# Modelling the Electron as a 4D Oscillator

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**Abstract**

This is a toy model for the electron. This essay explores the idea that the electron is a four dimensional oscillator, drifting along our time line with regular excursions forward and backward in time coupled with excursions in the $x$, $y$, and $z$ directions.

## Electron Properties Quick Reference

As a quick reference, here are various electron related properties in SI units.

| Unit | | Value | Unit | Explanation |
|---|---|---|---|---|
| $q$ | $=$ | $1.602 \times 10^{-19}$ | C | Charge |
| $m_e$ | $=$ | $9.10938 \times 10^{-31}$ | kg | Electron Mass |
| $\mu_e$ | $=$ | $e\hbar/(2m_e) = 9.274 \times 10^{-24}$ | J/T | Bohr Magneton |
| $\hbar$ | $=$ | $1.05457 \times 10^{-34}$ | J s | Planck's Constant |
| $\epsilon_0$ | $=$ | $8.85419 \times 10^{-12}$ | F/m | Electric Permittivity |
| $\mu_0$ | $=$ | $4\pi \times 10^{-7}$ | H/m | Magnetic Permeability |
| $c$ | $=$ | $2.99892 \times 10^{8}$ | m/s | Speed of Light |
| $\alpha$ | $=$ | $q^2/(4\pi\epsilon_0\hbar c) = 1/137.036$ | 1 | Fine Structure Constant |
| $\alpha_0$ | $=$ | $(4\pi\epsilon\hbar^2)/(mq^2)$ | m | Bohr Radius |
| | $=$ | $0.529 \times 10^{-10}$ | m | Bohr Radius |
| $r_e$ | $=$ | $\alpha^2\alpha_0 = 2.818 \times 10^{-15}$ | m | Classical Electron Radius |

## A Little Bit of History

Max Planck (1900) sucessfully modelled black body radiation. His model required proportionality between oscillator energy and frequency, $E = hf$.

Albert Einstein (1905) explained the photoelectric effect in metals by modeling the photon with both wave and particle properties. He postulated each photon had an energy $E$ proportional to frequency $f$. Our current understanding has photon linear momentum $p$ proportional to frequency and energy, inversely proportional to wavenumber $\lambda$, total angular momentum $S$ of constant magnitude $\hbar\sqrt{2}$, yet angular momentum in direction of travel constant at $\pm\hbar$, implying transverse angular momentum also of $\hbar$.

$$\begin{aligned} E &= hf = \hbar\omega \\ p &= h/\lambda = \hbar k = hf/c = E/c \\ S &= \sqrt{2}\hbar \\ S_z &= \pm\hbar \end{aligned}$$

Alfred Lauck Parson (1915) suggested that the electron is a spinning ring, suggesting magnetic moments and magnetic interactions as a method of explaining chemical bonding.

Arthur Compton (1923) demonstrated and explained the frequency dependence of the scattered xrays from a target.

$$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

The inferred size of electrons from this measurement was

$$\frac{h}{m_e c} = 2.43 \times 10^{-12} m$$

Louis de Broglie (1924) suggested wavelike behavior for electrons, with a frequency and wavelength associated with linear momentum $p$ as

$$
\begin{aligned}
\vec{p} &= \frac{m_0\vec{v}}{\sqrt{1-(v/c)^2}} \\
E &= \frac{m_0c^2}{\sqrt{1-(v/c)^2}} \\
&= \sqrt{p^2c^2+m_0^2c^4} \\
f &= E/h \\
&= \frac{m_0c^2}{h\sqrt{1-(v/c)^2}} = \frac{\sqrt{p^2c^2+m_0^2c^4}}{h} \\
\lambda &= \frac{h}{p} \\
&= \frac{h\sqrt{1-(v/c)^2}}{m_0v}
\end{aligned}
$$

From this point forward in time, ring and toroidal electron models are relegated to the speculative, fringe and mechanical insight model realms, as quantum mechanics is the preferred physical model. The following references illustrate the search for a mechanical electron models consistent with observations.

Plasma physicist Winston Bostick (1985) in *The Morphology of the Electron* International Journal of Fusion Energy, Vol. 3 No.1, January 1985, attempts a gravitationally bound writhing ring model of the electron, similar in form to electric currents in plasma.

David Bergman and J. Paul Wesley (1990), in *Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment* Galilean Electrodynamics. Vol. 1, No. 5, (Sept./Oct., 1990) present a spinning torus model for the electron, using self-inductance and self-capacitance as part of a circuit model for the electron.

