Within the following ResearchGate paper by Andrea Rossi, exploring the basis of his invention the E-Cat, the Zitterbewegung electron model as proposed by Celani et al., along with the Casimir force, is used within one possible theoretical framework as the basis for formation of dense exotic electron clusters, these being a probable precursor to energy release. An in-depth exploration of this 3D electron model may be of interest.

https://www.researchgate.net/publication/330601653_E-Cat_SK_and_long-range_particle_interactions

From the Zitterbewegung (ZBW) electron model as proposed by F. Celani, A.O. Di Tommaso and G. Vassallo, see references [8] and [15] within the above ResearchGate paper. (Figures from the same authors papers).

For an electron at rest, i.e. zero movement along the z-axis of rotation, the electron elementary charge is a sphere with the radius of the classical electron radius = r_0 , the charge is massless, its centre travels at the speed of light = c , the moving charge induces magnetic-electric interaction with an orthogonal centripetal force leading to a circular orbit, the radius of this orbit at rest is the ZBW radius = r_e , the circumference of one orbit at rest equals the Compton wavelength = $\lambda_c = 2\pi r_e = c\,T_e$, as all points on the charge sphere surface travel at exactly the speed of light, the charge sphere counter rotates once for each ZBW orbit loop.

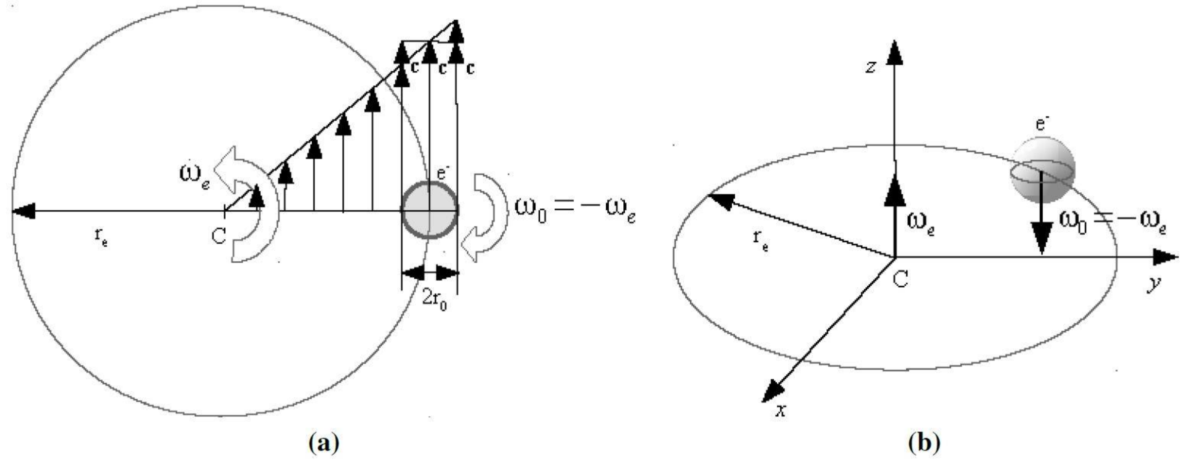
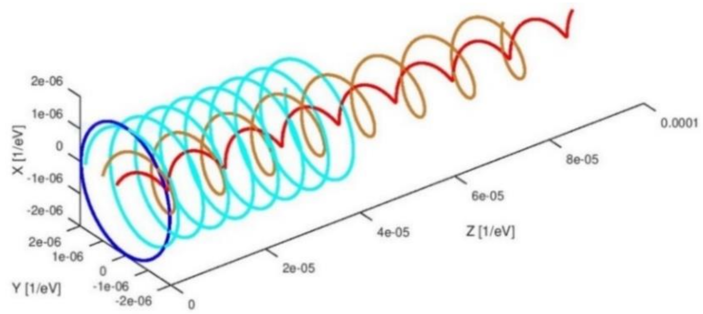


Figure 1. (a) ZBW model and speed diagrams of the electron charge (e^-). All points of the sphere have an absolute speed equal to c. (b) 3D representation. The charged sphere is rotating with the relative angular speed $\omega_0 = -\omega_e$ on the trajectory having radius r_e around the vertical axis passing through the center of the sphere.

For a free electron at rest with zero z-axis velocity, the electron rest momentum = $P_r = \frac{h}{\lambda_c} = \frac{h}{2\pi r_e} = \frac{\hbar}{r_e}$

As momentum is added in the z-axis direction, the electron accelerates in this direction, initial momentum P_r is increased, as Planck value = $h = 2\pi\hbar$ is constant, the ZBW radius r_e orthogonal to the z-axis must reduce, the charge circular orbit transitions to follow a helix pathway. After electron acceleration, for each increase in velocity along the z-axis of rotation = v_z , there is an increase in the z-axis distance travelled by a coil turn, the coil ZBW radius will also reduce, i.e., a different diameter constant pitch helix for each different velocity.



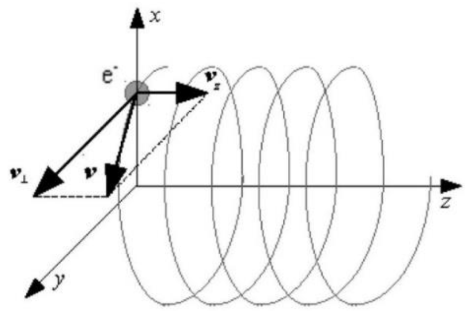
v/c = 0 , 0.43, 0.86, 0.98

Each of the charge pathway helixes depicted has a reduced ZBW radius, this radius = the ZBW radius of an electron at rest r_e , divided by the Lorentz factor γ based on the z-axis velocity v_z i.e. $r_e\ rest \rightarrow \frac{r_e}{\gamma}\ moving$

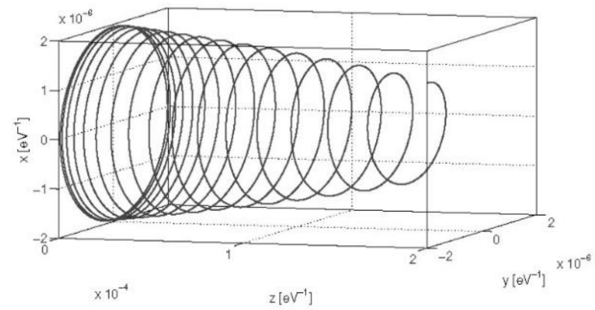
[Wikipedia](); "*The Lorentz factor or Lorentz term is a quantity that expresses how much the measurements of time, length, and other physical properties change for an object while that object is moving.*"

Lorentz factor γ = $\left(1-\frac{{v_z}^2}{c^2}\right)^{-0.5}$, inverting this = longitudinal z-axis velocity component = $v_z \;=\; c\left(1-\frac{1}{\gamma^2}\right)^{0.5}$

For an electron traveling at constant velocity along its z-axis, the charge following its helix pathway has the components of longitudinal z-axis velocity = v_z , velocity orthogonal to z-axis = $v_\perp$ and resultant velocity = v , for a constant z-axis velocity the time interval to travel the distance along each of the components is equal.



Constant z-axis velocity electron



Electron accelerating towards the right

From the ZBW electron model as proposed by Celani et al., the velocity of the electron charge moving in both the rest circular orbit and the helix pathways is constant and defined as $v \;=\; c$, the speed of light.

From Pythagoras $\quad v^2 \;=\; {v_z}^2 + {v_\perp}^2 \quad$ then $\quad v_\perp \;=\; (v^2 - {v_z}^2)^{0.5}$

Therefore, using $\quad v_z \;=\; c\left(1-\frac{1}{\gamma^2}\right)^{0.5} \quad$ and as $\quad v \;=\; c \quad$ then $\quad v_\perp \;=\; \left(c^2 - \left(c\left(1-\frac{1}{\gamma^2}\right)^{0.5}\right)^2\right)^{0.5} \;=\; \frac{c}{\gamma}$

As the electron velocity increases, the Lorentz factor increases, rest mass = m_e also increases as $m_e \to \gamma\, m_e$

As the Planck value h is constant, for loop time interval = $T_e \;=\; \frac{h}{E} \;=\; \frac{h}{m_e\, c^2}$, T_e must then decrease as $T_e \to \frac{T_e}{\gamma}$

The orthogonal orbit distance travelled will then be = velocity $v_\perp$ × loop time interval = $\frac{c}{\gamma} \times \frac{T_e}{\gamma} = \frac{\lambda_C}{\gamma^2}$

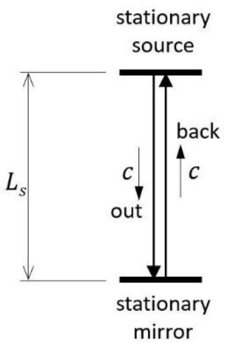
As the electron velocity increases, the ZBW radius reduces, $r_e \to \frac{r_e}{\gamma}$, and orthogonal distance = $\frac{2\,\pi\, r_e}{\gamma} = \frac{\lambda_C}{\gamma}$

The distance derived from velocity and time conflicts with distance derived from the ZBW radius.

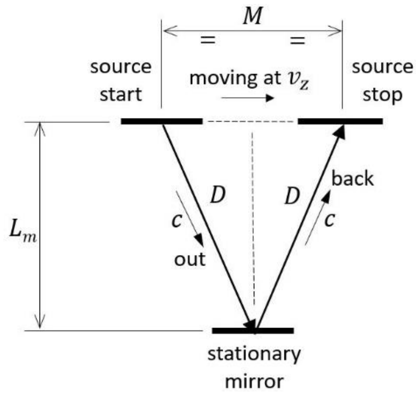
There is another conflict with $v \;=\; c$, as the ZBW radius r_e reduces, the mass m_e increases, from $r_0 \;=\; \frac{\mu_0\, e^2}{4\,\pi\, m_e}$ the charge sphere radius r_0 also reduces, this agrees with the fine structure constant = $\alpha \;=\; \frac{r_0}{r_e}$, as both ZBW and charge radii decrease at the same rate the ratio is constant, as an electron accelerates, the ZBW radius reduces and the helix pathway spirals inwards, at the same time the charge sphere radius also reduces, this inward surface velocity must be accounted for, for a sphere traveling with the centre moving at the speed of light the leading surface shrinks towards the centre, this surface travels slower than the speed of light, the trailing surface shrinks towards the centre, therefore this surface travels at a velocity greater than the speed of light. For a shrinking charge sphere travelling along the 3D curving pathway of a reducing spiral, there is no rotation geometry where all points on a sphere surface can maintain the same speed of light velocity.

As an alternative, the permitted velocity in the orthogonal plane is $v_\perp \;=\; c$, from $\omega_e \;=\; \frac{\alpha\, c}{r_0}$, as α and c are constants, as r_0 decreases the ZBW angular frequency = ω_e must increase, this confirms that the time for one circuit must reduce, the only way for a circuit time to reduce at the same rate as the ZBW radius is reducing is for the orthogonal velocity to be constant, i.e. $v_\perp \;=\; c$, consequently the velocity $v \to < \sqrt{2}\, c$

The Lorentz factor γ = $\left(1 - \frac{{v_z}^2}{c^2}\right)^{-0.5}$, this factor can be related to time difference in observations between a fixed and moving light source as seen by a stationary observer, *assume*; time out = time back & $v_z\,max = c$:



Source stationary $v_z = 0$



Source moving relative to stationary observer at mirror

T_s = Observed time at both source & mirror time for travel out plus travel back

$T_s = \frac{2\,L_s}{c}$ $\quad L_s = \frac{c\,T_s}{2}$ $\quad c$ = Velocity of light

T_m = Stationary observer with clock at mirror time for travel out plus travel back

$T_m = \frac{2\,D}{c}$ $\quad D = \frac{c\,T_m}{2}$ $\quad M = v_z\,T_m$

From Pythagoras $\quad D^2 = \left(\frac{M}{2}\right)^2 + {L_m}^2$

For $v_z = 0$ then $T_m = T_s$ and $L_m = L_s$

$$\left(\frac{c\,T_m}{2}\right)^2 = \left(\frac{v_z\,T_m}{2}\right)^2 + \left(\frac{c\,T_s}{2}\right)^2$$

(if $v_z\,max = c$, $M = v_z\,T_m = 2\,D = 2 \times \frac{c\,T_m}{2}$)

$$\left(\frac{c\,T_s}{2}\right)^2 = \left(\frac{c\,T_m}{2}\right)^2 - \left(\frac{v_z\,T_m}{2}\right)^2$$

$$\frac{c^2\,{T_s}^2}{4} = \frac{c^2\,{T_m}^2}{4} - \frac{{v_z}^2\,{T_m}^2}{4} = {T_m}^2\left(\frac{c^2}{4} - \frac{{v_z}^2}{4}\right)$$

$${T_s}^2 = \frac{4}{c^2}\,{T_m}^2\left(\frac{c^2}{4} - \frac{{v_z}^2}{4}\right) = {T_m}^2\left(1 - \frac{{v_z}^2}{c^2}\right)$$

$$T_s = T_m\sqrt{1 - \frac{{v_z}^2}{c^2}} \quad \rightarrow \quad T_s = \frac{T_m}{\gamma} \quad \text{where} \quad \gamma = \left(1 - \frac{{v_z}^2}{c^2}\right)^{-0.5}$$

therefore $\quad T_m = \frac{T_s}{\sqrt{1 - \frac{{v_z}^2}{c^2}}} \quad \rightarrow \quad T_m = \gamma\,T_s$

The time dilation interpretation: to a stationary and distant observer, the observed time T_m is the time interval taken for source moving at v_z to travel a distance M , time interval based on stationary observer's clock distant from source, as velocity v_z increases, observed time T_m for distance M travelled increases.

$$T_m = \text{Lorentz factor } \gamma \times \text{observed time interval when at rest } T_s \qquad T_m\,rest \rightarrow \gamma\,T_m\,moving$$

Local clock interpretation: a light source travels at velocity v_z for a distance of M , as velocity v_z increases the start to stop time interval T_s observed at local source decreases relative to the time interval observed by the clock of the distant observer, i.e., as velocity v_z increases, as γ increases, local source interval T_s decreases.

$$T_s = \frac{T_m\text{ distant observer time interval}}{\text{Lorentz factor }\gamma} \qquad T_s \rightarrow \frac{T_s}{\gamma},$$

i.e., for an electron $v_z = c\left(1 - \frac{1}{\gamma^2}\right)^{0.5}$ and $T_e \rightarrow \frac{T_e}{\gamma}$

Accelerating electrons emanate electromagnetics; frequency inversely proportional to both wavelength and time, therefore wavelength proportional to time, therefore wavelength decrease = time interval decrease.

Based on the electron model and equations as proposed in the 2017 paper: F. Celani, A.O. Di Tommaso and G. Vassallo - The Electron and Occam's Razor, a collection of property equations presented over a few pages, to allow an easier examination of relationships and attempt an understanding of the root basis.

Permitted velocity of light = $c = \frac{1}{\sqrt{\mu_0\,\varepsilon_0}} \quad \frac{\lambda_c}{T_e} = \frac{2\,\pi\,r_e}{T_e} = r_e\,\omega_e = \frac{r_0\,\omega_e}{\alpha} = \frac{P_r}{m_e} = \frac{E}{P_r} = \frac{E_f}{B_e} = \frac{H_f}{D_e} = \frac{J_d}{\rho_c}$ = m s^{-1}

Vacuum permeability = $\mu_0 = 4\,\pi\,10^{-7} = \frac{1}{\varepsilon_0\,c^2} = \frac{2\,\alpha\,R_K}{c} = \frac{2\,\alpha\,V_e}{I_e\,c} = \frac{2\,\alpha\,\phi_e}{e\,c} = \frac{2\,\alpha\,h}{e^2\,c} = \frac{\alpha^3\,m_e}{R_\infty\,e^2} = \frac{2\,B_e}{H_f}$ = V A^{-1} s m^{-1}

Vacuum permittivity = $\varepsilon_0 = \frac{1}{\mu_0\,c^2} = \frac{1}{4\,\pi\,k_e} = \frac{C_e}{2\,\alpha\,\lambda_c} = \frac{K_J\,e}{4\,\alpha\,c} = \frac{I_e}{2\,\alpha\,V_e\,c} = \frac{e}{2\,\alpha\,\phi_e\,c} = \frac{e^2}{2\,\alpha\,h\,c} = \frac{D_e}{2\,E_f}$ = V^{-1} A s m^{-1}

Resistance of vacuum structure = $Z_0 = \mu_0\,c = \left(\frac{\mu_0}{\varepsilon_0}\right)^{0.5} = \frac{1}{\varepsilon_0\,c} = \frac{4\,\pi\,k_e}{c} = \frac{2\,\alpha\,\phi_e}{e} = \frac{2\,\alpha\,V_e}{I_e} = \frac{2\,E_f}{H_f} = \frac{2\,B_e}{D_e}$ = V A^{-1}

Coulomb constant = $k_e = \frac{\mu_0\,c^2}{4\,\pi} = \frac{1}{4\,\pi\,\varepsilon_0} = \frac{Z_0\,c}{4\,\pi} = \frac{\alpha\,R_K\,c}{2\,\pi} = \frac{r_0\,R_K}{T_e} = \frac{r_0}{C_e} = \frac{r_0\,V_e}{e} = \frac{r_0\,E}{e^2} = \frac{\alpha\,\hbar\,c}{e^2}$ = V A^{-1} s^{-1} m

Fine structure constant (FSC) = α, a dimensionless constant. From the 2005 paper: Hans de Vries - The fine structure constant: A radiative series leading to it's exact value. For clarity in this series e = Euler's number.

