miniature magnetic domains extend to grain boundaries in the lattice where dominant spins of electrons and of positrons in the poly-crystal invert. Magnetic domains are unlikely to be detected at distances of more than a micrometre with the lattice constant measured at a few femtometres. Similarly, anisotropy of light speed due to grain orientation and grain boundaries is unlikely to be measurable except at extremely short distances and the calculated lattice constant using measured bond energy and the measured (defined) speed of light will represent averaged values.

The ground state 1s Bohr orbital of the hydrogen atom contains 137 (α^{-1}) Compton wave cycles in its circumference and only one de Broglie wave cycle, determined by the ratio of the speed of the electron to the speed of light, also 137, with α defined by Sommerfeld as the fine structure constant. The two de Broglie half-waves are each able to carry one electron - but of opposite spin. The closed, self sustaining wave-guide of epola accompanying waves circulating 137 times at the speed of light 'c' result in the de Broglie wave rotating at c/137 without radiated loss of energy.

The epola lattice constant l_0 relates directly to the Compton half-wave cluster and Sommerfeld's derivation of the fine structure constant. There are 137 epola cells in the radius of the cluster, well within the tolerance set by Simhony (and precisely for a lattice constant of 4.42fm):

$$l_0 = \frac{\lambda c}{4}.\alpha \qquad (l_0 = 4.42\text{fm}).$$

The radius of the Classical electron, Re, is given by:

$$\text{Re} = \frac{\lambda c}{2\pi}.\alpha$$

Thus, the circumference of the classical electron is:

$$2\pi\text{Re} = 4\ l_0$$

We note that renormalization applies for QCD at the range of the boundary of an epola cell containing a particle.

The cell is empty for an EM wave and the charge of the alternate clusters is provided by the excess bound particle included at the wave envelope. The coincidence of α^{-1} epola cells in the radius of the Compton half-wave cluster may confirm the independent calculation of the lattice constant by Simhony.

Virtual electron-positron pairs are said to shield a charged particle where charge intensity exceeds ~10^{18}V/m and thus within about 33fm of an electron[7] The distortion and expansion of epola cells around a hosted electron causes the bound electrons and positrons to move from their regular spacing but the effect is reduced from an expanded lattice dimension of 1.43 times l_0 until barely significant after seven cells (30fm) range with an increase of only 2 parts in one hundred million per surrounding cell. This provides a physical explanation of charge shielding and polarisation of the 'vacuum', as disclosed by a team from Perdue University[8] working with the TOPAZ detector at KEK.

It was reported[9] that high energy electron scattering experiments at 58GeV indicated the fine structure constant α (coupling constant) to be increased so that α^{-1} reduced from 137 to 128.5. P.Rowlands predicted[10] α^{-1} of 118 at 14TeV and S.Hawking suggested[11] that the ES, E-weak and the Strong forces might be unified at a Grand Unification Energy of not less than 10^{15} GeV.

Radio waves emanating from an antenna radiate in all directions but by their reflections and interference patterns it is clear that these are group behaviours of multiple waves. One cannot regard electromagnetic waves merely as the typically drawn continuous lines of sine-wave curves that represent the magnitude of E and/or H fields but as the physical half-wave spherical clusters of vibrating bound particles described by the epola model of M.Simhony.

To extract photon energy from a wave the receptor must coincide in space and time with the active cluster (or the transition into the new cluster), in which there may be as few photons as one per wave - and only ever one for waves of energy greater than 511keV.

Partial loss of energy from a wave carrying multiple photons (at wavelengths greater than the electron's Compton wave) does not cause its frequency to change, as we know from our experience of radio broadcasts. Signal intensity reduces but not the character of the wave. Half-wave clusters at maximum energy carrying capacity of the wave are spherical. Waves with less than maximum number of quanta (photons) retain the same wavelength but it must be questioned whether the half-wave clusters acquire ellipsoidal shape with reduced surface area or, having less charge difference between successive clusters, retain their spherical shape where the epola is less distorted such that there are fewer excess particles at the surface of a cluster and greater parity is held between numbers of bound electrons and positrons.