Phillip M. Kanarev (2000), in *Model of the Electron*, Apeiron Vol. 7 No. 3-4, July-October, 2000, presents a toroidal model for electron and positron, where different sign helicities along the torus are responsible for differing charges.

Horace R. Drew (2002) in *A Periodic Structural Model for the Electron Can Calculate its Intrinsic Properties to an Accuracy of Second or Third Order*, Apeiron Vol. 9, No. 4, October 2002, presents a four dimensional oscillator in two normal planes, similar to what is presented later here, with the difference that he locks the two oscillators in a 2:1 ratio.

Richard Wayte (2010) in *A Model of the Electron* presents a toroidal model where the major and minor radii are proportional to the fine structure constant. `http://vixra.org/pdf/1007.0055v1.pdf`

# Luminal Parson Ring Model of the Electron

The Parson ring (circa 1915) modelled the electron as a spinning filament, predicting magnetic moments and magnetic interactions as a method of explaining chemical bonding. This is string theory long before modern string theory. Most adherents of the Parson ring *assume* luminal ring speed. I show that luminal speed, instead of being a nice ad hoc assumption, eliminates the infinities associated with point source electron models. For a non-singular theory, luminal speed is a requirement, and will likely be enforced by the singularities above and below light speed for this classical ring.

## Electric Potential of a Charged Ring

$$\begin{aligned} V(\rho, \phi, z) &= \frac{q}{2\pi^2\epsilon} \frac{1}{\sqrt{(R+\rho)^2 + z^2}} K(k) \\ k &= \sqrt{\frac{4\rho R}{(\rho + R)^2 + z^2}} \end{aligned}$$

This has an infinity at $z = 0$, $\rho = R$ on the charged ring itself, due to $K(k = 1) = \infty$. $K(k)$ is the complete elliptic integral of the first kind.

## Vector Potential of a Current Loop

The magnetic vector potential $A_\phi$ for a current $I$ at $z = 0, \rho = R$ is

$$A_\phi(\rho, \phi, z) = \frac{\mu I}{2\pi} \frac{\sqrt{z^2 + (\rho + R)^2}}{\rho} \left[ \left( \frac{z^2 + \rho^2 + R^2}{z^2 + (\rho + R)^2} \right) K(k) - E(k) \right]$$

Once again, this has an infinity at $z = 0$, $\rho = R$ on the charged ring itself, due to $K(k = 1) = \infty$.

## Infinities Cancel at Speed $c$

The combined electrodynamic field experienced by the charge is $V - \vec{v} \cdot \vec{A}$, where the first term is the voltage due to electrostatic charges, and the second term is generator term due to motion in a magnetic field. Both terms will have singularities at $k = 1$ which occurs on the ring at $r = R, z = 0$. These singularities are due to $K(1) = \infty$. Our plan is to find where these singularities from the electrostatic and magnetic terms cancel each other. The well behaved function $E(k)$ has no singularities, and has $E(1) = 1$.

$$
\begin{aligned}
V - \vec{v} \cdot \vec{A} \quad = \quad & \frac{q}{2\pi^2\epsilon} \frac{1}{\sqrt{(R+\rho)^2 + z^2}} K(k) \\
& - \frac{\mu v I}{2\pi} \frac{\sqrt{z^2 + (\rho + R)^2}}{\rho} \left[ \left( \frac{z^2 + \rho^2 + R^2}{z^2 + (\rho + R)^2} \right) K(k) - E(k) \right]
\end{aligned}
$$

The singularity only occurs on the ring itself. To reduce the math, we can set $z = 0$ and $\rho = R$. We specialize to

$$
\begin{aligned}
V - \vec{v} \cdot \vec{A} \quad &= \quad \frac{q}{2\pi^2\epsilon} \frac{1}{\sqrt{(2R)^2}} K(k) \\
& \quad - \frac{\mu v I}{2\pi} \frac{\sqrt{(2R)^2}}{R} \left[ \left( \frac{2R^2}{(2R)^2} \right) K(k) - E(k) \right] \\
&= \quad \frac{q}{4R\pi^2\epsilon} K(k) - \frac{\mu v I}{\pi} \left[ \left( \frac{1}{2} \right) K(k) - E(k) \right] \\
&= \quad K(k) \left[ \frac{q}{4R\pi^2\epsilon} - \frac{\mu v I}{2\pi} \right] - E(k) \left[ \frac{\mu v I}{\pi} \right]
\end{aligned}
$$