Rearranging to get: $e^{\frac{\pi^2}{4}} = \sum_{n=0}^{\infty} \frac{\alpha^{(n-0.5)}}{(2\,\pi)^{\frac{n\,(n-1)}{2}}}$ [Is FSC related to a spiral between electron orbits - levels?]

By back calculation, α = 0.007 297 352 568 6539… $\frac{1}{\alpha}$ = 137.035 999 095 8297…

Input for Wolfram Alpha website; e^(π²/4)=∑α^(n-0.5)/(2π)^(n(n-1)/2),n=0..5 n=∞ limited to say n=5

Either the FSC is a mathematical constant, or the Hans de Vries series leads to a close CODATA coincidence.

$\alpha = \frac{r_0}{r_e} = \frac{r_0\,\omega_e}{c} = \sqrt{2\,R_\infty\,\lambda_c} = \frac{Z_0}{2\,R_K} = \frac{\mu_0\,c}{2\,R_K} = \frac{e^2}{4\,\pi\,\varepsilon_0\,\hbar\,c} = \frac{\mu_0\,e\,c}{2\,\phi_e} = \frac{\mu_0\,I_e}{2\,A_V} = \frac{r_0\,B_e}{A_V} = \frac{B_e}{R_K\,D_e} = \frac{E_f}{R_K\,H_f} = \frac{e\,E_f}{\phi_e\,H_f}$

Von Klitzing constant = $R_K = \frac{Z_0}{2\,\alpha} = \frac{\mu_0\,c}{2\,\alpha} = \frac{1}{2\,\alpha\,\varepsilon_0\,c} = \frac{h}{e^2} = \frac{\phi_e{}^2}{h} = \frac{\phi_e}{e} = \frac{V_e}{I_e} = \frac{r_e\,E_f}{I_e} = \frac{V_e}{r_0\,H_f} = \frac{E_f}{\alpha\,H_f} = \frac{B_e}{\alpha\,D_e}$ = V A^{-1}

Rydberg constant = R_∞, the Rydberg "constant" is not a constant, it increases with electron z-axis velocity

$R_\infty = \frac{\alpha^2}{2\,\lambda_c} = \frac{\alpha^3}{4\,\pi\,r_0} = \frac{\alpha^2}{4\,\pi\,r_e} = \frac{\alpha^2}{2\,c\,T_e} = \frac{\alpha^2\,\omega_e}{4\,\pi\,c} = \frac{\alpha^2\,P_r}{2\,h} = \frac{\alpha^2\,m_e\,c}{2\,h} = \frac{\alpha^2\,A_V}{2\,\phi_e} = \frac{\alpha^2\,I_e}{2\,e\,c} = \frac{\alpha\,\mu_0\,e^2\,c}{4\,\lambda_c\,h} = \frac{m_e\,e^4}{8\,\varepsilon_0{}^2\,h^3\,c}$ = m^{-1}

Electron Compton wavelength, charge orbit circuit length = $\lambda_c = 2\,\pi\,r_e = c\,T_e = \frac{\alpha^2}{2\,R_\infty} = \frac{h}{P_r} = \frac{e\,c}{I_e} = \frac{\phi_e}{A_V}$ = m

Electron charge radius = $r_0 = r_e\,\alpha = \frac{\alpha\,c}{\omega_e} = \frac{\alpha^3}{4\,\pi\,R_\infty} = \frac{\alpha\,\hbar}{P_r} = \frac{\mu_0\,\mu_e}{\phi_e} = \frac{k_e\,m_e}{A_V{}^2} = \frac{k_e\,e}{V_e} = k_e\,C_e = \frac{I_e}{H_f} = \frac{E}{H_f\,\phi_e}$ = m

ZBW orbit radius = reduced Compton wavelength = $r_e = \frac{r_0}{\alpha} = \frac{\lambda_c}{2\,\pi} = \frac{c}{\omega_e} = \frac{\alpha^2}{4\,\pi\,R_\infty} = \frac{\hbar}{P_r} = \frac{V_e}{E_f} = \frac{E}{E_f\,e}$ = m

Charge pathway travel time, one circuit = $T_e = \frac{2\,\pi}{\omega_e} = \frac{\lambda_c}{c} = \lambda_c\,\sqrt{\mu_0\,\varepsilon_0} = \sqrt{L_e\,C_e} = \frac{\alpha^2}{2\,c\,R_\infty} = \frac{h}{E} = \frac{e}{I_e} = \frac{\phi_e}{V_e}$ = s

ZBW angular frequency = $\omega_e = \frac{c}{r_e} = \frac{2\,\pi\,c}{\lambda_c} = \frac{2\,\pi}{T_e} = \frac{2\,\pi}{\sqrt{L_e\,C_e}} = \frac{4\,\pi\,R_\infty\,c}{\alpha^2} = \frac{2\,\pi\,I_e}{e} = \frac{2\,\pi\,V_e}{\phi_e} = \frac{E}{\hbar} = \frac{h}{2\,\pi\,r_e{}^2\,m_e}$ = rad s^{-1}

Electron inductance = $L_e = R_K\,T_e = \frac{\pi\,r_e{}^2\,\mu_0}{r_0} = \frac{\lambda_c\,\mu_0}{2\,\alpha} = \frac{\alpha\,\mu_0}{4\,R_\infty} = \frac{4}{K_J{}^2\,E} = \frac{T_e\,h}{e^2} = \frac{\phi_e{}^2}{E} = \frac{\phi_e}{I_e} = \frac{E}{I_e{}^2} = \frac{T_e{}^2}{C_e}$ = V A^{-1} s

Electron capacitance = $C_e = \frac{T_e}{R_K} = 4\,\pi\,r_0\,\varepsilon_0 = \frac{r_0}{k_e} = 2\,\alpha\,\lambda_c\,\varepsilon_0 = \frac{\alpha^3\,\varepsilon_0}{R_\infty} = \frac{T_e\,e^2}{h} = \frac{e^2}{E} = \frac{e}{V_e} = \frac{E}{V_e{}^2} = \frac{T_e{}^2}{L_e}$ = V^{-1} A s

Scalar potential, Volts in a field, oriented orthogonal to and encircling the pathway current = V_e = Volts

$$V_e = R_K I_e = \frac{T_e I_e}{C_e} = \frac{e}{C_e} = \frac{R_K e}{T_e} = \frac{\phi_e}{T_e} = \frac{\phi_e I_e}{e} = \frac{E}{e} = \frac{h}{T_e e} = \frac{Z_0 I_e}{2\alpha} = A_V c = \frac{P_r c}{e} = r_e E_f = \frac{2\mu_e B_e}{e} = \frac{R_K \mu_e}{\pi r_e^2}$$

Flux circling orthogonal to electron pathway current, flux crossing through ZBW area plane = ϕ_e = V s

$$\phi_e = R_K e = \frac{L_e e}{T_e} = L_e I_c = T_e R_K I_c = T_e V_e = \frac{2\pi V_e}{\omega_e} = \frac{E}{I_e} = \frac{h}{e} = \sqrt{R_K h} = A_V \lambda_c = \frac{P_r c}{I_e} = \frac{\lambda_c E_f}{\omega_e} = \frac{\mu_0 \mu_e}{r_0} = \frac{2}{K_J}$$

Josephson constant = $K_J = \frac{2}{\phi_e} = \frac{2\alpha^3 m_e}{R_\infty \mu_0 h e} = \frac{2 r_0}{\mu_0 \mu_e} = \frac{2e}{h} = \left(\frac{4}{R_K h}\right)^{0.5} = \frac{2}{R_K e} = \frac{1}{\pi r_e^2 B_e} = \frac{\omega_e}{\pi V_e} = \frac{2}{\lambda_c A_V}$ = V^{-1} s^{-1}

Vector potential, flux per length, Volt component of momentum transfer = A_V = V s m^{-1}

$$A_V = \frac{V_e}{c} = \frac{\phi_e}{\lambda_c} = \frac{R_K I_e}{c} = \frac{R_K e}{\lambda_c} = \frac{\mu_0 e}{2\alpha T_e} = \frac{\mu_0 I_e}{2\alpha} = \frac{h}{e\lambda_c} = \frac{\hbar}{e r_e} = \frac{\hbar \omega_e}{e c} = \frac{I_e \phi_e}{e c} = \frac{E}{e c} = \frac{P_r}{e} = \frac{E_f}{\omega_e} = r_e B_e = \frac{\mu_0 \mu_e}{\lambda_c r_0}$$

Electron charge scalar current = I_e = Amps, at rest a current orthogonal to the electron z-axis, orthogonal component only, inducing transverse electromagnetics only, at v_z a current oriented to the helix pathway with both orthogonal and axial I_e components, inducing both transverse and longitudinal electromagnetics.

$$I_e = \frac{V_e}{R_K} = \frac{T_e V_e}{L_e} = \frac{\phi_e}{L_e} = \frac{\phi_e}{T_e R_K} = \frac{e}{T_e} = \frac{e V_e}{\phi_e} = \frac{E}{\phi_e} = \frac{h}{T_e \phi_e} = \frac{2\alpha V_e}{Z_0} = \frac{2\alpha A_V}{\mu_0} = \frac{P_r c}{\phi_e} = r_0 H_f = \pi r_0^2 J_d = \frac{\mu_e}{\pi r_e^2}$$

Elementary charge = $e = \frac{\phi_e}{R_K} = \frac{C_e \phi_e}{T_e} = C_e V_e = \frac{T_e V_e}{R_K} = T_e I_e = \frac{2\pi I_e}{\omega_e} = \frac{E}{V_e} = \frac{h}{\phi_e} = \left(\frac{h}{R_K}\right)^{0.5} = \frac{P_r}{A_V} = \frac{2\mu_e}{r_e c}$ = A s

Electron magnetic moment = $\mu_e = \left(\frac{r_0 r_e h c}{2\mu_0}\right)^{0.5} = \frac{2 r_0}{\mu_0 K_J} = \frac{r_0 \phi_e}{\mu_0} = \frac{r_e e c}{2} = \pi r_e^2 I_e = \frac{\pi r_e^2 E}{\phi_e} = \frac{E}{2 B_e}$ = A m^2

Electron rest energy, product of a Volt based, and an Amp based component interaction = E = V A s

$$E = m_e c^2 = \frac{m_e}{\mu_0 \varepsilon_0} = P_r c = \frac{h}{T_e} = \hbar \omega_e = \frac{e^2}{C_e} = V_e e = \frac{\phi_e^2}{L_e} = \phi_e I_e = \frac{\phi_e e}{T_e} = V_e I_e T_e = 2\mu_e B_e = r_e E_f r_0 H_f T_e$$

Planck constant = $h = \phi_e e = \frac{\phi_e^2}{R_K} = R_K e^2 = \frac{4}{R_K K_J^2} = \frac{\mu_0 \mu_e e}{r_0} = \frac{2\mu_0 \mu_e^2}{r_0 r_e c} = e A_V \lambda_c = P_r \lambda_c = E T_e$ = V A s^2

Reduced Planck constant, angular momentum per radian orthogonal to the z-axis = $\hbar$ = rad^{-1} V A s^2

$$\hbar = \frac{h}{2\pi} = \frac{h}{\omega_e T_e} = \frac{E}{\omega_e} = r_e P_r = r_e m_e c = \frac{2\mu_e A_V}{c} = r_e e A_V = \frac{e}{\pi K_J} = \frac{R_K e^2}{2\pi} = \frac{e \phi_e}{2\pi} = \frac{V_e I_e T_e^2}{2\pi} = \frac{r_e E_f r_0 H_f T_e}{\omega_e}$$

Electron rest mass, local product of Volt and Amp rotations interacting with each other = m_e = V A s^3 m^{-2}

$$m_e = \frac{16\varepsilon_0 R_\infty}{\alpha K_J^2} = C_e A_V^2 = \frac{\mu_0 e^2}{2\alpha \lambda_c} = \frac{h}{\lambda_c c} = \frac{\hbar}{r_e c} = \frac{P_r}{c} = \frac{e A_V}{c} = \frac{e \phi_e}{\lambda_c c} = \frac{V_e I_e T_e}{c^2} = \frac{r_e E_f r_0 H_f T_e}{c^2} = \frac{E}{c^2} = \mu_0 \varepsilon_0 E$$

Electric field strength = $E_f = B_e c = \frac{\mu_0 H_f c}{2} = \frac{D_e}{2\varepsilon_0} = \frac{m_e^2 c^3}{e\hbar} = \omega_e A_V = \frac{V_e}{r_e} = \frac{\phi_e}{r_e T_e} = \frac{T_e I_e}{r_e C_e} = \frac{e}{r_e C_e}$ = V m^{-1}

Flux area density = $B_e = \frac{E_f}{c} = \frac{\mu_0 H_f}{2} = \frac{\mu_0 D_e c}{2} = \frac{m_e^2 c^2}{e\hbar} = \frac{A_V}{r_e} = \frac{V_e}{r_e c} = \frac{\phi_e}{2\pi r_e^2} = \frac{\mu_0 I_e}{2 r_0} = \frac{e}{r_e C_e c}$ = V s m^{-2}

Magnetic field strength = $H_f = D_e c = \frac{2E_f}{\mu_0 c} = \frac{2B_e}{\mu_0} = \frac{E}{\mu_0 \mu_e} = \frac{I_e}{r_0} = \frac{e}{r_0 T_e} = \frac{T_e V_e}{r_0 L_e} = \frac{\phi_e}{r_0 L_e} = \frac{\phi_e}{\pi r_e^2 \mu_0}$ = A m^{-1}

Charge area density = $D_e = \frac{H_f}{c} = 2\varepsilon_0 E_f = \frac{2B_e}{\mu_0 c} = \frac{H_f B_e}{E_f} = \frac{A_V}{r_0 R_K} = \frac{I_e}{r_0 c} = \frac{\alpha e}{2\pi r_0^2} = \frac{2\varepsilon_0 V_e}{r_e} = \frac{\phi_e}{r_0 c L_e}$ = A s m^{-2}

Current area density = $J_d = \rho_c c = \frac{2\varepsilon_0 E_f c}{\pi r_0} = \frac{H_f}{\pi r_0} = \frac{2 D_e}{\alpha T_e} = \frac{\mu_e}{\pi r_0^2 \pi r_e^2} = \frac{V_e}{\pi r_0^2 R_K} = \frac{I_e}{\pi r_0^2} = \frac{e}{\pi r_0^2 T_e}$ = A m^{-2}

Charge volume density = $\rho_c = \frac{J_d}{c} = \frac{2\varepsilon_0 E_f}{\pi r_0} = \frac{H_f}{\pi r_0 c} = \frac{A_V}{\pi r_0^2 R_K} = \frac{\phi_e}{\pi r_0^2 \lambda_c R_K} = \frac{I_e}{\pi r_0^2 c} = \frac{e}{\pi r_0^2 \lambda_c}$ = A s m^{-3}

For all the above equations, based on a single free electron at rest, there are no multiples of 3 or 5 in the equations numerator or denominator, if R_∞ was twice its value and / or if K_J and μ_0 were half their values (i.e. μ_0 based on $2\,\pi$ instead of $4\,\pi$), many of the 2's disappear from equations, neither Volts or Amps within the units have exponents greater than one, Volt or Amp based properties are often squared, also there is nothing relating to the volume of a charge sphere, disk areas often seen, as either the charge cross section area $\pi\, r_0{}^2$ orthogonal to the charge pathway or the charge orbit ZBW area $\pi\, r_e{}^2$ orthogonal to the z-axis. All equations above are valid for a free electron at rest relative to the vacuum structure, no velocity v_z along the electron charge orbit longitudinal z-axis, no interaction with surrounding environment, as an electron increases its velocity relative to its surroundings, say the vacuum structure, it is known that some properties also increase in value, i.e. energy, mass, momentum, some decrease, i.e. length, and some stay the same, i.e. Planck constant, if internal property value changes are proportional to Lorentz factor increase for a velocity v_z increase, for the equations above to be valid at any z-axis velocity v_z the following must be true.