Light emitting diodes (LEDs) with differing and variable light intensity offer us a glimpse of the true nature of light waves. Valence electrons are excited by external charges (current) and by sufficient energy (eV) until liberated into the conduction band of a doped semiconductor from where electrons collapse back across the band-gap, each with the release of the representative quantum of energy (photon) at the characteristic frequency (colour) of the diode material.

Multiple collapses of excited electrons occurring in nearby atoms within the radius of a half-wave cluster can build up, analogously to the reactive near-field around a radio antenna, and collectively self-propagate (radiate) as a single light wave. Otherwise they can radiate as multiple waves to different directions else be lost as heat in random thermal vibrations of the epola particles. Not all emissions from a continuously stimulated source are simultaneous nor released in the same direction but in one half-wave cluster the wave has a resultant momentum and single direction of self-propagation. Subsequent clusters may form, indeed are likely to form behind the first, from continued excitation and heating of the source, probably assisted by the forward collapsing cluster to locate in the same region but only by chance transmitted in the same direction Other waves nearby but outside the scope of the half-wave cluster must propagate in other waves and to other directions, requiring reflectors and lenses for control of the beam.

The recent innovation of an entangled light emitting diode[12] (ELED), utilising a 10nm quantum dot on an LED substrate, for generation of only two photons, reinforces our epola description of EM waves. Are all the waves emitted from a source in the same half-period entangled, are all the photons within one half-wave cluster of a single wave entangled?

5. Speculations

The limiting epola wavelength (high frequency cut-off) is reached at 8.8fm, with two lattice constants of the epola medium, and energy of the wave at 140MeV, representing the single photon in the wave carried by the kinetic energy of either a single electron or positron in the leading half-wave cluster. A classical electron cannot be '*perceived'* beyond this cut-off frequency at 3.4×10^{22}Hz and it is suggested that during the short periodicity of these very high frequencies only a part of the substructure of the electron can be 'materialised' or monitored in the Relativistic Classical world. This energy level at cut-off (140MeV) corresponds to that of the pion (pi-meson) family members, particles acknowledged by QCD to comprise of permutations of two up/down quarks/anti-quarks, (Table 1) and related to the leptons via the W bosons. The extension of wave into particle with equivalence of the two half-waves assists understanding the superposition of states of the pion.

Report of high energy gamma ray delay by the MAGIC telescope consortium[13] could confirm that all quanta above the cut-off frequency represent kinetic *quantum world* particles travelling at, near or even above the speed of light. The epola model does allow for superlumic travel of small particles, but only when the confronting lattice is breached by impacts in excess of the lattice binding energy. Such particles would be decelerated eventually by loss of energy to secondary *Bremsstrahlung* radiation[14] that then arrives from the distant source before the parent particles of the 'gamma ray burst' arrive and finally decay in Earth's atmosphere.

This concept concurs with the earlier argument for the stability of the lattice and cause of SRR by a gyrating dynamic model of the electron having quark-like substructure, bridging the classical and quantum scales.

We propose that at EM wave energies greater than 140MeV a 'portion' of the classical electron may be observed as a quark-like entity in a toroidal path lacking 4pi gyrations to describe a sphere (Fig.2d; and see ref.4f). Pion particles are without dipolar magnetic moment, as a lack of 'spin' would imply, and are associated with the leptonic attribute during their decay into muon or electron plus neutrino.