To kill the singularity at $K(k = 1)$ requires the factor of $K$ to go to zero.

$$
\left[ \frac{q}{4R\pi^2\epsilon} - \frac{\mu v I}{2\pi} \right] \quad = \quad 0
$$

or

$$
\frac{q}{4R\pi^2\epsilon} \quad = \quad \frac{\mu v I}{2\pi}
$$

The current due to a circulating ring is $I = qv/2\pi R$, so

$$
\begin{aligned}
\frac{q}{4R\pi^2\epsilon} &= \frac{\mu v I}{2\pi} \\
I &= \frac{qv}{2\pi R} \\
\frac{q}{4R\pi^2\epsilon} &= \frac{\mu q v^2}{4\pi^2 R} \\
v^2 &= \frac{1}{\mu\epsilon} \\
v^2 &= c^2 \\
v &= \pm c
\end{aligned}
$$

We see that the criteria for elimination of infinities, is simply that the ring *must* rotate at $c$. I suggest the $\pm$ corresponds to clockwise or counter-clockwise current choices.

While we have accelerated charges, no radiation occurs due to the stationary configuration of this system, which looks the same at all points in time. However, should we accelerate this ring, stationarity will be lost, and radiation (or absorption) must occur.

Given that the ring rotates at $c$, it is now trivial to find the effective potential at the ring. On the ring, we have $z = 0$, $\rho = R$, $k = 1$, and $E(1) = 1$.

$$
\begin{aligned}
V - \vec{v} \cdot \vec{A} &= K(k)\left[\frac{q}{4R\pi^2\epsilon} - \frac{\mu v I}{2\pi}\right] - E(k)\left[\frac{\mu v I}{\pi}\right] \\
&= -\frac{\mu c I}{\pi} \\
&= -\frac{\mu c^2 q}{2\pi^2 R} \\
&= -\frac{q}{2\epsilon\pi^2 R}
\end{aligned}
$$

The ring charge times this potential becomes one source of rest mass for the electron.

## Problems with the Parson Ring Model

The primary problem with the Parson ring model, aside from electrons showing no structure over $10^{-20}$m, is conflicting values for radius, between electrostatic energy estimates versus magnetic moment from current loop estimates.

### Estimate $R$ from Mass

Given a rest mass of 511 keV, we find the estimate for radius.

$$\begin{aligned} 511\text{keV} &= \frac{q}{2\epsilon\pi^2 R} \\ R &= \frac{q}{2\epsilon\pi^2 * 511\text{keV}} \\ &= 1.79 \times 10^{-15}\text{m} \end{aligned}$$

which compares with the classical electron radius of $2.818 \times 10^{-15}$ m.

### Estimate $R$ from Magnetic Moment

The electron has an intrinsic magnetic moment, measured at $9.274 \times 10^{-24}$J/T. Modelling this as a current loop, we can estimate a radius for this loop.

$$\begin{aligned} \mu &= I * Area = \frac{qc}{2\pi R}\pi R^2 = \frac{qcR}{2} \\ R &= \frac{2\mu}{qc} = 3.859 \times 10^{-13} = 137.04 * 2.816 \times 10^{-15} \end{aligned}$$

This calculated radius is too big compared to the classical electron radius by the inverse of the fine structure constant, yet too small for the Bohr radius for hydrogen the same inverse fine structure constant.

This radius is also the same number found using the de Broglie frequency for the electron, for an electron travelling at $c$ in a circular path at the de Broglie frequency.

### Hope for an Enhanced Model

These greatly differing estimates for electron geometry led to the dismissal of this model in favor of standard quantum mechanics. I hope to resurrect some consideration of an extended model, which in 3D looks like a torus, with the major radius defining the macroscopic magnetic moment, and the minor radius defining the bulk of the self-energy (mass) of the electron.

Before discussing the enhanced Parson model, we need to discuss rotations in two versus four dimensions, as well as curve description using pathlength and intrinsic curvatures.

## Rotations in Two and Three Dimensions

In two and three dimensions, we have only one plane supporting rotation.

The defining characteristic of a rotation is a coordinate transformation where the distance from a point remains unchanged. In two dimensions, we usually use polar coordinates $r$ and $\theta$, with the center of rotation at the origin. For time changing behavior, we use an angular speed $\omega = d\theta/dt$.