The values of the following properties local to an electron are constant, i.e., are conserved, do not change with any change in the value of the Lorentz factor γ for the electron longitudinal z-axis velocity v_z :
$\pi \quad c \quad \mu_0 \quad \varepsilon_0 \quad Z_0 \quad k_e \quad \alpha \quad R_K \quad \phi_e \quad K_J \quad e \quad h \quad \hbar$

The following electron property values are not conserved, they increase as a multiple of the Lorentz factor:
$R_\infty \quad \omega_e \quad V_e \quad A_V \quad I_e \quad E \quad m_e \quad P_r$

The following electron property values decrease, as a multiple of the inverse of the Lorentz factor:
$\lambda_c \quad r_0 \quad r_e \quad T_e \quad L_e \quad C_e \quad \mu_e$

The following electron property values increase, as a multiple of the square of the Lorentz factor:
$E_f \quad B_e \quad H_f \quad D_e$

The following electron property values increase, as a multiple of the cube of the Lorentz factor:
$J_d \quad \rho_c$

Electron momentum, product of Volt and Amp interactions, electron at rest, zero z-axis velocity = P_r

$$P_r = m_e\, c = \frac{E}{c} = \frac{E\,T_e}{\lambda_c} = \frac{h}{\lambda_c} = \frac{h}{2\,\pi\, r_e} = \frac{\hbar}{r_e} = \frac{e\,\phi_e}{\lambda_c} = \frac{C_e\, V_e{}^2}{c} = \frac{L_e\, I_e{}^2}{c} = \frac{e\, V_e}{c} = e\, A_V = \frac{\phi_e\, I_e}{c} = \phi_e \times \left(\frac{\mathrm{A\,s}}{\mathrm{m}}\right) = \mathrm{V\,A\,s^2\,m^{-1}}$$

After acceleration from rest, as electron moves along its z-axis, as $P_r \rightarrow \gamma\, P_r$, resultant total momentum = P_t

After electron acceleration, momentum P_r is increased by a multiple of the Lorentz factor γ for velocity v_z, as angular momentum is conserved, then λ_c and radius r_e must decrease, $r_e \rightarrow \frac{r_e}{\gamma}$. As electromagnetics emanate during acceleration, and as electromagnetics enable momentum transfer, with radial $P_\perp$ proportional to h , and longitudinal P_Z increasing as all received z-axis component momentum is accepted, any received radial component momentum that is excess, but less than an additional $\frac{h}{2}$ or h ? must be rejected and emitted.

$$P_t = \gamma\, P_r = \frac{\gamma\,\hbar}{r_e} = \frac{E}{\sqrt{c^2 - v_z{}^2}} = \sqrt{P_\perp{}^2 + P_Z{}^2} = \sqrt{P_r{}^2 + P_Z{}^2} = \text{original momentum + that received - that emitted}$$

As momentum $P_r = e\, A_V = \frac{V_e\, I_e\, T_e}{c}$ increases, as the vector potential $A_V = \frac{V_e}{c}$ = Volts divided by the speed of light, for A_V to increase where c is constant, the scalar potential V_e = Volts must also increase, also as charge $e = I_e\, T_e$ = Amps × seconds is constant at any velocity, and as circuit time decreases as velocity and momentum increase, the current I_e must then increase to keep the charge constant, therefore Amps must increase. As momentum increases / decreases during acceleration / deceleration, momentum components, i.e., both Volts and Amps, may be received or transmitted concurrently via some form of electromagnetics.

From Aharonov and Bohm it is known that electrons can be phase shifted in a region where both electric field strength **E** and flux density **B** are zero, i.e., relative change in orientation's, i.e., changes in electron's momentum, therefore Volts may be transferred via vector potential A_V , but where do Amps come from?

When an electron receives V A s^2 m^{-1} , depending on electron z-axis orientation relative to incoming axis and handing of solenoidal components, there is momentum change, precession, and acceleration or deceleration to a new velocity. As the properties E_f , B_e , A_V , ϕ_e and V_e all contain Volts only, and if Amps are not created local to an electron or extracted from the vacuum by any property interacting with μ_0 or ε_0 , if both Volts and Amps can be transferred by electron or photon interaction, then as a photon is believed to have zero charge and zero mass, what is the physical property within a photon that transfers Amps? … $\left(\frac{\mathrm{A\,s}}{\mathrm{m}}\right)$?

Increase in momentum = increase in V A s^2 m^{-1} , i.e., an increase in both Volts and Amps within an electron that has increased its velocity, this can be derived by dimensional analysis of Volts, Amps, time, and length.

For an electron or particle moving at velocity v_z , with the resulting Lorentz factor γ , the following is known:

Energy $E = m_e\, c^2$ increases with an increase in velocity v_z , $E\ rest \rightarrow \gamma\ E\ moving$ = units V A s

Momentum $P_r = m_e\, c$ increases with an increase in velocity v_z $P_r\ rest \rightarrow \gamma\ P_r\ moving$ = units V A s^2 m^{-1}

Planck constant h remains constant at any velocity v_z , $h\ rest \rightarrow h\ moving$ = units V A s^2

Electron elementary charge e remains constant at any velocity v_z , $e\ rest \rightarrow e\ moving$ = units A s

From rest, the values of the following ratios all increase with an increase in electron z-axis velocity; therefore, the following can be derived from the units:

Ratio $\frac{E}{e}$, in units = $\frac{\mathrm{V\,A\,s}}{\mathrm{A\,s}} = \mathrm{V}$, therefore as velocity increases, Volts V increase, $\mathrm{V} \rightarrow \gamma\,\mathrm{V}$

Ratio $\frac{e\,E}{h}$, in units = $\frac{\mathrm{A\,s} \times \mathrm{V\,A\,s}}{\mathrm{V\,A\,s^2}} = \mathrm{A}$, therefore as velocity increases, Amps A increase, $\mathrm{A} \rightarrow \gamma\,\mathrm{A}$

Ratio $\frac{E}{h}$, in units = $\frac{\mathrm{V\,A\,s}}{\mathrm{V\,A\,s^2}} = \frac{1}{\mathrm{s}}$, therefore as velocity increases, local time interval s decreases, $\mathrm{s} \rightarrow \frac{\mathrm{s}}{\gamma}$

Ratio $\frac{P_r}{h}$, in units = $\frac{\mathrm{V\,A\,s^2}}{\mathrm{m}}\,\frac{1}{\mathrm{V\,A\,s^2}} = \frac{1}{\mathrm{m}}$, therefore as velocity increases, local length m decreases, $\mathrm{m} \rightarrow \frac{\mathrm{m}}{\gamma}$

The result of this dimensional analysis / logic is in alignment with the equations above, and the papers by Celani et al. referred to above, i.e., $m_e \rightarrow \gamma\, m_e$ & $r_e \rightarrow \frac{r_e}{\gamma}$, these combinations of increasing or decreasing units are the only scenario that can be found to work for an electron increasing or decreasing its velocity.

The following combinations of V, A, s, & m are therefore constant at any velocity, i.e., Lorentz invariant:

$\mathrm{V\,m}$, $\mathrm{V\,s}$, $\mathrm{A\,m}$, $\mathrm{A\,s}$, $\frac{\mathrm{m}}{\mathrm{s}}$, $\frac{\mathrm{V}}{\mathrm{A}}$, $\frac{\mathrm{V}}{\mathrm{A}}\frac{\mathrm{s}}{\mathrm{m}}$, $\frac{\mathrm{A}}{\mathrm{V}}\frac{\mathrm{s}}{\mathrm{m}}$, V A m^2 , and V A s^2 , i.e., units of known constants:

Permitted light velocity = Speed of light = c = m s^{-1} : ratio of local length to local time interval is constant

Vacuum permeability constant = μ_0 = V A^{-1} s m^{-1} : local Volts to Amps induction rate is constant

Vacuum permittivity constant = ε_0 = V^{-1} A s m^{-1} : local Amps to Volts induction rate is constant

Coulomb constant = k_e = V A^{-1} s^{-1} m : the unit inverse of ε_0

Resistance of the vacuum structure = Impedance of free space = Z_0 = V A^{-1}

Von Klitzing constant = A measure of resistance = R_K = V A^{-1} : ratio of Volts to Amps is constant

Josephson constant = K_J = V^{-1} s^{-1} : the product of Volts and time is constant

The following are also constant at any velocity: Planck constant = h = V A s^2 , Electron charge = e = A s ,

$h\,c^2$ = V A m^2 , $e\,c$ = A m , and $\phi_e\,c$ = V m , therefore flux = $\phi_e = \frac{h}{e} = \frac{2}{K_J}$ = V s is a constant.

As noted above, Rydberg constant = R_∞ = $\frac{1}{\mathrm{m}}$, The Rydberg "constant" is not a constant, $R_\infty \to \gamma\, R_\infty$

The Rydberg "constant" R_∞ depends on local length contraction, and this depends on local average velocity of atoms, electrons, and particles, i.e., local Lorentz factor for this velocity, as the CODATA Rydberg constant is a consolidated value obtained from historical experiments, this leads to the question, what is the group velocity of atoms, electrons, and particles within these defining historical experiments? As most experiments were performed using equipment sited on the surface or orbiting our moving planet Earth, for the duration of an experiment at what velocity was the Earth moving relative to what fixed unmoving background?

According to the 2020 paper by the Planck Collaboration – "Planck 2018 results. I. Overview and the cosmological legacy of Planck" - table 3, from the Planck satellite measurement of the Cosmic Microwave Background (CMB) surrounding our solar system, it has been established that the peculiar velocity of our sun relative to the CMB rest frame is 369.82 ± 0.11 km s^{-1} towards the constellation Crater, (see also Wikipedia : Cosmic microwave background). This measurement provides an average velocity relative to a universal vacuum structure for any experiment, (IF vacuum structure μ_0 + ε_0 is uniform across the entire universe), the actual velocity will be + or – dependent on the velocity of the experiment orbiting relative to the sun. For any experiment, where electrons used in measurements are moving at velocity relative to the experiment, the group orientation and group velocity of these electrons relative to the CMB will require to be accounted for.

This peculiar velocity of our sun, say = v_z , then equates to a CMB Lorentz factor γ = 1.000 000 760 869

The value may be small, but it is not insignificant considering the claimed accuracy of some experiments.

Historically, the electron magnetic moment μ_s experimental value has deviated from the μ_e calculated value derived from the CODATA properties of either e , h , $\hbar$, m_e , or K_J or combinations thereof, this deviation appears in the value of the electron spin g-factor = g_e , and the anomalous magnetic dipole moment = a_e

Experimentally measured spin electron magnetic moment $\mu_s = \frac{g_e\,\mu_e}{2} = (1 + a_e)\,\mu_e \qquad a_e = \frac{g_e - 2}{2}$

Another deviation pre-2018, was in calculating the electron magnetic moment μ_e directly from the CODATA values of either e , h , $\hbar$, m_e , or K_J , where they each gave slightly different calculated values, and all different to the experimentally measured value = μ_s = CODATA 2022 value = 9.284 764 6917 x 10^-24

Permeability constant = μ_0	= pre-2018 value = $4\,\pi\,10^{-7}$	vs.	CODATA 2022 value
Magnetic moment = μ_e = $\frac{e\,\hbar}{2\,m_e}$	= 9.274 010 060 06 x 10^-24	vs.	9.274 010 060 06 x 10^-24
Magnetic moment = μ_e = $\frac{\alpha^3}{2\,\pi\,\mu_0\,R_\infty\,K_J}$	= 9.274 010 064 69 x 10^-24	vs.	9.274 010 065 91 x 10^-24
Magnetic moment = μ_e = $\left(\frac{\alpha^7\,m_e\,c^2}{64\,\pi^2\,\mu_0\,{R_\infty}^3}\right)^{0.5}$	= 9.274 010 064 95 x 10^-24	vs.	9.274 010 065 56 x 10^-24
Magnetic moment = μ_e = $\left(\frac{\alpha^5\,h\,c}{32\,\pi^2\,\mu_0\,{R_\infty}^2}\right)^{0.5}$	= 9.274 010 065 00 x 10^-24	vs.	9.274 010 065 61 x 10^-24
Magnetic moment = μ_e = $\frac{\alpha^2\,e\,c}{8\,\pi\,R_\infty}$	= 9.274 010 065 64 x 10^-24	vs.	9.274 010 065 64 x 10^-24

Pre-2018, these differences may have been regarded as small, but they were significant in comparison with the claimed accuracy of the electron g-factor QED calculation, after the CODATA 2018 unit value change, the permeability constant μ_0 is no longer precisely = $4\,\pi\,10^{-7}$, and as a consequence of this small but significant CODATA revision, when calculating the electron magnetic moment directly from e , h , $\hbar$, m_e , or K_J , more of the equations now produce similar values and hence the electron spin g-factor relationship between the magnetic moment μ_e calculated values, μ_s experimental value, and QED calculation is now more aligned.

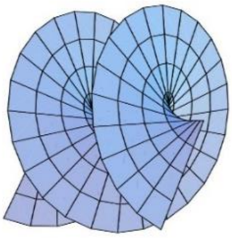
Using dimensional analysis of the units as above, the electron magnetic moment can be examined, for an electron moving at z-axis velocity v_z , with the resulting Lorentz factor γ , with the following imposed unit changes obtained from above, $\mathrm{A} \rightarrow \gamma\, \mathrm{A}$ (Amps increase), and $\mathrm{m} \rightarrow \frac{\mathrm{m}}{\gamma}$ (length decreases)

Then $\mu_e = \frac{r_e\, e\, c}{2} = \pi\, r_e^{\,2}\, I_e = \gamma\, \mathrm{A}\, \frac{\mathrm{m}^2}{\gamma^2} = \frac{1}{\gamma}\, \mathrm{A\, m}^2$ therefore $\mu_e\; rest \rightarrow \frac{\mu_e}{\gamma}\; moving$

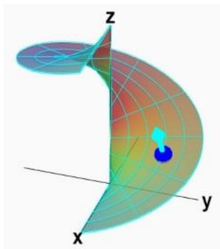
As an electron accelerates with resulting Lorentz factor γ increase, the magnetic moment should decrease, however experiments obtain an increased value to that calculated, although the CMB Lorentz value may have an influence on experiment calculations, ($R_\infty \rightarrow \gamma\, R_\infty$), it is far less than can account for the g-factor.

The electron magnetic moment μ_s experimentally measured value is greater than the μ_e calculated value, on the basis that the units = $\mathrm{A\, m^2}$, if $\mathrm{A\, m^2}$ is greater, either Amps are greater, area is greater or both.

As the Lorentz factor increases, $\mathrm{A} \rightarrow \gamma\, \mathrm{A}$, there is a small increase in Amps, i.e., current, is it possible there is also an increase in area, the increase in area required is greater than the charge cross section area $\pi\, r_0^{\,2}$ orthogonal to the charge pathway but less than the electron charge orbit ZBW area $\pi\, r_e^{\,2}$ orthogonal to the z-axis. The electron magnetic moment = $\mu_e = \pi\, r_e^{\,2}\, I_e$, is the product of an area and an encircling current, at rest the enclosed area is a disk orthogonal to the z-axis, but at velocity along the z-axis, with a current following a helix pathway, the current now possessing orthogonal and additional longitudinal components, what is the enclosed area of a helix pathway current, is it a single turn of a helicoid surface?