Time is the 'essence' of all forms of energy and it is suggested that the quarks represent reference to a single dimension extended (or offset) in the time dimension where quark and anti-quark extend in opposite directions of time. The colour charge, with its liberty to undertake change, would represent application of the three orthogonal spatial dimensions.

hadrons & quarks			
Particle	*Hadron*	*Symbol*	*Quarks*
+ve pion	meson	π^+	$u\bar{d}$
-ve pion	meson	π^-	$d\bar{u}$
neutral pion	meson	π^0	$u\bar{u}$ or $d\bar{d}$
proton (+ve)	baryon	P	uud
antiproton (-ve)	baryon	$\bar{\text{P}}$	$\overline{uud}$
neutron (neutral)	baryon	n	ddu

Table 1

A quark-lepton unification is suggested; the first generation fermions (Table 2), might thus be reconciled by the apparent relationship of electrons and the substructure of pions (up/down - quarks/anti-quarks). Quarks that can gain 3D existence in our Relativistic world with flowing Time (as 4D space-time) either by rotations in two dimensions of 'our' space to become leptons or by combination with two other coloured quarks to become baryons.

Charge and charge fields would be represented by the topology of space-time and it is noted that the up quark carries +⅔, the down quark carries -⅓ electric charge. A displacement of spatial dimension relative to time would begin or end (coincide) with the moment and point of observation or interaction in 'our' space-time. Such displacements would not be symmetrical in our real world, those having already occurred being more 'real' than those that are yet to complete and could explain the preponderance of free electrons compared to positrons and of protons compared to anti-protons, other than in stabilised bound aggregation states. The decay of a neutron by the emission of an electron and anti-neutrino (as an exciton of the epola[15]) hints, by the stability of the resulting proton comprising 2u+1d quarks, that the up quarks represent the 'having occurred' particle with positive ES charge. The anti-neutrino can be compatible with the bound epola containing stabilised anti-particles.

The stable electron apparently has quantum substructure containing a single down quark, representing the 'having occurred' negative particle, rotating in the other two 'colours' of spatial dimensions for dimensional 'reality', whilst antiproton and positron contain the relevant 'yet to complete' anti-quarks. It is suggested that second and third generation fermions have greater extension in time to present stronger charges and more energetic and elusive particles.

First Generation Fermions			
Fermion	*Symbol*	*Electric Charge*	*Colour charge*
Electron	e^-	-1	1
Positron	e^+	+1	1
Electron neutrino	ν_e	0	1
Up quark	u	+2/3	3
Up antiquark	$\bar{u}$	- 2/3	$\bar{3}$
Down quark	d	-1/3	3
Down antiquark	$\bar{d}$	+1/3	$\bar{3}$