Here are some relationships for a rotating coordinate system using time, frequency, radial position as well as $x$ and $y$ coordinates.

$$
\begin{aligned}
\theta &= \int \omega dt \\
r &= \sqrt{x^2 + y^2} \\
x &= r\cos\theta = r\cos(\omega t) \\
y &= r\sin\theta = r\sin(\omega t) \\
\vec{a}_r &= \vec{a}_x \cos(\omega t) + \vec{a}_y \sin(\omega t) \qquad \text{unit radial vector} \\
\vec{a}_\theta &= -\vec{a}_x \sin(\omega t) + \vec{a}_y \cos(\omega t) \qquad \text{unit azimuthal vector} \\
\frac{d\vec{a}_r}{dt} &= \omega \vec{a}_\theta \\
\frac{d\vec{a}_\theta}{dt} &= -\omega \vec{a}_r \\
\vec{\omega} &= \omega \vec{a}_z \qquad \text{cylindrical 3D coordinates}
\end{aligned}
$$

Using polar coordinates, a moving particle has a velocity and acceleration given by

$$
\begin{aligned}
\vec{v} &= \frac{d\vec{r}}{dt} = \frac{d}{dt}\left(r\vec{a}_r\right) \\
&= \frac{dr}{dt}\vec{a}_r + r\omega\vec{a}_\theta = \frac{dr}{dt}\vec{a}_r + \vec{\omega}\times\vec{r} \\
\vec{a} &= \frac{d^2r}{dt^2}\vec{a}_r + 2\frac{dr}{dt}\omega\vec{a}_\theta - \omega^2 r\vec{a}_r
\end{aligned}
$$

The Merry-Go-Round is a nice example of a rotating coordinate system. We have a center of rotation at the axle, and with the Merry-Go-Round turning, physics clearly distinguishes radial versus azimuthal coordinates for the passengers on the turntable.

As a dragged frame, the turntable is a non-inertial frame of reference. Relationships between the moving frame, as seen by passengers, versus an inertial frame (fixed star reference) are

$$
\begin{aligned}
\frac{d}{dt} &= \left(\frac{D}{dt} + \vec{\omega}\times\right) \\
\frac{d\vec{r}}{dt} &= \vec{v} = \frac{D\vec{r}}{dt} + \vec{\omega}\times\vec{r} \\
\frac{d\vec{v}}{dr} &= \vec{a} = \frac{D^2\vec{a}}{dt^2} + 2\left(\vec{\omega}\times\frac{D\vec{r}}{dt}\right) + \vec{\omega}\times\left(\vec{\omega}\times\vec{r}\right) + \frac{d\vec{\omega}}{dt}\times\vec{r}
\end{aligned}
$$

where the capital D indicates derivatives in the moving frame of reference.

A general principle to mention here, is that the most generic differential motion can be broken into scaling (diagonal matrix terms), shearing (symmetric matrix terms) and twisting (anti-symmetric matrix term) components. In two and three dimensions, we can express the anti-symmetric portion with a cross product, and the symmetric part looks like translation and scaling. In four dimensions, we can extend the cross product using quaternions, or simply use matrix transformations.

As we move to three dimensions, we often use cylindrical coordinates, which blend a plane described by polar coordinates with a z axis.

For spherical coordinates, we use two angles, one being the deviation from the z axis $\phi$, and the other angle being planar deviation from $x$ being $\theta$.

$$
\begin{aligned}
z &= r\cos(\phi) \\
y &= r\sin(\phi)\sin(\theta) \\
x &= r\sin(\phi)\cos(\theta) \\
r &= \sqrt{x^2+y^2+z^2} \\
\theta &= \tan^{-1}\left(\frac{y}{x}\right) \\
\phi &= \tan^{-1}\left(\frac{\sqrt{x^2+y^2}}{z}\right) = \cos^{-1}\left(\frac{z}{r}\right)
\end{aligned}
$$

**Intrinsic Coordinates Parameterized by Pathlength**

One dimensional curves are specified by distance $s$ (deviation from a point). Lines have infinite extent.

Plane curves can be specified using simple curvature $\kappa$ (deviation from a line) and arclength $s$. The curve of constant curvature is the circle. The circle has a maximum, finite extent.

For three dimensional curves, we use curvature $\kappa$, torsion (deviation from a plane) $\tau$, and arclength $s$. The curve of constant curvature and torsion is the spiral. The spiral, like the line, has infinite extent.

For four dimensions, we use curvature $\kappa$, torsion $\tau$, lift $\gamma$ and arclength $s$. In four dimensions, the curve of constant curvature, torsion and lift is a Clifford Sphere, which is finite extent object.