Helicoid surface from Wolfram MathWorld



From mathinsight.org

When the magnetic moment is experimentally measured, what exactly is being measured, a measurement must be the average of many electron moments, none of these electrons will be at rest, does the moment of each electron only act about the z-axis, so only related to the ZBW area $\pi\, r_e^{\,2}$ visible along the z-axis, or for moving electrons with the charge now traversing a helix pathway, is there precession of the moment axis around the z-axis with an impact on the group measurement. At rest, the charge cross section area $\pi\, r_0^{\,2}$ is parallel to the z-axis and the ZBW area $\pi\, r_e^{\,2}$ is orthogonal to the z-axis, as the electron accelerates, with the charge cross section disc orthogonal to a now helix pathway, the initially perpendicular charge disc, pivots towards parallel with the ZBW area, a change in angle from perpendicular (helix pitch angle) that increases as the z-axis velocity increases, (pathway curves in 3D), when observed along the z-axis the charge cross section disc is tilted and now becomes visible as an ellipse area, i.e. an area in addition to the ZBW area.

Electron magnetic moment = $\mu_e = \pi\, r_e^{\,2}\, \pi\, r_0^{\,2}\, J_d = \pi\, r_e^{\,2} \left(\frac{V_e}{2\, R_K} + \frac{I_e}{2} \right) = \frac{\pi\, r_0^{\,2}\, V_e}{\alpha\, \mu_0\, c} + \frac{\pi\, r_e^{\,2}\, I_e}{2} = \frac{r_0\, \phi_e}{2\, \mu_0} + \frac{r_e\, e\, c}{4}$

The measured magnetic moment can be viewed as a product of property components associated to each of the two intersecting 2D disc area planes, at rest a charge following a closed circle loop pathway with flux circling orthogonal to the loop pathway, at velocity a charge following an open helix pathway with flux circling orthogonal to the helix pathway, theoretical moment is at rest with discs perpendicular to each other, experimental moment is moving electrons where the disc area planes are angled to each other, with precession of both the charge cross section disc area and the flux circling this area about the electron z-axis.

Of note, rest + fraction of rest = $\frac{c + v_z}{c} = 1 + \frac{v_z}{c}$ = 1.00123359… is within 0.0074 % of $\frac{\mu_s}{\mu_e}$ = 1.00115965…

Also of note, is that for electrons traveling at an average of the CMB velocity = v_z , where the z-axis distance travelled by the electron charge for one coil turn of the helix pathway, say = d_z , is within 6.3% of the electron charge radius r_0 dimension, (the classical electron radius), this leads to the following coincidence:

$$1 + \frac{d_z}{\lambda_\perp} = 1 + \frac{v_z\left(\frac{T_e}{\gamma}\right)}{\left(\frac{\lambda_C}{\gamma}\right)} \text{ is a close match to } 1 + \frac{r_0}{2\,\pi\,r_e} = 1 + \frac{\alpha}{2\,\pi} \approx \frac{\mu_S}{\mu_e}, \quad \frac{\alpha}{2\,\pi} = \text{Schwinger factor term}$$

Perhaps the solution to the anomalous magnetic dipole moment is in the structure of a moving 3D electron.

When examining both equations and units above, and comparing between for symmetries, it can be viewed that there are some properties missing, i.e., units unaccounted for, say the units described as follows:

Electron electric moment = $\mu_V = \frac{r_0\,\phi_e\,c}{2} = \frac{r_0\,h\,c}{2\,e} = \frac{\pi\,r_0^2\,V_e}{\alpha} = \frac{\pi\,r_0^2\,E}{\alpha\,e} = \frac{E}{2\,D_e} = \frac{\mu_e\,B_e}{D_e} = \frac{\mu_e}{2\,\varepsilon_0\,c} = \frac{r_e\,e}{4\,\varepsilon_0} =$ V m^2

Vector current, charge per length, Amp component of momentum transfer = J_I = A s m^{-1}

$$J_I = \frac{I_e}{c} = \frac{e}{\lambda_C} = \frac{\phi_e}{R_K\,\lambda_C} = \frac{V_e}{R_K\,c} = \frac{A_V}{R_K} = \frac{2\,\varepsilon_0\,\mu_V}{\pi\,r_e^2} = \pi\,r_0^2\,\rho_c = r_0\,D_e = \frac{\alpha\,H_f}{\omega_e} = \frac{r_0\,E}{2\,\mu_V} = \frac{P_r}{\phi_e} = \frac{h}{\phi_e\,\lambda_C} = \frac{h}{A_V\,\lambda_C^2} = \frac{m_e}{A_V\,T_e}$$

Potential area density = $A_d = \rho_F\,c = \frac{\alpha\,J_d}{2\,\varepsilon_0\,c} = \frac{E_f}{\pi\,r_e} = \frac{\mu_0\,H_f}{T_e} = \frac{2\,B_e}{T_e} = \frac{\alpha\,\mu_V}{\pi\,r_0^2\,\pi\,r_e^2} = \frac{\hbar\,\omega_e}{\pi\,r_e^2\,e} = \frac{V_e}{\pi\,r_e^2} =$ V m^{-2}

Flux volume density = $\rho_F = \frac{A_d}{c} = \frac{\alpha\,\rho_c}{2\,\varepsilon_0\,c} = \frac{E_f}{\pi\,r_e\,c} = \frac{B_e}{\pi\,r_e} = \frac{\mu_0\,H_f}{\lambda_C} = \frac{R_K\,J_I}{\pi\,r_e^2} = \frac{A_V}{\pi\,r_e^2} = \frac{V_e}{\pi\,r_e^2\,c} = \frac{\phi_e}{\pi\,r_e^2\,\lambda_C} =$ V s m^{-3}

The electron energy rest value, can be obtained from any of the following: (x) represents equations using a property that only has Volts within its unit, and (y) represents equations using a property with only Amps.

(x) $E = C_e\,V_e^2 = \frac{\phi_e^2}{L_e} = C_e\,A_V^2\,c^2 = C_e\,r_e^2\,E_f^2 = C_e\,r_e^2\,B_e^2\,c^2 = \frac{C_e\,\mu_V^2}{\pi\,r_0^2\,\pi\,r_e^2} = C_e\,\pi^2\,r_e^4\,A_d^2 = C_e\,\pi^2\,r_e^4\,\rho_F^2\,c^2$

(y) $E = L_e\,I_e^2 = \frac{e^2}{C_e} = L_e\,J_I^2\,c^2 = L_e\,r_0^2\,H_f^2 = L_e\,r_0^2\,D_e^2\,c^2 = \frac{L_e\,\mu_e^2}{\pi\,r_e^2\,\pi\,r_e^2} = L_e\,\pi^2\,r_0^4\,J_d^2 = L_e\,\pi^2\,r_0^4\,\rho_c^2\,c^2$

Of note, the equations of (x) and (y) each have a single property that is squared and is in combination with either C_e or L_e , when comparing (x) and (y) equations, it can be observed that there is symmetry between pairs of equations, and with Volts swapped for Amps, the same symmetry can be observed in the units of the property used in each equation. As proposed in the Celani et al. papers referred to above, of the total energy there is a 50/50 split between electrostatic and magnetic energy, this can be observed in the following pair:

From $E = C_e\,V_e^2 = L_e\,I_e^2$ then, total electron rest energy $E = \frac{C_e\,V_e^2}{2} + \frac{L_e\,I_e^2}{2} = W_C + W_L$

$W_C = \frac{1}{2}\,C_e\,V_e^2$ energy in a capacitor is equal to $W_L = \frac{1}{2}\,L_e\,I_e^2$ energy in an inductor

Both W_C and W_L are known equations, W_C is the equation for the stored capacitance energy associated with a charge, and W_L is the equation for the stored inductance energy associated with a current loop.

From above it can be observed that the total electron rest energy can be based on any equation pair from (x) and (y), each divided by two then added, i.e. $E = \frac{(\text{x})}{2} + \frac{(\text{y})}{2}$, alternatively, any equation pair from (x) and (y), multiplied together then the square root taken of the result, i.e. $E = \sqrt{(\text{x}) \times (\text{y})}$, resulting in the following:

Total electron rest energy $E = V_e\,I_e\,T_e = \frac{\phi_e\,e}{T_e} = A_V\,J_I\,T_e\,c^2 = r_e\,E_f\,r_0\,H_f\,T_e = r_e\,B_e\,r_0\,D_e\,T_e\,c^2 = \frac{\mu_V\,\mu_e\,T_e}{\alpha\,\pi^2\,r_e^4}$

As $\sqrt{L_e\,C_e} = T_e$, both L_e and C_e disappear from equations, the resulting total electron rest energy equations based on counterpart property interaction can then be viewed as being 50% Volt based × 50% Amp based.

From above, it can be viewed that the electron electric moment = μ_V = V m^2 is a valid counterpart to the electron magnetic moment = μ_e = A m^2 , the following equations are then also valid:

Torque = τ = energy = $E = 2\,\mu_e\,B_e = 2\,\mu_V\,D_e$ therefore $E = \mu_e\,B_e + \mu_V\,D_e$ (i.e., g-factor = 2 - parts)

The electron magnetic "moment" μ_e has the units = A m^2 , this is not the units of a moment, moment = N m = tangential electric force F_t applied to move charge × ZBW radius lever arm r_e = torque τ = work done = Joule = energy required for one rotation of something relative to a resisting something else = E , all are equivalent to = V A s . The debate is whether radians should be included in units, perhaps if the radians were included where applicable in units, this may inform us of a property's role within an electron.

When the electron magnetic "moment" μ_e interacts with the flux area density B_e the outcome is something that is measured as a torque (a spin) in an experiment, it is the effect of μ_e that is the moment, the outcome of an electron electric "moment" μ_V interacting with the charge area density D_e will also produce a torque. However the magnetic moment μ_e acts in the plane of the ZBW area $\pi\,r_e^{\,2}$ orthogonal to the z-axis, and the electric moment μ_V acts in the plane of charge cross section $\pi\,r_0^{\,2}$ orthogonal to the charge pathway, the axis of this cross section constantly tilting as the charge follows a curving pathway around a circuit, for an electron at rest this circuit is a circle, at axial velocity v_z the circuit is a helix, at rest the electric moment is orthogonal to the magnetic moment, there is zero z-axis component, there is nothing to be measured along the electron z-axis, for an electron at velocity, say traveling at the CMB velocity = v_z , with the charge cross section now rotated by the helix pitch angle, the electric moment μ_V and the charge area density D_e product torque now has a z-axis component that is in addition to the z-axis product torque of the magnetic moment μ_e and flux area density B_e , this total torque when measured in an experiment deviates from that calculated. Again, it can be viewed that half the electron energy enables the magnetic moment and the other half the electric moment, however for an experiment with low electron velocities the z-axis magnetic "moment" half is measurable and only part of the electric "moment" half is measurable, i.e., the anomalous total moment.

Experimental magnetic moment $\mu_s = \frac{g_e\,\mu_e}{2} = (1 + a_e)\,\mu_e = \mu_e + a_e\,\frac{\mu_V\,D_e}{B_e}$ $\qquad a_e = \gamma_{vz} = \left(1 + \frac{c^2}{v_z^{\,2}}\right)^{-0.5}$

The total electron moment can be viewed as a total of a Volt "moment" plus an orthogonal Amp "moment".

As above it can be viewed that the vector current = J_I = A s m^{-1} is also a valid counterpart to the vector potential = A_V = V s m^{-1} , the following equations are then also valid:

Momentum $P_r = \frac{e\,A_V}{2} + \frac{\phi_e\,J_I}{2} = A_V\,J_I\,\lambda_c$ Energy $E = \frac{e\,A_V\,c}{2} + \frac{\phi_e\,J_I\,c}{2} = A_V\,J_I\,\lambda_c\,c$ Planck $h = A_V\,J_I\,\lambda_c^{\,2}$

As the vector potential A_V can interact with a massless electron charge e to produce momentum, it can be viewed that a vector current J_I can also interact with the electron flux ϕ_e to produce momentum, maybe both the vector potential and the vector current are not just theoretical but real properties of an electron, maybe both can be transmittable agents of momentum, a source of incoming Volts and / or Amps received by an electron from another electron or a photon, incoming Volts and / or Amps interacting with existing Volts × Amps leading to "transfer" of momentum. This leads to the following possible photon properties:

Photon momentum = $P_{photon} = A_p\,J_p\,\lambda$ Photon energy = $E_{photon} = A_p\,J_p\,\lambda\,c$

Both the vector potential A_p and the vector current J_p may then be physical properties of a photon, traveling together at velocity $v_z = c$, parallel to each other, not interacting, being transmitted concurrently both are the same wavelength, maybe photon linear and circular polarization are then a phase relation of A_p to J_p .

Also, photon mass = $m_{photon} = A_p\,J_p\,T = 0$ as $v_z = c$, local circuit time $T = 0$ (no time interaction)

The momentum product "transferred" by a photon can be viewed as 50% Volt based × 50% Amp based.

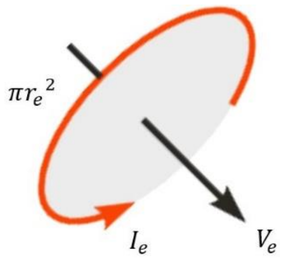
The electron mass value can be obtained from any Volt or Amp property squared or any 50/50 permutation:

Rest mass $m_e = \frac{T_e\,V_e^{\,2}}{2\,R_K\,c^2} + \frac{R_K\,T_e\,I_e^{\,2}}{2\,c^2} = \frac{V_e\,I_e\,T_e}{c^2} = \frac{r_0\,\phi_e^{\,2}}{2\,k_e\,\lambda_c^{\,2}} + \frac{k_e\,e^2}{2\,r_0\,c^2} = \frac{\phi_e\,e}{T_e\,c^2} = \frac{C_e\,A_V^{\,2}}{2} + \frac{L_e\,J_I^{\,2}}{2} = A_V\,J_I\,T_e$ = V A s^3 m^{-2}

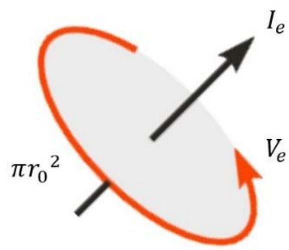
The properties μ_0 , ε_0 , Z_0 , k_e , R_K , L_e and C_e , can be viewed as induction rate operators, commuting any Volt or Amp property squared, into any combined Volts × Amps property, say any of the properties E , h , $\hbar$, P_r or m_e , it then becomes a choice as to express one property in terms of another, each choice equally valid. A Volt or Amp based property interacting with an operator induces / displaces a counterpart perpendicular cross product Amp or Volt property. Are induction rate operators a form of mathematical book-keeping that has been introduced over the historical era or do they represent real characteristics of a vacuum structure?

From equations of properties above, it can be viewed that Volts is the product of Amps encircling an area, Amps is the product of Volts encircling an area, based on electromagnetics right-hand rule convention:

$V_e = \frac{\mu_0\,\pi\,r_e^{\,2}\,I_e}{r_0\,T_e}$

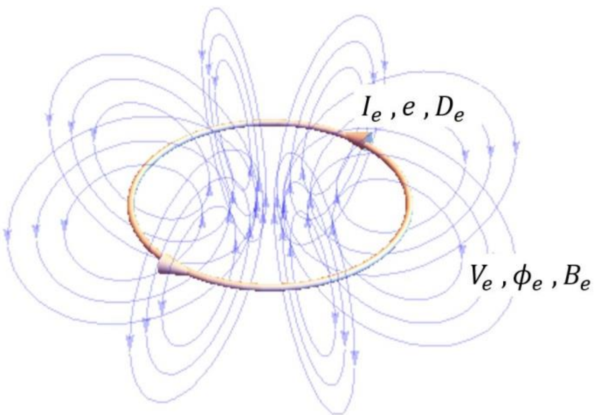


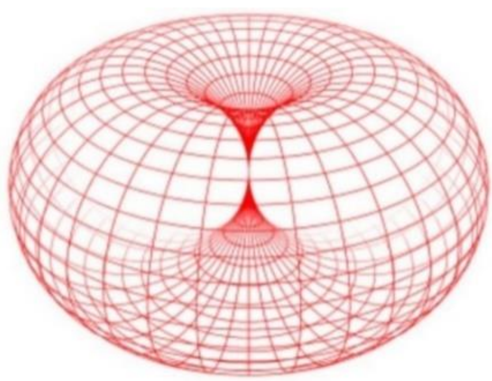
$I_e = \frac{4\,\varepsilon_0\,\pi\,r_0^{\,2}\,V_e}{r_0\,T_e}$



ZBW cross section area ← intersects with → Charge cross section area

It can be viewed that there is time displacement of Amps through the moving cross section area $\pi\,r_0^{\,2}$, i.e. charge = Amp seconds, (Amps stationary, disc moving), inducing orthogonal same time displacement of Volts through the intersecting ZBW area $\pi\,r_e^{\,2}$, i.e. flux = Volt seconds, (Volts moving, disc stationary), inducing same time circulation of a charge, inducing same time circulation of a flux, inducing same time circulation of a charge, with a possibility of zero internal restraint within the electron confines, superconducting forever.