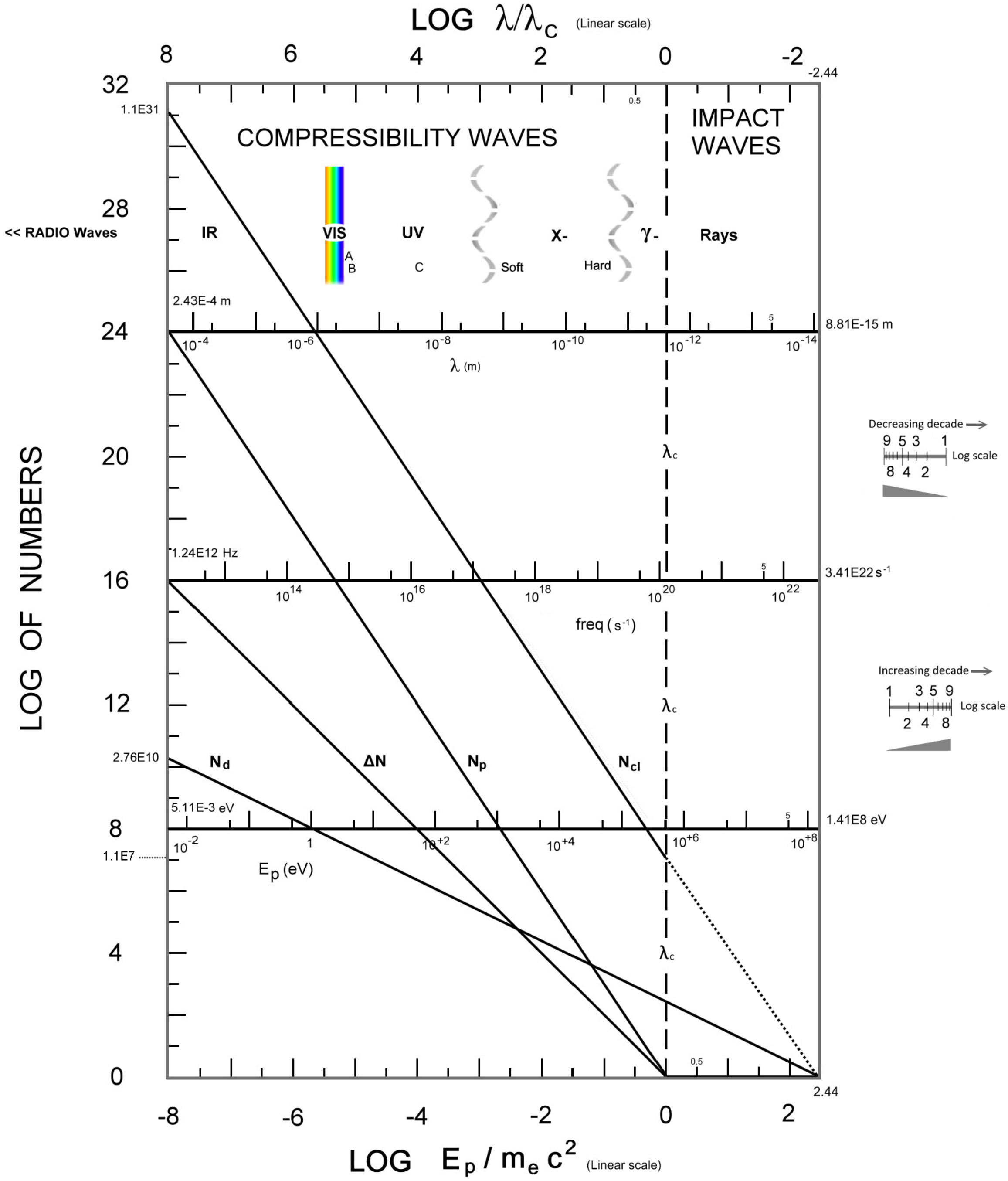
Table 2

In conclusion, the epola model of space is recommended for further consideration and investigation by its wide application and potential for insights into the physical interpretations of Relativity and Quantum Theories and for practical advantage in experimental physics.

6. Appendix

Spectrum of epola waves (electromagnetic waves) Revised Oct 2009 RGG

from: *"The Electron-Positron Lattice Space", (Fig. 4, page 64)*, M. Simhony (1990) [www.epola.org]



epola half-wave cluster characteristics

N_d epola particles on diameter

ΔN excess particles in cluster

N_p photons in cluster

N_{cl} epola particles in cluster

λ_c Compton Wave of electron, positron

Energy of photon, $E_p = E_c \times \lambda_c / \lambda = m_e c^2 \times \lambda_c / \lambda = 1.24E\text{-}6/\lambda$ eV.m^{-1}; [where E_c = energy of the Compton wave λ_c]

$N_{cl} = 1.1E7\ (\lambda/\lambda_c)^3$; $\Delta N_{(\lambda \le \lambda c)} = 1$; $\Delta N_{(\lambda > \lambda c)} = (\lambda/\lambda_c)^2$; $N_d = \lambda/2l_0$;

$E_{cl} = Ec \times \Delta N = m_e c^2(\lambda/\lambda_c)^2 = N_p E_p$; $N_p = E_{cl}/E_p = (\lambda/\lambda_c)^3$

7. References

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C. Booklet: M.Simhony, **The Story of Matter and Space**, Physics Section 5, The Hebrew University, Jerusalem 1999 (72 pp.); [Website: www.epola.co.uk]

2 The helium nucleus has 2 x10^4 greater mass density than the epola.

3 Earnshaw, S., On the nature of the molecular forces which regulate the constitution of the luminiferous ether., Trans. Camb. Phil. Soc., 7, pp 97-112 (1842)

4 Toroidal and loop models of the electron date from the early twentieth century after the electron was discovered by J.J.Thomson in 1897. W.Thomson (Lord Kelvin), was the first to propose a vortex model of the electron. **Others include:**