In even dimensional spaces, trajectories with constant curvatures form compact objects, such as circles and Clifford Sphere. In odd dimensions, we have infinite extention for the highest curvature, such as distance with the line and torsion with the spiral.

# Rotations in Four and Five Dimensions

As we transition from three to four dimensions, we find a new normal plane capable of supporting rotation.

## Bicylindrical Coordinates Easily Reveal Dual Rotations

As an illustration of dual rotations, choose the xy and zt planes for the planes of rotation. The following equations describe independent rotations in these two zones. Radii and frequencies do not need to match between the two plane sets. This setup is called four dimensional bicylindrical coordinates. Our four variables become $r_1, \theta, r_2$ and $\phi$. The two cylindrical systems are totally normal to each other.

$$\begin{aligned} x &= r_1 \cos(\theta) \\ y &= r_1 \sin(\theta) \\ z &= r_2 \cos(\phi) \\ t &= r_2 \sin(\phi) \\ r &= \sqrt{x^2 + y^2 + z^2 + t^2} = \sqrt{r_1^2 + r_2^2} \end{aligned}$$

We have $r$, $r_1$ and $r_2$ constant regardless of rotations in $\theta$ and $\phi$ directions.

## Polar Coordinates Obscure Dual Rotations

We can define four dimensional coordinates with an analog of polar coordinates. Our four variables are $r, \psi, \phi$, and $\theta$.

$$\begin{aligned} t &= r \cos(\psi) \\ z &= r \sin(\psi) \cos(\phi) \\ y &= r \sin(\psi) \sin(\phi) \cos(\theta) \\ x &= r \sin(\psi) \sin(\phi) \sin(\theta) \\ r &= \sqrt{x^2 + y^2 + z^2 + t^2} \end{aligned}$$

These coordinates work well for spherical problems, but do not as easily reveal dual rotation as the dual cylindrical coordinate set.

## Curves of Constant Curvature, Torsion and Lift

For this discussion, I will be able to describe the path using pathlength as a parameter, and two radii as well as two angular positions. Eliminating time as a parameter is important, as it is necessary to eliminate infinities in velocity and acceleration which occur at turning points in time, where $dt = 0$.

$$\begin{aligned} x &= r_1 \cos(\omega_1 s) \\ y &= r_1 \sin(\omega_1 s) \\ z &= r_2 \cos(\omega_2 s) \\ t &= r_2 \sin(\omega_2 s) \end{aligned}$$

Curves of constant curvature, torsion and lift trace curves on the surface of a hypersphere with fixed radius.

$$R^2 = \frac{\tau^2 + \gamma^2}{\kappa^2 \gamma^2}$$

The trajectory parameterized by pathlength (self-history) has two frequency components and two orthogonal radii.

$$\begin{aligned} \omega_1 &= \frac{1}{\sqrt{2}} \sqrt{(\kappa^2 + \tau^2 + \gamma^2) + \sqrt{(\kappa^2 + \tau^2 + \gamma^2)^2 - 4\kappa^2\gamma^2}} \\ \omega_2 &= \frac{1}{\sqrt{2}} \sqrt{(\kappa^2 + \tau^2 + \gamma^2) - \sqrt{(\kappa^2 + \tau^2 + \gamma^2)^2 - 4\kappa^2\gamma^2}} \end{aligned}$$

$$\begin{aligned} r_1 &= \frac{\sqrt{(\kappa^2 - \omega_2^2)^2 + \kappa^2\tau^2}}{\omega_1 (\omega_1^2 - \omega_2^2)} = \frac{1}{\omega_1} \sqrt{\frac{\kappa^2 - \omega_2^2}{\omega_1^2 - \omega_2^2}} \\ r_2 &= \frac{\sqrt{(\kappa^2 - \omega_1^2)^2 + \kappa^2\tau^2}}{\omega_2 (\omega_1^2 - \omega_2^2)} = \frac{1}{\omega_2} \sqrt{\frac{\omega_1^2 - \kappa^2}{\omega_1^2 - \omega_2^2}} \end{aligned}$$

We have the relationship

$$(r_1\omega_1)^2 + (r_2\omega_2)^2 = 1$$

The product of these two frequencies the also the product of curvature and lift

$$\omega_1 * \omega_2 = \kappa\gamma$$

The ratio of these two frequencies is usually not a rational number.

$$\frac{\omega_1}{\omega_2} = \frac{(\kappa^2+\tau^2+\gamma^2)+\sqrt{\left(\kappa^2+\tau^2+\gamma^2\right)^2-4\kappa^2\gamma^2}}{2\kappa\gamma}$$

Consequently, the curve usually covers a band on the foursphere. However, for specific values of curvature, torsion and lift, we can have the two frequencies harmonically locked, resulting in a filament, rather than a surface on the the foursphere.