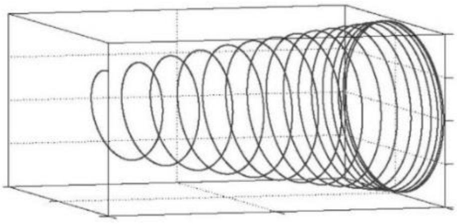
Electron at rest, one circuit of charge & flux Horn torus from tex.stackexchange.com

From the equations above it can be viewed that the flux circling orthogonal to the charge pathway extends out to an area equal to the ZBW area, i.e., a torus swept volume multiplied by the flux volume density.

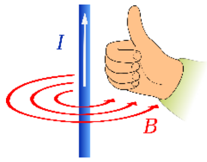
Flux = $\phi_e = \pi\,r_p^{\,2}\,\lambda_c\,\rho_F$ = V s the poloidal radius = r_p = the ZBW toroidal radius = r_e

For an isolated electron at rest, i.e., zero z-axis velocity, the swept volume of the flux area over one time circuit of the charge travelling around the circle pathway is then the volume of a horn torus, the swept volume of the Amps pathway is then a torus centred within the flux horn torus. For a moving electron, the flux horn torus transforms to a coiled tube, a spring shape containing the helix charge pathway within.

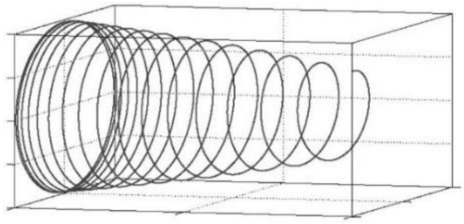
When momentum is added in the z-axis direction, the electron accelerates, the ZBW radius reduces, the z-axis distance travelled by the charge with each coil increases, the helix stretches, if momentum is then added in the opposite z-axis direction, the z-axis distance travelled decreases, the ZBW radius increases, the helix compresses, until a state is reached where the electron is back at the rest circular loop, as with acceleration, as orthogonal momentum is h dependent, with z-axis momentum decreasing as all received opposing z-axis is accepted, any received radial momentum that is excess must be rejected and emitted. Continue to add momentum in this same direction and the charge will now follow an opposite helix pathway to that previous.



Electron accelerating to the left or decelerating to the right



Right-hand rule for conventional current



Electron accelerating to the right or decelerating to the left

There is two possible opposite hand helix charge / current pathways, but the flux encircling each charge pathway still follows the right-hand rule, right-hand curl around current pathway, potentially each helix handing then with opposite response to an external electric or magnetic field, for a large group of electrons moving in the same direction, on average 50% of electrons will have opposite helix / flux handing's to the other 50%, i.e., 50% of electrons will respond as "spin up", 50% of electrons will respond as "spin down", i.e., a Stern-Gerlach type experiment conducted with electrons producing a result of two opposite hand spins.

The property momentum, is a vector, i.e., possesses magnitude and direction, increasing the momentum of an object, adding momentum, adding V A s^2 m^{-1} , adding Volts × Amps, can be viewed as increasing a torsion, a distortion, a stress, when an equal magnitude but opposite direction momentum vector is added, torsion / distortion / stress is opposite in sign acting to reverse / restore the object to a previous lower entropy state.

Within their ZBW electron model as described above, Celani et al. propose a moving rotating massless charge that is spherical in shape, what is the evidence for this sphere? from above the electron capacitance = $C_e = 4\,\pi\,\varepsilon_0\,r_0$, this is the known equation for a spherical charge, but is there any other possible shape?

Considering the charge as a capacitor, capacitance = $C_e = \frac{\varepsilon_0\,Area}{distance} = \frac{\varepsilon_0\,\pi\,{r_0}^2}{0.25 \times r_0} = \frac{4\,\pi\,{r_0}^2\,\varepsilon_0}{r_0} = 4\,\pi\,\varepsilon_0\,r_0$

The charge shape can also be viewed as being a thin disc, cross section area = $\pi\,{r_0}^2$, and thickness = $\frac{r_0}{4}$

The circular disc having the capacitor associated properties of displacement current I_e across the thickness, a displacement current density D_e , an encircling flux density B_e , and a charge e

For the charge as a sphere or disc with thickness, the question can be asked, what is inside? The charge is not a point, it is a structure with dimensions, with possibility to rotate about an axis, if the charge is a disc region with spin and travel orientation, is it a polarization, distortion, torsion, vortex, singularity? as it moves along a pathway, is it an asymmetric capacitor, is there an asymmetric ε_0 gap in the vacuum structure?

In their model, Celani et al. propose that the charge sphere counter rotates about the z-axis once for each ZBW orbit, ensuring that all points on the sphere surface travel at the speed of light, but what dictates this?

Zooming out and examining a single electron as a whole object, i.e., how it interacts with its surroundings, we know that the electron z-axis velocity can be close to but not equal to the speed of light, we know from equations that some internal aspect of the electron travels at exactly the speed of light, what then dictates that some resultant internal to the electron structure cannot have a value greater than the speed of light?

The electron charge, whether sphere or disc, at rest or moving, as alternatively proposed above, the charge centre point velocity orthogonal to the z-axis = $v_{\perp} = c$, i.e., a constant speed of light velocity around the periphery of the ZBW disc cross section area, what if the charge also rotates poloidally, what if there is one rotation for each period of travel around the ZBW area, the charge rotating into and through the ZBW area, for each circuit, one rotation of intersection / interaction / induction between two regions, two regions that rotate at the same ZBW angular frequency, (two separate spins? $\frac{\hbar}{2} + \frac{\hbar}{2}$? but only one detectable), the charge periphery orthogonal to the pathway moving at a velocity = αc , and the electron z-axis maximum velocity $v_z = < c$, within the electron structure resultant velocities at some points greater than the speed of light.

Say the charge is a disc, a disc region that when acted on produces outcomes, acted on by what? what if the ZBW disc area is a counterpart region, one disc orbiting the periphery of the other disc, when the two disc areas intersect at an angle there is interaction, a region of charge (Amps) at an angle to and crossing through a region of flux (Volts), the areas intersect and induction occurs, each area acting on the other, fields are generated, an Amp field intersecting / interacting / crossing a Volt field produces a force, and vice versa.

Say the charge is a disc and has a form of polarity, in the electron this polarity is the right-hand rule, two opposite hand helix charge pathways, each with the flux encircling the charge pathway following the right-hand rule, right-hand curl around current pathway, what if the charge disc was flipped / turned over 180 degrees, polarity now being the left-hand rule, two opposite hand helix charge pathways, each with the flux encircling the charge pathway following the left-hand rule, i.e., left-hand curl around current pathway, each with an opposite polarity charge to the electron, i.e., spin up and spin down positrons.

Electrons and positrons at rest, spin up and spin down, same Planck, same energy, same momentum, same mass, all the same object but with opposites in handing and rotations, i.e., spin and polarity, when moving, electric fields intersecting different direction magnetic fields with opposite hand forces, different response of attraction or repulsion to the atoms and electrons of the detecting instruments in a (moving) experiment.

What if after a collision the charge disc is flipped only part way, an in-between state half way between right-hand and left-hand rules, the charge disc plane is now parallel to the ZBW disc plane, discs still orbiting each other, the orbital angular frequency after flipping then dependent on collision momentum + / - transfer of Volts × Amps, the charge disc still rotating still moving forward travelling at the speed of light, both discs orthogonal to z-axis of travel, both now travelling at the speed of light, Amps rotating and moving a distance = vector current = A s m^{-1} , Volts rotating and moving a distance = vector potential = V s m^{-1} , properties travelling parallel to each other, not interacting, depending on previous helix handing either rotating clockwise or anti-clockwise moving forward, i.e., chirality, as there is no interaction between the two discs, zero induction, no outcomes, no flux, no charge, no electric or magnetic fields, no time rotation of one disc through the other, local circuit time $T = 0$ therefore zero mass, but still with z-axis momentum, do we now have a photon as a neutral transition state between electron and positron? all the same object just different states, through collision with atoms electrons being the preferred state. A low energy mostly symmetric momentum collision of an electron and a positron leads to two energetic photons, a high energy collision of an electron and a positron with possibly asymmetric momentum leads to production of products that in time decay / break down into neutrinos. What is the mechanism within the collision, for electrons and positrons to transform into a variety of products? the higher the energy the heavier some products before decaying.

The electron described above is single, isolated and at rest relative to the vacuum structure, however this condition will likely be transitory, most free electrons are transferring momentum, changing state via atoms, accelerating colliding decelerating, being collided with and accelerating again, a charge travelling in a helix pathway, i.e., rest properties now with additional components from travelling a helix, components that can interact with properties of other electrons and atoms with induction of forces, transference of momentum.

As described above, for the Celani et al. ZBW electron model at rest, with zero velocity along the z-axis, the electron elementary charge follows a circular orbit around the z-axis, as momentum is added in the z-axis direction, the charge circular orbit pathway transitions to now follow a smaller ZBW radius helix pathway, after electron acceleration, for any constant velocity along the z-axis, there is a related constant pitch helix, the higher the z-axis velocity the smaller the ZBW radius and the greater the helix pitch angle.

As the elementary charge moves along a pathway there is an associated current, at rest the pathway is a circle with the current orientated orthogonal to the electron z-axis, orthogonal current component only, at velocity a current oriented to the helix pathway, now with both orthogonal and axial current components. Along with the current component that is parallel to and irrotational to the z-axis of electron movement, there will be an associated component of encircling flux area density i.e., this component is then orthogonal and solenoidal to the z-axis of travel. The higher the electron velocity the greater the helix pitch angle, the greater the magnitudes of z-axis components, i.e., the z-axis current and the associated orthogonal flux area density, both increasing as the Lorentz factor γ increases with electron z-axis velocity, resultant total current increases as $I_e\ rest \rightarrow \gamma\ I_e\ moving$ and resultant total flux area density increases as $B_e\ rest \rightarrow \gamma^2\ B_e\ moving$.

For an electron at rest with a charge following a circular orbit there is associated Volt and Amp only based properties, for a moving electron, these Volt and Amp only based properties will now have a corresponding longitudinal component in addition to the original orthogonal component. Rest orthogonal components inducing transverse electromagnetics only, at velocity the helix pathway now with both orthogonal and longitudinal components inducing both transverse and longitudinal electromagnetics. Due to the rate of the Lorentz factor γ increase, the z-axis component magnitudes will initially increase slowly, hence difficult to detect at low electron velocities, and only increase rapidly when approaching relativistic velocities.

As an electron is accelerated from rest, there is continuous growth of both the z-axis irrotational current and associated orthogonal solenoidal flux area density, producing a current density gradient and a longitudinally orientated vector potential, both are associated with longitudinal electromagnetics, i.e., a scalar-longitudinal wave, see 2020 paper by D. Reed and L. Hively, reference [43]. Therefore, as an electron is accelerated in the z-axis direction of the electron travel, there is possibility of both a longitudinally orientated vector potential and a vector current, i.e., propagation / transmission of momentum forwards in the same z-axis direction.

If a single electron is accelerated, it will accelerate for as long as sufficient z-axis momentum is supplied, accelerate until a limiting condition or until the electron collides with something, on collision the electron will transfer z-axis momentum forward to the object it collided with and decelerate during the process, the momentum receiving object accelerating either unchanged or transforming / breaking down into products depending on the amount of momentum received. The ability to generate longitudinal electromagnetics before collision is limited by the degree of acceleration within the environment free path length available.

The possibility of longitudinal electromagnetics is rejected in both physics and engineering, in part due to the environment we live in, consisting of materials, chemistry and actions upon objects resulting in mainly low electron velocities and short free path lengths, leading to minimal longitudinal currents with emissions that are potentially below detectable levels, with no consequent effects that show up in daily life, and in part as a result of James Clerk Maxwell discounting normal (longitudinal) vibrations at an early stage. If people were educated that something did not exist, and throughout life believed that something did not exist, who will search for it? From the 1865 paper: J.C. Maxwell - A dynamical theory of the electromagnetic field, page 501.

"*Hence electromagnetic science leads to exactly the same conclusions as optical science with respect to the direction of the disturbances which can be propagated through the field; both affirm the propagation of transverse vibrations, and both give the same velocity of propagation. On the other hand, both sciences are at a loss when called on to affirm or deny the existence of normal vibrations.*"

Nikola Tesla in his early experiments with electricity, noted that some kind of wave was producing a force at a distance, even penetrating an interposing object. Nikola Tesla later named these waves Radiant Energy. From the 1892 paper: Nikola Tesla - On the dissipation of the electrical energy of the Hertz resonator.

"*When the electric density of the wire surfaces is small, there is no appreciable local heating, nevertheless energy is dissipated in air, by waves, which differ from ordinary sound-waves only because the air is electrified. These waves are especially conspicuous when the discharges of a powerful battery are directed through a short and thick metal bar, the number of discharges per second being very small. The experimenter may feel the impact of the air at distances of six feet or more from the bar, especially if he takes the precaution to sprinkle the face or hands with ether. These waves cannot be entirely stopped by the interposition of an insulated metal plate."* [i.e., accelerated electrons > longitudinal waves > weak skin effect]

Over the 150+ years since J.C. Maxwell's paper, people on the fringe of respectable physics (& beyond) have experimented with obscure electrical phenomena, electromagnetic propulsive force, scalar waves, papers have been published, patents pursued, many finding strange behaviour beyond the accepted physics of the time, some of these strange results may be directly or indirectly attributable to electron acceleration and longitudinal waves. People continue to experiment to the present day. In a December 2023 YouTube video interviewing Dr Charles Buhler after the APEC 12/23 conference, there is a claim in a presentation, that the latest propulsion experiment designs, tested in a vacuum chamber, where a large kV voltage differential is applied between a dielectric and a conductor, (electron acceleration), achieve a thrust / mass of ≈ 1.0 g_0.

How can the production of longitudinal electromagnetics be maximized? From the above model, it can be viewed that, the higher the electron velocity, the greater the helix pitch angle, the greater the magnitudes of z-axis components. Maximizing longitudinal electromagnetics requires attaining the highest velocity within the free path length of electron travel, this implies maximizing availability of electrons to accelerate, with the highest acceleration, in the longest unobstructed path possible, within a still conductive environment. So possibly a high Volt × low Amp applied across a cathode and anode with a suitable conductive environment between, i.e., low gas density to reduce collisions, low pressure, practicable temperature, relatively narrow Electron Energy Distribution Function, ref: [6] (Fig. 2), the high Volts are applied as sharp unipolar pulses going from low to high, with as high a Volt rise as possible over the shortest time period, i.e., $\frac{\mathrm{dV}}{\mathrm{dt}}$ with high Volts, as quick a return to low voltage as possible, then repeat. Repeated electron acceleration as a sequence creating longitudinal electromagnetic pulses, a possibility of longitudinally orientated vector potential and vector current, and propagation of a modulated? scalar-longitudinal wave in the direction of electron travel.

A gas plasma and cathode / anode may be efficient for production of longitudinal electromagnetics, but it is not the only material and / or method, there are reports of experimental devices that produce scalar waves, for example the soliton pulses generator experiment by Jean-Louis Naudin, with a test demonstrating pulse transmission through a 5mm thick aluminium plate EM shield, also the Magnetic Scalar Field Generator by V. Zamsha and V. Shevtsov. In the 2022 paper: F. Righes, G. Vassallo, and G. Parchi – Conduction state transition induced by solitons in a graphene junction at room temperature, a high voltage soliton pulse generator, (neither origin or design of generator is given), is used to control conductivity between layers of contacting graphene, i.e., influence electron behaviour deep within a stack of different conductive materials.