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b) H. Stanley Allen, "The Case for a Ring Electron", Proceedings of the Physical Society of London, V31, N1, pp. 49-68 (Dec 1918).

c) Winston H. Bostick, "Morphology of the Electron, Photon, and Neutron: The Plasmoid Construction of the Superstring", Physics Essays, V3, N4, (1990).

d) David L. Bergman, "New Spinning Charged Ring Model of the Electron", Twin Cities Creation Conference, (Jul 29-Aug 1, 1992).

e) H.J.Auvermann, An Elementary Electron Model for Electron-Electron Scattering Based on Static Magnetic Field Energy, (2001), Army Research Lab , Adelphi, MD, http://handle.dtic.mil/100.2/ADA387469.

f) W.H.F.Christie (1997), Wavicle model of electron. "Conclusion…..for example, by applying the Definition of Rest (Energy) Mass according to the Wavicle, a radius R*q*, at which a hypothetical wave of the quark is rotating at the speed of light… R*q* is calculated to be … about 1.2x10^{-13} cm [1.2fm]" http://mypage.direct.ca/c/christie/Wavicle.html

g) J G Williamson and M B van der Mark, Is the electron a photon with toroidal topology? Annales de la Fondation Louis de Broglie, Volume 22, no.2, 133 (1997)

h) Qiu-Hong Hu, The nature of the electron,, Physics Essays, Vol. 17, No. 4, 2004. .arXiv:physics/0512265v1 [physics.gen-ph].

5 see Ref 1B, Sect 6.6, page 53

6 NASA Goddard Space Centre http://imagine.gsfc.nasa.gov/docs/ask_astro/answers/970412e.html

7 F J Dyson , Advanced Quantum Mechanics (Polarisation of the vacuum p76) http://arxiv.org/abs/quant-ph/0608140 (Note by Nigel Cook, http://nige.wordpress.com/comment-to-blog-of-andrew-thomas/)

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http://www.physics.purdue.edu/topaz/research/emagcoupl.html

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10 P. Rowlands , Zero to Infinity, Appendix A, p631; Grand Unification (1999)...Grand unification is predicted to occur at the Planck mass. *[1.2 x 10^{19}GeV].* electric fsc is predicted to be 1/118 at 14TeV *(1.4 x 10^{13} eV).*

11 S. Hawking, (1988). *A Brief History of Time*.Bantam. p.167 ISBN 0-593-01518-5 : "..not be very surprising if ...between the electroweak unification energy of about 100GeV and the grand unification energy of about a thousand million million GeV. We might indeed expect to find several new layers of structure more basic than the quarks and electrons we now regard as 'elementary' particles."

12 C.L.Salter et al, An entangled-light-emitting-diode , Nature, Vol **465** 594 (accepted April 2010) Toshiba Research Europe Ltd and Cavendish Laboratory, University of Cambridge. See also: http://www.toshiba-europe.com/research/crl/qig/entangledled.html

13 Probing quantum gravity using photons from a flare of the active galactic nucleus Markarian 501 observed by the MAGIC telescope arXiv:0708.2889v3 [astro-ph] *[MAGIC; Major Atmospheric Gamma-ray Imaging Cherenkov telescope]*

14 *Bremsstrahlung (braking)* radiation may include or be accompanied by Cherenkov radiation (where the vacuum is not pure), Larmor and Hawking-Unruh radiation.

15 The epola model claims that an electron-neutrino is an electron-positron pair, partially bound into the lattice as an exciton: *see:* The Neutrino-Excitonm Analogy, *M. Simhony (Hebrew U.)* http://flux.aps.org/meetings/YR97/BAPSAPR97/abs/G280030 Neutrinos and Positronium as Quantized States of Mobile Electron Positron Pairs in the e^-e^+ Latice (Epola) Space, *M. Simhony (Hebrew U.)*
http://flux.aps.org/meetings/YR97/BAPSAPR97/abs/G280031