Since the curves of constant curvature and lift orbit at two radii and frequencies in orthogonal planes, we can write formulas relating curvatures, radii and frequency.

$$\begin{aligned}
1 &= r_1^2\omega_1^2 + r_2^2\omega_2^2 \\
\kappa^2 &= r_1^2\omega_1^4 + r_2^2\omega_2^4 \\
\tau^2 &= \frac{1}{\kappa^2}\left[\left(\kappa^2-\omega_1^2\right)^2(r_1\omega_1)^2 + \left(\kappa^2-\omega_2^2\right)^2(r_2\omega_2)^2\right] \\
\gamma^2 &= \frac{\left(\kappa^2+\tau^2-\omega_1^2\right)^2}{\kappa^2\tau^2} r_1^2\omega_1^4 + \frac{\left(\kappa^2+\tau^2-\omega_2^2\right)^2}{\kappa^2\tau^2} r_2^2\omega_2^4
\end{aligned}$$

Given three curvatures, we can calculate frequencies, then radii, and we can then align our coordinates system for easy calculation of our basis vectors.

$$\begin{aligned}
x &= r_1\cos(\omega_1 s) \\
y &= r_1\sin(\omega_1 s) \\
z &= r_2\cos(\omega_2 s) \\
t &= r_2\sin(\omega_2 s)
\end{aligned}$$

$$\begin{aligned}
\tilde{u} &= \frac{d\tilde{r}}{ds} \\
u_x &= -r_1\omega_1\sin(\omega_1 s) \\
u_y &= r_1\omega_1\cos(\omega_1 s) \\
u_z &= -r_2\omega_2\sin(\omega_2 s) \\
u_t &= r_2\omega_2\cos(\omega_2 s)
\end{aligned}$$

$$
\begin{aligned}
\tilde{n} &= \frac{1}{\kappa}\frac{d\tilde{u}}{ds} \\
n_x &= \left(-r_1\omega_1^2/\kappa\right)\cos(\omega_1 s) \\
n_y &= \left(-r_1\omega_1^2/\kappa\right)\sin(\omega_1 s) \\
n_z &= \left(-r_2\omega_2^2/\kappa\right)\cos(\omega_2 s) \\
n_t &= \left(-r_2\omega_2^2/\kappa\right)\sin(\omega_2 s)
\end{aligned}
$$

$$
\begin{aligned}
\tilde{b} &= \frac{1}{\tau}\left(\frac{d\tilde{n}}{ds} + \kappa\tilde{u}\right) \\
b_x &= \left[\left(r_1\omega_1^3/\kappa - \kappa\omega_1 r_1\right)/\tau\right]\sin(\omega_1 s) \\
b_y &= \left[\left(-r_1\omega_1^3/\kappa + \kappa\omega_1 r_1\right)/\tau\right]\cos(\omega_1 s) \\
b_z &= \left[\left(r_2\omega_2^3/\kappa - \kappa\omega_2 r_2\right)/\tau\right]\sin(\omega_2 s) \\
b_t &= \left[\left(-r_2\omega_2^3/\kappa + \kappa\omega_2 r_2\right)/\tau\right]\cos(\omega_2 s)
\end{aligned}
$$

$$
\begin{aligned}
\tilde{w} &= \frac{1}{\gamma}\left(\frac{d\tilde{b}}{ds} + \tau\tilde{n}\right) \\
w_x &= \left[\left(\left[\left(r_1\omega_1^4/\kappa - \kappa\omega_1^2 r_1\right)/\tau\right] - \tau\omega_1^2 r_1/\kappa\right)/\gamma\right]\cos(\omega_1 s) \\
w_y &= \left[\left(\left[\left(r_1\omega_1^4/\kappa - \kappa\omega_1^2 r_1\right)/\tau\right] - \tau\omega_1^2 r_1/\kappa\right)/\gamma\right]\sin(\omega_1 s) \\
w_z &= \left[\left(\left[\left(r_2\omega_2^4/\kappa - \kappa\omega_2^2 r_2\right)/\tau\right] - \tau\omega_2^2 r_2/\kappa\right)/\gamma\right]\cos(\omega_2 s) \\
w_t &= \left[\left(\left[\left(r_2\omega_2^4/\kappa - \kappa\omega_2^2 r_2\right)/\tau\right] - \tau\omega_2^2 r_2/\kappa\right)/\gamma\right]\sin(\omega_2 s)
\end{aligned}
$$

In fourspace, most curves of constant curvatures will form a hyper torus, as the trajectories do not overlay each other. Figure 1 shows a tracing of a $\kappa = 1, \tau = 1, \gamma = 1$ curve.