In the D. Reed and L. Hively paper of above, the scalar-longitudinal wave is claimed to be unconstrained by the classical skin effect, as there is no magnetic field to generate dissipative eddy currents in a conductor. Can a scalar-longitudinal wave transfer momentum to electrons and atoms deep inside a material, the wave attenuating as it travels through a material, depending on orientation / handing of receiving electrons and atoms, increase or reduce their momentum / entropy, maybe the wave can reverse electron spin handing, align spins, drive / manipulate 3D electrons to form in-phase clusters, i.e., long-range particle interactions.

By change of units to V , A , s , and m , the physical action / influence - force can now be dimensionally analysed. Wikipedia; "*In physics, a force is an influence that can cause an object to change its velocity.*" and "*Newton's second law states that the net force acting upon an object is equal to the rate at which its momentum changes with time.*"

Force = $F = \frac{momentum}{time} = \frac{\mathrm{VA\,s^2}}{\mathrm{m}}\frac{1}{\mathrm{s}} = \frac{\mathrm{V\,A\,s}}{\mathrm{m}}$ then $F = \gamma\,\mathrm{V}\,\gamma\,\mathrm{A}\,\frac{\mathrm{S}}{\gamma}\,\frac{\gamma}{\mathrm{m}} = \gamma^2\frac{\mathrm{V\,A\,s}}{\mathrm{m}}$ therefore $F \rightarrow \gamma^2 F$

For say an electron accelerated from rest towards the speed of light over the period of one charge circuit. For an acceleration of $a = \frac{\gamma\,c}{T_e}$, The required force is then $F = m_e\,a = \gamma\,m_e \times \frac{\gamma\,c}{T_e} = \gamma^2\frac{m_e\,c}{T_e}$, $F \rightarrow \gamma^2 F$

As force is a transfer of momentum over a time period, interaction of both Volts and Amps during transfer between those received with those existing in an object, with change in property values, it can be observed from the unit changes that as an electron is accelerated, as energy increases by , as momentum increases by γ , as the mass increases by γ , as both Volts and Amps increase by γ , the required force increases as γ^2

As all forces have the same units of V A s m^{-1} they are all just the same transfer of momentum, the same interaction of Volts and Amps, the question then is, what is the specific mechanism that creates a particular force? whether Casimir, strong nuclear, electromagnetism, weak nuclear or the force from gravity, as an atom, electron, or a particle is accelerated, all of these forces are subject to the same $F \rightarrow \gamma^2 F$

By change of units to V , A , s , and m , the Gravitational constant can now be dimensionally analysed.

Gravitational constant = G = m^3 Kg^{-1} s^{-2} , as Kg = $\frac{\mathrm{V\,A\,s^3}}{\mathrm{m^2}}$, then $G = \mathrm{m}^3\frac{\mathrm{m^2}}{\mathrm{V\,A\,s^3}}\frac{1}{\mathrm{s^2}} = \frac{\mathrm{m^5}}{\mathrm{V\,A\,s^5}}$ = V^{-1} A^{-1} sec^{-5} m^5

For an atom / electron / particle moving at velocity v_z , with the resulting Lorentz factor γ , with the following imposed unit changes obtained from above, $\mathrm{V} \rightarrow \gamma\,\mathrm{V}$, $\mathrm{A} \rightarrow \gamma\,\mathrm{A}$, $\mathrm{s} \rightarrow \frac{\mathrm{S}}{\gamma}$ and $\mathrm{m} \rightarrow \frac{\mathrm{m}}{\gamma}$

Then $G = \frac{1}{\gamma\,\mathrm{V}}\frac{1}{\gamma\,\mathrm{A}}\frac{1}{\left(\frac{\mathrm{S}}{\gamma}\right)^5}\left(\frac{\mathrm{m}}{\gamma}\right)^5 = \frac{1}{\gamma^2}\frac{\mathrm{m^5}}{\mathrm{V\,A\,s^5}}$ therefore $G\ rest \rightarrow \frac{G}{\gamma^2}\ moving$

Therefore, the gravitational "constant" G is not a constant. The conventional use of G is for large relatively slow bodies, the "constant" G is then a local average, dependent on group velocity of all the body atoms / electrons / particles relative to the vacuum structure, as the group velocity increases, the gravitational "constant" G then decreases by the multiple of $\frac{1}{\gamma^2}$, for any individual atom / electron / particle, the local associated G is dependent on velocity, when accelerated to a new velocity the associated G decreases.

The units impose that $\frac{G\,m_e}{T_e} = \frac{\mathrm{m^3}}{\mathrm{s^3}}$ is a constant for electrons at any velocity, i.e., space / time in three axes.

Then $\frac{G\,m_e}{T_e} = \frac{G\,h}{\lambda_c{}^2} = G\,A_V\,J_I = \frac{\delta_e\,c^3}{2\,\pi}$, δ_e = no units = electron gravitational invariant; ref: J. Maruani [33](34)

Then this invariant = $\delta_e = \frac{m_e\,l_P}{m_P\,r_e} = \frac{m_e{}^2}{m_P{}^2} = \left(\frac{2\,\pi\,l_P}{\lambda_c}\right)^2 = \frac{l_P{}^2}{r_e{}^2} = \left(\frac{2\,\pi\,t_P}{T_e}\right)^2 = \omega_e{}^2\,t_P{}^2 = \frac{G\,m_e{}^2}{\hbar\,c} = \frac{\omega_e\,G\,m_e}{c^3} = \frac{G\,64\,\pi\,R_\infty{}^2}{\alpha^3\mu_0\,c^4\,K_J{}^2}$

Planck mass = $m_P = \sqrt{\frac{\hbar\,c}{G}}$ Planck length = $l_P = \sqrt{\frac{\hbar\,G}{c^3}}$ Planck time = $t_P = \sqrt{\frac{\hbar\,G}{c^5}}$ $\frac{G\,m_P}{t_P} = c^3$

For an electron moving on average at a velocity equal to the peculiar velocity of our solar system, how do we know that the value of the local gravitational "constant" G for an electron is the same G value as that for a larger more massive body like a planet, is this just an assumption? What if value $= \frac{G}{\delta_e}$, δ_e being variable.

The equations for the properties m_e and G can be shown as follows:

Electron rest mass $m_e = \frac{\delta_e\,r_e\,c^2}{G} = \frac{\mathrm{V\,A\,s^3}}{\mathrm{m^2}}$ and Gravitational constant $G = \frac{l_P\,c^2}{m_P} = \frac{\delta_e\,r_e\,c^2}{m_e} = \frac{\mathrm{m^5}}{\mathrm{V\,A\,s^5}}$

From the units, the gravitational constant can be viewed as almost an inverse of the electron mass, where in the electron mass unit's numerator there is a presence of Volts × Amps, in the gravitational constant units Volts × Amps appear in the denominator signifying an absence, for mass there is a presence of Volts × Amps i.e., energy-momentum-mass, for gravity there is an absence of energy-momentum-mass. Perhaps gravity is the absence of momentum-energy between bodies, a screening / shadowing / blocking / occlusion by momentum-energy absorbing dense bodies of the intervening space between these same bodies from a vector component of the momentum-energy (zero-point energy?) of the surrounding universe, the resulting momentum-energy imbalance leading to forces pushing bodies together, there is no attraction force, there is no pull due to gravity, only an external push, the gravitational constant is then a measure of this asymmetry.

The force from gravity on the scale of large occluding bodies can be viewed as being like the Casimir force on the scale of small, occluded gaps, both are forces pushing with the same units of measure, both are transfers of momentum, just different in scale. Occlusion of an intervening space's light cone visibility, likely depends on distance / gap between bodies, and the ability of bodies to absorb and store momentum-energy, blocking the passage through, i.e., atoms, electrons, and particles as momentum receivers / re-transmitters, each with a cross section therefore each is a "plate", it then depends on plate orientation and cross sectional density of plate areas vs momentum traverse distance through the body, i.e., the number off and ability of each type of plate to absorb and store momentum, i.e., total area of receiver plates within the body, leading to progressive absorbing of momentum-energy as it passes through bodies converging on an occluded space.

Gravitational constant $G = \frac{\delta_e\, c^3}{2\,\pi\, A_V\, J_I} = \frac{2\,\delta_e\,\pi\, r_e{}^2\, c^3}{h}$ Maybe δ_e is related to the degree of occlusion

Perhaps at the scale of two electrons in proximity with an occluded space between, the degree of occlusion / blocking then depends on the space / gap available for either electron to retransmit a wavelength into, and the orientation of one electron 3D structure relative to the other, the orientation varying from a ZBW area plate being orthogonal to incoming vacuum momentum-energy with full momentum collection to a plate being "edge on" with zero collection, occlusion is maximized when electron plates are orientated parallel and axially aligned, maybe the force from gravity is then equal to the Casimir force, i.e. the Casimir force is the force from gravity, (is this then the source of the strong nuclear force?), as this space between electrons is opened up the degree of occlusion falls and so does the value of the gravitational "constant", at the scale of apples, people and planets, the gravitational "constant" is greatly reduced from that local to electrons.

Within the ResearchGate paper by Andrea Rossi referred to at the start above, non-point like electrons, treated as two parallel plates with an external Casimir force balancing a separating Coulomb force, are used within one possible theoretical framework as the basis for formation of dense exotic electron clusters.

Based on my post on the Journal of Nuclear Physics website (JONP) of 2021-09-24 10:54 KeithT
https://www.journal-of-nuclear-physics.com/?p=892&cpage=638#comment-1543804

Referring to the Andrea Rossi ResearchGate paper:
https://www.researchgate.net/publication/330601653_E-Cat_SK_and_long-range_particle_interactions

Within section 1; Charge clusters and the Casimir force, it is stated, "*According to another Zitterbewegung electron model [8, 15, 31], the electron can be modeled by a current loop, with radius* r_e *, generated by a charge distribution that rotates at the speed of light.*" Within references [8] , [15] & [31] there is an outline of the Zitterbewegung (ZBW) electron model as proposed by F. Celani, A.O. Di Tommaso and G. Vassallo.

Each electron with its orbiting charge plane is treated as a circular "plate", for a sufficiently high density of low entropy electrons, where two electrons can have the same spin direction, positioned on the same axis, with plates parallel to each other, as the electrons then approach to proximity, vacuum energy is occluded from between electron receiver plates, the external Casimir force pushes electron plates together against electron Coulomb force repelling apart, the electrons position at a point of balance separation distance.

Based on the non-point like ZBW electron model, for the case where two electrons are on the same axis and positioned as two parallel plates, a separation distance is obtained between two electron plates by balancing the Coulomb repulsion force between the two electrons; $F_e\,(d)$ = equation (5), with a Casimir force applied external to the two electron plates pushing them together; $F_C\,(d)$ = equation (4) multiplied by four for the larger plate area of a ZBW electron model, the resulting point of balance between opposing Coulomb versus Casimir forces for two electrons is at a separation distance d_b approximately equal to four reduced Compton wavelengths, i.e. $d_b \approx 1.54 \times 10^{-12}$ m. (Reduced Compton wavelength = $\frac{\lambda_c}{2\pi} = r_e$ = the ZBW radius)

$$\text{Force} = F_C\,(d) = \frac{\pi\,\hbar\,c\,\lambda_c^{\,2}}{3840\,d^4} \qquad (4)$$

$$\text{Force} = F_e\,(d) = \frac{1}{4\,\pi\,\varepsilon_0}\frac{e^2}{d^2} \qquad (5)$$

$$\text{For} \qquad 4 \times F_C\,(d) = F_e\,(d) \qquad \text{then} \qquad 4 \times \frac{\pi\,\hbar\,c\,\lambda_c^{\,2}}{3840\,d^4} = \frac{1}{4\,\pi\,\varepsilon_0}\frac{e^2}{d^2}$$

$$\frac{d^4}{d^2} = \frac{\pi^2\,\lambda_c^{\,2}\,\hbar\,\varepsilon_0\,c}{240\,e^2}$$

$$d = d_b \approx 4 \times \frac{\lambda_c}{2\,\pi} = 4\,r_e \approx 1.54 \times 10^{-12}\ \text{m}$$

Based on the model outlined in the Andrea Rossi ResearchGate paper, if the Coulomb force is halved, i.e., equation (5) is divided by two, the resulting point of balance between the now smaller opposing Coulomb versus Casimir forces is at an increased separation distance of $d_b \approx 2.3 \times 10^{-12}$m, i.e., 2.3 picometres.

$$\text{For} \qquad 4 \times F_C\,(d) = \frac{1}{2} \times F_e\,(d) \qquad \text{then} \qquad 4 \times \frac{\pi\,\hbar\,c\,\lambda_c^{\,2}}{3840\,d^4} = \frac{1}{2} \times \frac{1}{4\,\pi\,\varepsilon_0}\frac{e^2}{d^2}$$

$$\frac{d^4}{d^2} = \frac{\pi^2\,\lambda_c^{\,2}\,\hbar\,\varepsilon_0\,c}{120\,e^2}$$

$$d = d_b \approx 2.2978 \times 10^{-12}\text{m} \approx 2.3\ \text{pm}$$

Within the references of the above paper, this value of 2.3 pm separation distance can be found in reference [15]; A.O. Di Tommaso and G. Vassallo – Electron Structure, Ultra-Dense Hydrogen and Low Energy Nuclear Reactions, section 6; Hypotheses on the Structure of Ultra-Dense Hydrogen, distance di $\approx 2.3 \times 10^{-12}$ m, this being the theoretical distance between two ultra-dense hydrogen atoms where the electron charge orbit planes are parallel to each other and the charge positions in their orbits are π radians out of phase relative to each other, i.e., diagonally opposite between two planes. As also cited in reference [15], this 2.3 pm distance has been computed by Leif Holmlid for a particular form of ultra-dense deuterium.

As to what leads to the Coulomb force being halved, Coulombs law deals with two charges repelling each other, what if there was a group of electrons and within this group three electrons were to align then balance in a chain, the central electron shielded from outside electron or vacuum structure influence by the two outer electrons, how would this affect the outcome, is isolated vacuum structure $\mu_0 + \varepsilon_0$ local to central shielded electron unaffected, is $v_\perp = c$ unaffected, it may be that electron charge energy associated with the Coulomb force is split between the two sides of an electron "plate" with the force on each side halved, another consideration from the ZBW electron model is that half the electron energy is in the charge orbiting the rest loop or helix pathway and half in the flux circling this pathway, does this affect the outcome? Alternatively, 2.3 pm is also possible if the Casimir force is doubled, say from whole h instead of $\frac{h}{2}$, whatever the scenario, maybe it is possible to have electrons with a point of balance separation distance of 2.3 pm.