By contrast, certain combinations of curvatures, as seen in Figure 2, will retrace and overlay, resulting in what I call ‘potato chip curves.’

To obtain the filamentary curves, we find we need harmonic relationships among the frequencies. We find the condition for harmonic solution to be that, for integral values for $\kappa$, $\tau$ and $\gamma$, that $\sqrt{\left(\kappa^2 + \tau^2 + \gamma^2\right)^2 - 4\kappa^2\gamma^2}$ be an integer, or that $(\kappa^2 + \tau^2 + \gamma^2)$ be the hypotenuse of a Pythagorean triple, with $2\kappa\gamma$ being one of the sides.

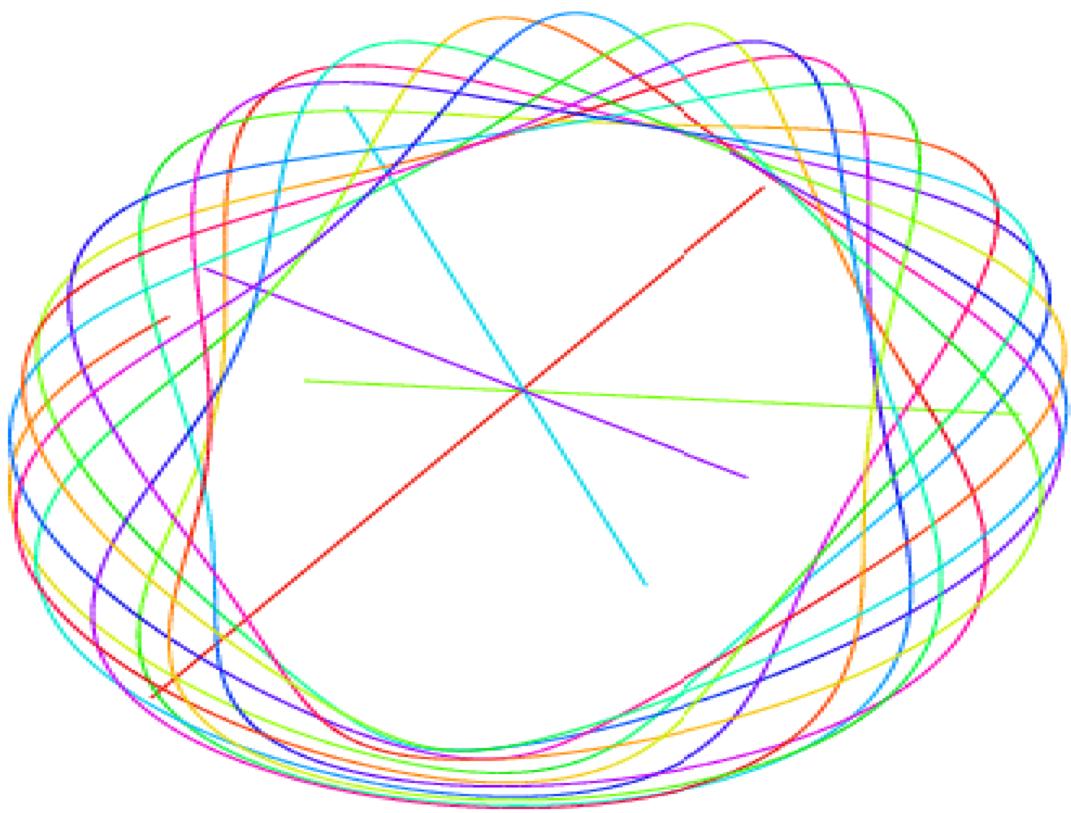

Figure 1: $\kappa = 1, \tau = 1, \gamma = 1$ Curve

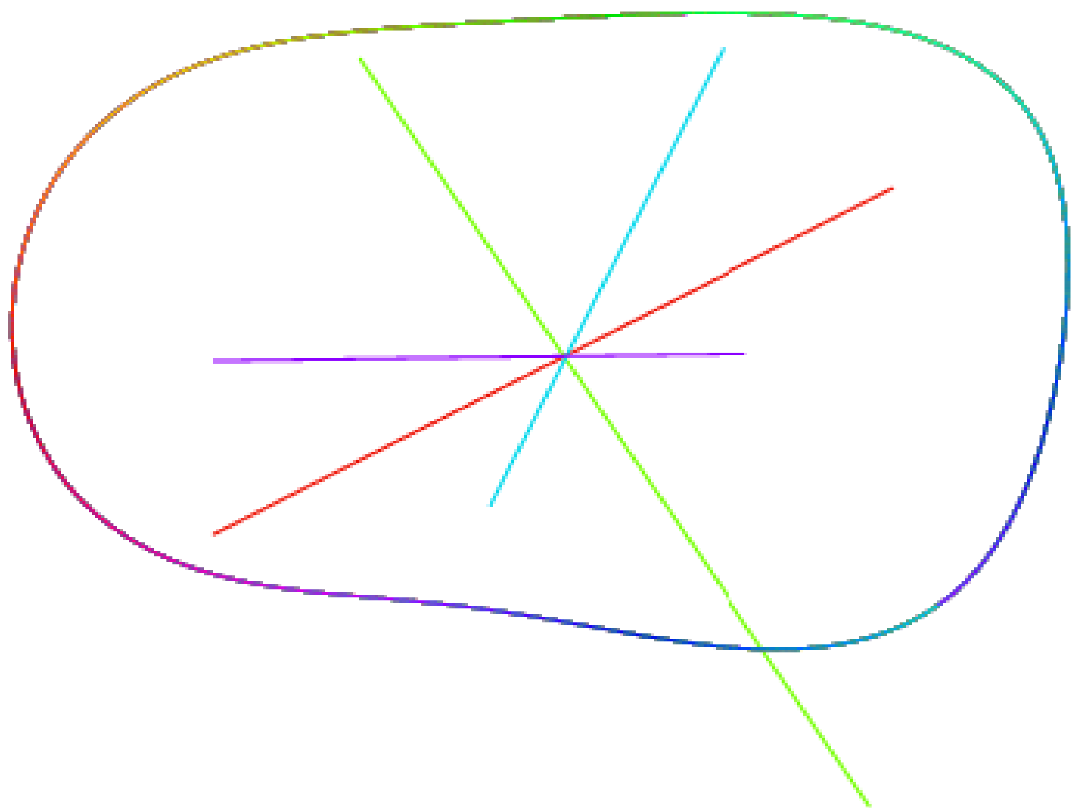

Figure 2: $\kappa = 3, \tau = 4, \gamma = 5$ Curve

# Enhanced Parson Ring Model

With all the previous discussion out of the way, I propose a simple extension of the Parson Ring model. I have a four dimensional oscillator with the major radius determining the magnetic moment of the electron, and the minor radius determining the internal electrostatic energy of the electron. Our two conflicting estimates are resolved by becoming two different parameters. My toy model with constant curvatures reflects an isolated electron non-interacting with itself or others. In practice, I expect the curvatures to vary during interactions, but that is a later effort.

## Three Space Plus Time Experience

Assume such an electron is measured, localizing its position in spacetime. As this electron advances along its worldline (internal pathlength $s$), it will begin to pierce our point in time, and appear first as a negative going electron (positron), then as a forward going electron, present for an infinitesimal point of time, at a spatial coordinate given by its internal evolution. These instances, I assert, are virtual particles. As the observor's time increases from the time of measurement and localization, the average electron position becomes smeared out, and the electron cloud model becomes more appropriate. In modelling this time and space travelling electron, we will likely find DeBroglie/Bohm statistical mechanics for a single particle useful.

# Implications of the Black Hole Model for Our Local Universe

The black hole model for our local universe models our universe as the membrane of a black hole in a five dimensional space. This is a time-centric point of view, requiring all particles on this membrane to travel at lightspeed, with curved paths. The Parson ring model, with the enforcement of lightspeed, is consistent with this model.

## Constant Angular Momentum and Superfluids

Changing a point of view, with time becoming just another axis, the requirement of lightspeed becomes simply a statement that trajectory slopes maintain a constant angle with respect to the time axis, while varying in the other dimensions. This is very reminiscent of precession about a gyroscope axis. The rotations, in turn, are related to the anti-symmetric terms in transformation matrices mentioned earlier. Given that black holes leak information very slowly, we can treat our space as having zero viscosity or superfluid characteristics over the short term. Under these conditions, angular momentum density is a hard conservation, spin vortices will persist, and our quantum of spin may simply reflect the initial conditions for our local black hole universe.

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