Looking at the history of the Casimir force per unit area equation as used in the above paper; equation (3), it was a mathematical solution for a larger scale, (a convenient round number like 240, does nature operate on a base 10 number system?), maybe this equation can be regarded as an approximation when it is used at the scale of electron properties and dimensions. If the Casimir force per unit area equation (3) is divided by the sum of $\pi^3/240$ then multiplied by the sum of $2 \times \alpha \times (\pi^2 - 1)$, α = the fine structure constant (FSC), both sums dimensionless, the result is different by less than 0.2%, this modified equation when used with half the Coulomb force, then gives an approximate electron separation of 2.3 pm, and a diagonal distance between electron charges that are π radians out of phase of exactly one electron Compton wavelength.

$$\frac{F_C\,(d)}{Area} = \frac{\pi^2\,\hbar\,c}{240\,d^4} \qquad (3)$$

Modified Casimir force per unit area equation = $\frac{F_C\,(d)}{Area} = \frac{2\,\hbar\,c\,\alpha\,(\pi^2-1)}{\pi\,d^4}$

For the ZBW electron model the ZBW radius = $r_e = \frac{\lambda_c}{2\,\pi}$, λ_c = the Compton length is the circumference

Therefore, the ZBW electron "plate" area = $Area = \pi\,{r_e}^2$

Equation (4) is now modified to; Force = $F_C\,(d) = \frac{2\,\hbar\,c\,\alpha\,(\pi^2-1)}{\pi\,d^4}\,\pi\,{r_e}^2 = \frac{2\,\hbar\,c\,\alpha\,{r_e}^2\,(\pi^2-1)}{d^4}$

For Force = $F_C\,(d)$ modified = $\frac{1}{2} \times F_e\,(d)$ then $\frac{2\,\hbar\,c\,\alpha\,{r_e}^2\,(\pi^2-1)}{d^4} = \frac{1}{2} \times \frac{1}{4\,\pi\,\varepsilon_0}\frac{e^2}{d^2}$ $\left[= \frac{\alpha\,\hbar\,c}{2\,d^2}\right]$

$$\frac{d^4}{d^2} = \frac{16\,\pi\,\hbar\,\varepsilon_0\,c\,\alpha\,{r_e}^2\,(\pi^2-1)}{e^2}$$

$$d^2 = \frac{16\,\pi\,\hbar\,\alpha\,{r_e}^2\,(\pi^2-1)}{e^2\,\mu_0\,c}$$

As $e^2 = \frac{4\,\pi\,\hbar\,\alpha}{\mu_0\,c}$

$$d^2 = \frac{16\,\pi\,\hbar\,\alpha\,{r_e}^2\,(\pi^2-1)}{\mu_0\,c}\,\frac{\mu_0\,c}{4\,\pi\,\hbar\,\alpha} = 4\,{r_e}^2\,(\pi^2-1)$$

$$d = 2\,r_e\,(\pi^2-1)^{0.5}$$

Then the separation distance between two electron "plates" = $d = d_b \approx$ 2.30011 × 10^-12m ≈ 2.3 pm

As $2\,r_e$ is the electron ZBW area diameter and d_b is the distance between two parallel orbiting charges, the diagonal distance between two electron charges that are π radians out of phase = D_d , then by Pythagoras

$$ {D_d}^2 = (2\,r_e)^2 + {d_b}^2$$

$$ {D_d}^2 = (2\,r_e)^2 + (2\,r_e\,(\pi^2-1)^{0.5})^2$$

$$ {D_d}^2 = (2\,r_e)^2 + (2\,r_e)^2\,(\pi^2-1)$$

$$ {D_d}^2 = (2\,r_e)^2\,(1+\pi^2-1)$$

$$ {D_d}^2 = (2\,\pi\,r_e)^2$$

$D_d = \lambda_c$, i.e., the diagonal distance equals one electron Compton wavelength

Are scalar-longitudinal waves the source of the momentum mass energy within the vacuum structure? Look up at night and you can see the stars, each star radiating photons, radiating unseen energy, all converging at a point in your eye, every star radiating energy towards every point in the universe, every point, every atom with converging vector momentum "zero-point" vacuum energy, atoms balancing in the fluctuating maxima and minima sea, until there is occlusion producing a major imbalance, I.e., the Casimir effect, i.e., gravity.

Under what conditions are electrons likely to balance? maybe an environment where free electrons are available and very slow moving relative to each other, where electrons are hindered from escaping, an environment that encourages electrons to collect and group together in proximity, within, next to or around a static high stress location, so a relatively low temperature, low energy, low entropy environment, maybe within a highly stressed ordered structure where degrees of freedom / mobility of atoms is limited.

Free electrons that are slow moving relative to each other in a locality are still likely to have a group velocity component of the CMB velocity = v_z , electrons that are local to each other and appear to be slow moving relative to each other and their environment can still be moving as a group relative to the CMB. If it can be arranged for local electrons to have their degrees of freedom restricted, with same spin handing and moving in the same direction, for two same spin handed electrons moving in the same direction, plates orientated parallel to each other, a slightly faster electron can catch up on a slightly slower electron, on approach, the gap between the two electrons is increasingly occluded, the two electrons increasingly shield the gap against external incoming vacuum momentum-energy, the electromagnetic fields of the faster electron increasingly interact with the fields of the slower electron, they move to align on the same axis, the faster electron will radiate forward towards the slower electron transferring momentum and decelerate, the slower electron accepts z-axis momentum and accelerates, as the gap closes and the electrons find a balance separation distance for Casimir force vs Coulomb force, excess momentum is radiated as required to enable a group match in z-axis velocity, and for orbiting charges to become locked in phase relative to each other.

In the above scenario the pair of electrons can be both spin up or both spin down, i.e., as a pair, must match in spin handing, what if it was two positrons, as a pair either spin up or down, they will also balance at a separation distance. What if a positron slowly approached an electron with matching spin handing or vice versa, Casimir force pushing them together, but this time the charges attract, as the electron and positron flux fields are opposite in rotation direction do they oppose each other, the electron still balances the positron at a separation distance but now the aggregate is charge neutral. As electrons and positrons exist as both spin up and down, it then depends on which pair approach each other, the combinations of opposite hand spins; $\mathrm{e}\upharpoonleft + \mathrm{e}\downharpoonleft$, $\mathrm{p}\upharpoonleft + \mathrm{p}\downharpoonleft$, $\mathrm{e}\upharpoonleft + \mathrm{p}\downharpoonleft$, and $\mathrm{e}\downharpoonleft + \mathrm{p}\upharpoonleft$, likely to be deflected from each other, only same hand spins are able to approach; $\mathrm{e}\upharpoonleft + \mathrm{e}\upharpoonleft$, $\mathrm{p}\upharpoonleft + \mathrm{p}\upharpoonleft$, and $\mathrm{e}\upharpoonleft + \mathrm{p}\upharpoonleft$, and their opposite hands, the four pairs of electron or positron, all spin up or all spin down, balancing in the same above scenario, the two electron + positron combinations also balancing but possibly at a closer distance where fields interact.

The above scenario is for electrons and positrons positioning and balancing on the same z-axis of travel, what if electrons and positron pairs can position and balance with z-axis's parallel, a pair comprising two opposite spin objects, one spin up parallel to one spin down, the **B** field moving out of one ZBW area then circles to feed into the **B** field ZBW area of the other, through and out to circle back to where it started.

A circling **B** field will always try to revert to lowest entropy, i.e., shortest loop encircling an area, say there is elliptical **B** field lines in closed loop pathways around a moving charge, with field lines diverging out from the charge centre cutting through **B** field lines, as lines cut perpendicular through each other, the interaction creates a radial magnetic force in line with the field line, $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$, the force will be highest where inwards or outwards polarity field lines have the greatest curvature and are trying to revert back to straight radial, i.e., at the greatest curvature of the **B** field line loop, i.e., the end points of the ellipse, therefore to balance radial forces all along the **B** field line loop pathway, the ellipse loop tries to revert towards an ideal circle.

In the case of two opposite spin electrons, the **B** field line looping through the two electron ZBW centres, tries to revert towards the shortest path possible enclosing a flux area, i.e., a circular loop, imbalanced radial forces around the **B** field loops then push the two electrons together, but the electrons having the same polarity charges push apart, a point of balance separation between the two z-axis's will be reached.

The positioning of electrons / positrons pairs can then be balancing on axis therefore parallel, and balancing as opposite spins parallel, therefore anti-parallel. Maybe due to initial individual momentum vectors before the balance, the anti-parallel pair will orbit around each other about the common centre. Is either type of balancing / orbiting possible for atoms or between the electrons of atoms? say two hydrogen atoms $\rightarrow H_2$

Is there any scenario where, due to combination of helix handing spins, and charge rotation polarities, and a sufficiently high momentum collision, the structures can merge, either with one enhanced charge circling an enhanced ZBW area, or two separate charges circling diametrically opposite around a common ZBW area, maybe with multiple merges at higher and higher energies, you can obtain increasingly rare exotic objects.

If you can have objects merging, then the opposite should be possible, what if electron type structures are only stable with Volt or Amp quantum increments, maybe structures decay due to an imbalance after a quantum or a non-quantum increment of either is added or radiated through collision, what if during break down of a high energy particle, with division of unstable charge or flux regions into stable regions, quantum and / or smaller non-quantum region increments are ejected, an ejected regions handing based on the handing of the object breaking down, the quantum increments proceed into electron type structure states, the remnant non-quantum increments forced to flip into low energy neutral photon type structure states.

What happens when two objects that are stationary relative to each other, are so close that the charge of one can rotate through the flux of the other or vice versa, does extra interaction change induction activity? What if you have two stationary objects balancing each other that are then in a collision with a third object. What happens when objects that are at high velocities relative to each other collide, during the interaction the charge of one rotates through the flux of the other. What if through collision, longitudinal component momentum of one can be translated into orthogonal momentum in the other, decay may be vice versa.

If an electron has h of angular momentum and this comes from the interaction action of the charge rotating through the flux, and half of an electron's energy is in the flux and half is in the charge, it can be said that the flux contributes $\frac{h}{2}$ and the charge $\frac{h}{2}$; $h = \phi_e \, e = \frac{C_e \, {\phi_e}^2}{2 \, T_e} + \frac{L_e \, e^2}{2 \, T_e} = \frac{h}{2} + \frac{h}{2}$, one spin at an angle to the other.

What if during a collision longitudinal component momentum can be translated to orthogonal component angular momentum in increments. What if either or both the charge and flux can be increased by quantum increments of $h/2$. What if during a collision the charge and flux components can be transferred separate, resulting in charge with one particle, flux with the other particle, one staying, one increment transferring.

For an elastic collision of two "rigid" particles, momentum is summed up before and after, total momentum is conserved, the particles recoil from each other in new paths, both still with same mass as before collision. However for a collision of two particles, where there is interaction between internal structures, depending on phase relation / orientation between the charge / flux of the two particles, if a momentum component vector is at least an increment of $h/2$, longitudinal component momentum-mass of one may be translated to an increase in the orthogonal angular momentum-mass in the other, the z-axis velocity of both particles adjust, total momentum of particles before and after is conserved, but the rest mass of one particle has increased, if insufficient momentum there is no transfer, recoil as existing masses, with an increment there is transfer of charge or flux, or with sufficient momentum, transfer of both, possibly in multiples of either.

What if the charge poloidal rotation through the flux with interaction, and vice versa, is also quantized, the interaction between the two regions controlled by the vacuum permeability and permittivity constants, for additional flux or charge, poloidal rotation changing in increments, or maybe increments are related to ratio of charge disc cross section to ZBW disc section and hence increments of intersection. Quantum increments of interaction leads to increments of radial magnetic force, leads to increments of ZBW radius reduction, a tighter curvature of pathway leads to an increment increase in rest mass, mass is stored momentum.

With an $h/2$ increase, increase in Volts x Amps interaction, there will be an increase in centripetal magnetic force F_r , the charge will be pushed inwards, the charge then following a spiral path inwards to a new stable orbit, what if orbit travel, i.e., radius changes are quantized, changes in ZBW orbit may be governed by the fine structure constant, what if the path curve is related to the FSC, the FSC being a mathematical constant based on a series, each quantum of ZBW radius and associated ZBW area then related to this FSC series.

What if we take an electron and add $h/2$ of say flux only, with an increase in Volts x Amps interaction, there is an increase in radial magnetic force, the charge pushed spiralling inwards to a new stable orbit, the ZBW orthogonal orbit component = λ_c , is forced to reduce by a multiple of the FSC, i.e., as $\lambda_c = 2\,\pi\,r_e$, the ZBW radius r_e is also reduced by the same multiple, do we now have a Muon particle, and if we take a Muon and add another $h/2$ of flux, and the ZBW radius is further forced to reduce by a multiple of the square root of the FSC, do we now have a Tau particle, the charge poloidal rotation handing is unchanged therefore same handing rule, same charge polarity, the helix pathway handing is unchanged therefore still same spin.

$$\text{Electron rest mass} = m_e = \left(\frac{h}{2}+\frac{h}{2}\right)\times\frac{1}{\alpha^0}\times\frac{1}{\lambda_c\,c} = \frac{1.0\times h}{\alpha^0\,\lambda_c\,c} = \frac{h}{\lambda_c\,c} = \frac{h}{2\,\pi\,r_e\,c} = \frac{\hbar}{r_e\,c}$$

$$\text{Muon mass} = m_\mu = \left(\frac{h}{2}+\frac{h}{2}+\frac{h}{2}\right)\times\frac{1}{\alpha^1}\times\frac{1}{\lambda_c\,c} = \frac{1.5\times h}{\alpha^1\,\lambda_c\,c}$$ rest value is within 0.6% of CODATA value

$$\text{Tau mass} = m_\tau = \left(\frac{h}{2}+\frac{h}{2}+\frac{h}{2}+\frac{h}{2}\right)\times\frac{1}{\alpha^{1.5}}\times\frac{1}{\lambda_c\,c} = \frac{2.0\times h}{\alpha^{1.5}\,\lambda_c\,c}$$ rest value is within 9% of CODATA value

As the flux to charge ratio, i.e., the Volts / Amps ratio is no longer = resistance of vacuum structure = Z_0 , the Volts × Amps interaction is no longer symmetrical, the particles are unstable, with the smaller ZBW radius, shorter loop time interval, faster rate of interaction, the Tau particle decaying faster than the Muon particle.

There are rich fields of obscure phenomena to research, ranging from Cold Fusion / LENR to electromagnetic propulsive force, and scalar waves, anomalous behaviour has often been claimed, but rarely replicable, often triggered by electrical activity, pulses, sparks, sharp electrical change, even Sonofusion has atoms / electrons accelerated towards a focus. What if some observed behaviour is driven by the underlying action of electron acceleration, the basis is not fission, not fusion, not nuclear reactions, just electron states. The experiments of N. Tesla, J. Papp, E.V. Gray, K. Shoulders, M. Fleischmann & S. Pons, B.L. Power, A. Rossi, A.G. Parkhomov, F. Celani & team, possibly related to 3D electron acceleration and longitudinal electromagnetics.

Knowing that an electron is non-point like and has a 3D structure, knowing that the electron has handing and orientation, knowing that this structure can be manipulated, knowing that an accelerating electron can produce a vector potential that can affect other electrons at a distance, can this be used to advantage?

On the basis that electrons can balance in proximity, in an optimally structured atomic environment, say a FCC metal lattice loaded with hydrogen atoms trapped within O-sites, mobile electrons migrate to surround an O-site atom increasing the local electron density, if this group of electrons is then induced by weak skin effect electromagnetics to align in spin orientation, the electrons may then proceed to interact and form an in-phase condensate, with reduced degrees of freedom, a reduction in entropy, becoming arrayed, ordered, close positioned relative to each other, to then balance, with electromagnetics now interacting, this united in-phase electron cluster may then have dominance to force a momentum transfer, forcing a different phase electron associated with the O-site atom that is now trapped inside the electron cluster cage, to become in-phase with the cluster cage electrons, forcing a change from a higher entropy to a lower entropy, the phase change of this electron associated with the atom releasing stored momentum mass energy, i.e., zero-point Volts × Amps energy, the O-site atom is forced to a deep Dirac level, i.e., an ordered environment within a plasma > promotes electron interaction via local forces > local lowering of entropy > neutral aggregate synthesis > outwards momentum energy transfer > movement of electrons in an external electric circuit.

Is the above just speculation, what ifs and maybes? Likely. However, is it possible, that with just one change, a deeper understanding can be developed of the many known outcome's observable in mainstream physics, also resolving the rare contrary outcomes observed at the fringes of physics. Maybe all that is required is acceptance of a single change in something very basic and very central to current physics, the acceptance of a non-point like, 3D electron structure type of object, with internal variable attributes.

What if an electron has hidden variables, its many properties governed by internal variable attributes, say; rotation, handing, scale, Volt × Amp interaction quantum increments, merging, and break down, when this mutable object is combined with an ability, when multiples of these objects are proximate, to then balance, orbit each other, and assemble into ordered structures, the resulting products will be a whole zoo full of different object states, some stable, some short lived, maybe recognisable as the same basic building blocks of current accepted physics. The properties of these different singular and aggregate objects, i.e., particles and atoms, with rules of interplay between, regulating electromagnetics, forces, and momentum, then dictating the higher-level interactions underlying the chemistry and material science of the world we live in.

What if there is only one object, only one force, then depending on object internal state and interplay between objects, the outcome is a wide variety of emergent behaviour, our fine-tuned universe.

In exploring the 3D electron model as proposed by Celani et al. in the papers referred to above, it can be observed that this is a 3D model that changes scale and geometry depending on velocity, the consequences of this must be accounted for, by taking basic, non-historical, non-orthodox viewpoints, logically examining relationships from different perspectives, focusing on geometrical structure, the resulting interpretations, speculation and notes are an attempt at a step towards this accounting, with intent of promoting thought.

By avoiding the human created historical units: Coulomb, Farad, Henry, Hertz, Joule, Newton, Ohm, Tesla, Weber, and kilograms, and by converting all electron properties to the four units: Volts, Amps, seconds, and metres, it becomes easier to understand direct relationships, the units: Volts, Amps, seconds, and metres, being more aligned with the equations above and possibly can be regarded as more fundamental to nature. When converting constants to a geometrized natural unit system like $c = \varepsilon_0 = \hbar = 1$, connections may become more observable, but in converting there is a loss of information that may be important. Some properties, say energy E = Kg m^2 s^{-2} have length within their unit, where in nature, unit = V A s , there is no length, the units of vacuum permittivity ε_0 = F m^{-1} , the units of the Coulomb constant should be an inverse, however k_e = N m^2 C^{-2} , this determination to name properties and units to honour scientists leads to a loss of clarity. Historically both B_e and H_f have been described as magnetic fields, however one has units based on Volts the other on Amps, historical property descriptions are not consistent with the content of the units. It is difficult to determine from the units how a property should be described, should electric be associated with units composed of Volts only, and magnetic be associated with units of Amps only, or vice versa, as Volts induce magnetic effects and Amps induce electric effects, so is the property to be named for the cause or the effect? for the above properties, an attempt is made to avoid electric / magnetic in the description.

With a single equation, simple or complex, however elegant it is, it may be difficult to interpret for or against something, alternatively, by use of the units of Volts, Amps, seconds and metres for all electron properties, by expressing these properties in terms of each other in many equations, by presenting them over a few pages and examining the overall picture of both equations and units, then patterns, symmetries and relations can be observed, particularly, how they physically relate to geometric aspects of the proposed electron 3D structure, i.e. step by step you can build up to a full physical interpretation, the use of these same units with the application of the Lorentz factor for a moving electron highlighting how some properties are constants, some increase, some decrease, how combinations of these property unit value changes still work when used within the equations above, these changes directly connected to a moving 3D electron.

A caveat regarding the above equations is that although they all equate correctly with units of measure and known unit values, some of the equations are unsatisfactory in that there appears to be an un-necessary presence of a multiple of two, is there a scaling problem, or is this multiple a quanta factor?

In conclusion, the three-dimensional, non-point like, Zitterbewegung electron model as proposed by the authors of the papers [8] & [15] referred to above: F. Celani, A.O. Di Tommaso and G. Vassallo, reveals an electron possessing many properties, all of these properties are interlinked and can in turn be linked to a simple structure, a 3D structure that can be visualized, this model or something very close to it with a 3D structure, with handing, rotations, and orientation, along with properties that are velocity and quantized unit (i.e., h and α) dependent, may lead the way towards a geometric model connection to the underlying Volts × Amps, solenoidal + irrotational, gradient, divergence and curl, scalar + vector maths of the 3D space plus time vacuum structure, the connection to known equations and known experimental results, and as Celani et al. explain using the principle of Occam's razor, the simplest model is the most likely model.

Irrespective of my reasoning, interpretations, speculations, and conclusions in the notes above regarding what is observable in the proposed 3D model and equations, I believe that the F. Celani, A.O. Di Tommaso and G. Vassallo, Zitterbewegung electron model basis is the correct path forward, and is the correct 3D electron model that will allow electron manipulation as described within the paper above by Andrea Rossi.

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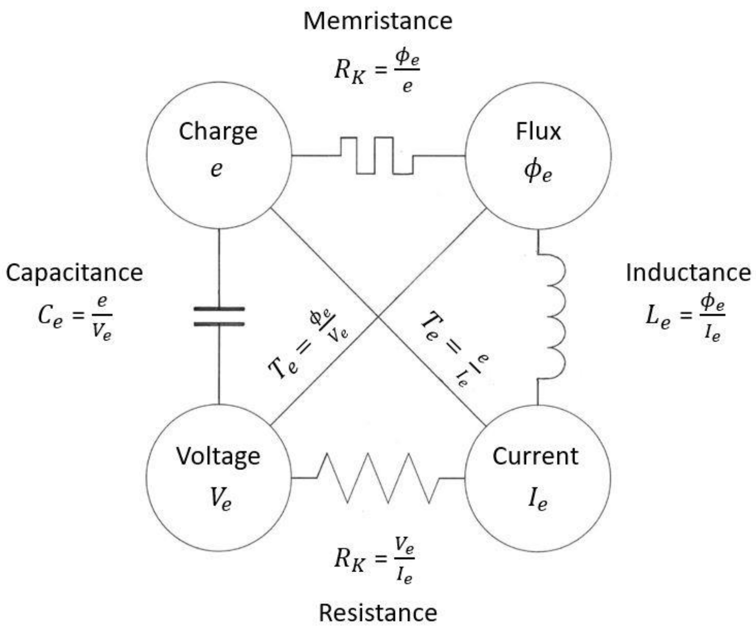
Electrical circuit fundamental components, equivalence for e , ϕ_e , V_e , and I_e



Motion through space of our solar system, the sun, the planets, the people and their experiments, and the atoms, electrons, and particles that they are composed of, relative to the surrounding universe:

https://www.forbes.com/sites/startswithabang/2018/08/30/our-motion-through-space-isnt-a-vortex-but-something-far-more-interesting/?sh=517dbed37ec2

Property	Symbol	Source *	Local Value **	Units	S.I. Units
Speed of light in vacuum	c	$CODATA\ (A)$	299 792 458	m s^{-1}	m s^{-1}
Vacuum structure permeability	μ_0	$4\ \pi\ 10^{-7}\ (B)$	1.256 637 061 44 x 10^-6	V A^{-1} s m^{-1}	N A^{-2}
Vacuum structure permittivity	ε_0	$\frac{1}{\mu_0\ c^2}$	8.854 187 817 62 x 10^-12	V^{-1} A s m^{-1}	F m^{-1}
Resistance of vacuum structure	Z_0	$\mu_0\ c$	376.730 313 462	V A^{-1}	Ohm
Coulomb constant	k_e	$\frac{\mu_0\ c^2}{4\ \pi}$	8.987 551 787 x 10^9	V A^{-1} s^{-1} m	N m^2 C^{-2}
Fine structure constant	α	$CODATA\ (C)$	7.297 352 5643 x 10^-3	none	none
Inverse of fine structure constant	α^{-1}	α^{-1}	137.035 999 178	none	none
Von Klitzing constant	R_K	$\frac{\mu_0\ c}{2\ \alpha}$	25 812.807 463	V A^{-1}	Ohm
Rydberg "constant" – local value **	R_∞	$CODATA\ (D)$	10 973 731.568 157	m^{-1}	m^{-1}
Electron Compton wavelength	λ_c	$\frac{\alpha^2}{2\ R_\infty}$	2.426 310 235 35 x 10^-12	m	metre
Electron charge radius	r_0	$\frac{\alpha^3}{4\ \pi\ R_\infty}$	2.817 940 320 42 x 10^-15	m	metre
Electron Zitterbewegung (ZBW) radius	r_e	$\frac{\alpha^2}{4\ \pi\ R_\infty}$	3.861 592 674 31 x 10^-13	m	metre
Charge pathway circuit travel time	T_e	$\frac{\alpha^2}{2\ R_\infty\ c}$	8.093 299 783 26 x 10^-21	s	second
Electron ZBW angular frequency	ω_e	$\frac{4\ \pi\ R_\infty\ c}{\alpha^2}$	7.763 440 716 95 x 10^20	rad s^{-1}	Hertz
Electron inductance	L_e	$\frac{\mu_0\ \alpha}{4\ R_\infty}$	2.089 107 890 x 10^-16	V A^{-1} s	Henry
Electron capacitance	C_e	$\frac{\alpha^3}{\mu_0\ R_\infty\ c^2}$	3.135 381 455 x 10^-25	V^{-1} A s	Farad
Josephson constant	K_J	$CODATA\ (E)$	483 597.848 4… x 10^9	V^{-1} s^{-1}	Hz V^{-1}
Scalar potential	V_e	$\frac{4\ R_\infty\ c}{\alpha^2\ K_J}$	510 998.951	Volts	Volts
Flux circling through ZBW area	ϕ_e	$\frac{2}{K_J}$	4.135 667 697 x 10^-15	V s	Weber
Electron electric moment	μ_V	$\frac{\alpha^3\ c}{4\ \pi\ R_\infty\ K_J}$	1.746 900 359 x 10^-21	V m^2	V m^2
Electric field strength (Schwinger limit)	E_f	$\frac{16\ \pi\ R_\infty{}^2\ c}{\alpha^4\ K_J}$	1.323 285 478 x 10^18	V m^{-1}	V m^{-1}
Potential area density	A_d	$\frac{64\ \pi\ R_\infty{}^3\ c}{\alpha^6\ K_J}$	1.090 780 114 x 10^30	V m^{-2}	V m^{-2}
Vector potential, flux per distance	A_V	$\frac{4\ R_\infty}{\alpha^2\ K_J}$	1.704 509 026 x 10^-3	V s m^{-1}	Wb m^{-1}
Flux area density (Schwinger limit)	B_e	$\frac{16\ \pi\ R_\infty{}^2}{\alpha^4\ K_J}$	4.414 005 231 x 10^9	V s m^{-2}	Tesla
Flux volume density	ρ_F	$\frac{64\ \pi\ R_\infty{}^3}{\alpha^6\ K_J}$	3.638 450 819 x 10^21	V s m^{-3}	Wb m^{-3}
Electron charge pathway scalar current	I_e	$\frac{8\ R_\infty}{\alpha\ \mu_0\ K_J}$	19.796 333 717	Amps	Ampere
Electron elementary charge	e	$\frac{4\ \alpha}{\mu_0\ c\ K_J}$	1.602 176 6338 x 10^-19	A s	Coulomb
Electron magnetic moment	μ_e	$\frac{\alpha^3}{2\ \pi\ \mu_0\ R_\infty\ K_J}$	9.274 010 064 69 x 10^-24	A m^2	J T^{-1}
Magnetic field strength	H_f	$\frac{32\ \pi\ R_\infty{}^2}{\alpha^4\ \mu_0\ K_J}$	7.025 107 513 x 10^15	A m^{-1}	A m^{-1}
Current area density	J_d	$\frac{128\ \pi\ R_\infty{}^3}{\alpha^7\ \mu_0\ K_J}$	7.935 445 463 x 10^29	A m^{-2}	A m^{-2}

Vector current, charge per distance	J_I	$\frac{8\,R_\infty}{\alpha\,\mu_0\,c\,K_J}$	6.603 346 145 x 10^-8	A s m^{-1}	C m^{-1}
Charge area density-displacement field	D_e	$\frac{32\,\pi\,{R_\infty}^2}{\alpha^4\,\mu_0\,c\,K_J}$	23 433 236.31	A s m^{-2}	C m^{-2}
Charge volume density	ρ_c	$\frac{128\,\pi\,{R_\infty}^3}{\alpha^7\,\mu_0\,c\,K_J}$	2.646 979 686 x 10^21	A s m^{-3}	C m^{-3}
Total electron rest energy	E	$\frac{16\,R_\infty}{\alpha\,\mu_0\,{K_J}^2}$	8.187 105 788 x 10^-14	V A s	Joule
Planck constant	h	$\frac{8\,\alpha}{\mu_0\,c\,{K_J}^2}$	6.626 070 150 x 10^-34	V A s^2	J Hz^{-1}
Reduced Planck constant	$\hbar$	$\frac{h}{2\,\pi}$	1.054 571 818 x 10^-34	Rad^{-1} V A s^2	J s
Electron rest momentum	P_r	$\frac{16\,R_\infty}{\alpha\,\mu_0\,c\,{K_J}^2}$	2.730 924 534 x 10^-22	V A s^2 m^{-1}	Kg m s^{-1}
Electron rest mass	m_e	$\frac{16\,R_\infty}{\alpha\,\mu_0\,c^2\,{K_J}^2}$	9.109 383 7134 x 10^-31	V A s^3 m^{-2}	Kilogram

* $CODATA$ = 2022 edition, $4\,\pi\,10^{-7}$ is CODATA pre-2018 , ** Local values based on R_∞ for a moving Earth.

The table property values above can be obtained from Pi , (*A*), (*B*), (*C*), (*D*) & (*E*), of these, the values (*A*) & (*B*) were set by historical agreement, (pre-2018), the values (*D*) & (*E*) are obtained from historical experiments to a high accuracy, and a FSC value (*C*), that whether it is the CODATA 2022 value or a mathematical constant that is within one part per billion of the CODATA 2022 value, (previously, constant was within the standard uncertainty of the CODATA 2018 value), there is negligible difference in outcome. By setting values for R_∞ and K_J based on experiments, this allows property values to be obtained from some or all combinations of the following components: Pi = π , (*A*) = c , (*B*) = μ_0 , (*C*) = α , (*D*) = R_∞ , and (*E*) = K_J , of these, it should be noted that (*D*) the Rydberg "constant" is the only variable, being dependent on electron z-axis velocity and hence the Lorentz factor, all other components are fixed constants. For the electron properties listed in the table, if the property requires the use of Pi = π , the units may contain radians, if the property requires the use of (*D*) = R_∞ , the property value is variable and dependent on the electron z-axis velocity, if not required the property is a constant, for an experiment with electrons at rest or at least low velocity, the values obtained will change little, but as electrons approach high velocities the values obtained deviate rapidly.

As an alternative to the CODATA value for K_J , with the use of the following equation: $K_J = \frac{2\,\alpha^3\,m_e}{R_\infty\,\mu_0\,e\,h}$ in conjunction with the CODATA property values: μ_0 , α , R_∞ , e , h and m_e , one property value based on historical agreement and other properties with consolidated values obtained from historical experimental results, a value for K_J can be obtained averaging the major influential historical inputs, this value can be used to obtain property values that are all from the same basis of (*A*), (*B*), (*C*), (*D*) and (*E*), the use of these values then producing more consistent and clear outputs when used in say a spreadsheet like Microsoft Excel.

Josephson constant = $K_J = \left(\frac{8\,\alpha}{\mu_0\,h\,c}\right)^{0.5} = \left(\frac{16\,R_\infty}{\alpha\,\mu_0\,E}\right)^{0.5} = \left(\frac{16\,R_\infty}{\alpha\,\mu_0\,P_r\,c}\right)^{0.5} = \left(\frac{16\,R_\infty}{\alpha\,\mu_0\,m_e\,c^2}\right)^{0.5}$ = V^{-1} s^{-1}

$$= \left(\frac{4\,T_e}{L_e\,h}\right)^{0.5} = \left(\frac{4}{L_e\,E}\right)^{0.5} = \left(\frac{4}{L_e\,P_r\,c}\right)^{0.5} = \left(\frac{4}{L_e\,m_e\,c^2}\right)^{0.5}$$

$$= \frac{2\,\pi\,r_0\,r_e}{T_e\,\mu_V} = \frac{2}{\phi_e} = \frac{2}{T_e\,V_e} = \frac{2}{T_e\,c\,A_V} = \frac{2}{T_e\,r_e\,E_f} = \frac{2}{T_e\,c\,r_e\,B_e} = \frac{2}{T_e\,\pi\,{r_e}^2\,A_d} = \frac{2}{T_e\,c\,\pi\,{r_e}^2\,\rho_F}$$

$$= \frac{2\,\pi\,{r_e}^2}{L_e\,\mu_e} = \frac{2\,T_e}{L_e\,e} = \frac{2}{L_e\,I_e} = \frac{2}{L_e\,c\,J_I} = \frac{2}{L_e\,r_0\,H_f} = \frac{2}{L_e\,c\,r_0\,D_e} = \frac{2}{L_e\,\pi\,{r_0}^2\,J_d} = \frac{2}{L_e\,c\,\pi\,{r_0}^2\,\rho_c}$$

Von Klitzing constant = $R_K = \frac{L_e}{T_e} = \frac{Z_0}{2\,\alpha} = \frac{\mu_V}{\alpha\,\mu_e} = \frac{\phi_e}{e} = \frac{V_e}{I_e} = \frac{A_V}{J_I} = \frac{E_f}{\alpha\,H_f} = \frac{B_e}{\alpha\,D_e} = \frac{A_d}{\alpha^2\,J_d} = \frac{\rho_F}{\alpha^2\,\rho_c}$ = V A^{-1}