Electromagnetic Soliton Theory

an excerpt from

A Novel Constructive Electromagnetic Quantum Theory describes the Origin of Mass and Unifies the Forces.

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Ryde, United Kingdom

September 29, 2023

Presentation to the

International Seminar-Type Online Workshop on

Topological Solitons

Slide 2: What is a wave? (The d'Alembert wave equation)

Towne[1] states that the requirement for a physical condition to be referred to as a wave, is that its mathematical representation give rise to a partial differential equation of particular form, known as the wave equation. The classical form

$$\frac{\partial^2 w}{\partial p^2} - \frac{1}{u^2}\frac{\partial^2 w}{\partial t^2} = 0 \qquad \text{or} \qquad \nabla^2 w - \frac{1}{u^2}\frac{\partial^2 w}{\partial t^2} = 0.$$

was proposed in 1748 by d'Alembert for a one-dimensional continuum. A decade later, Euler established the equation for the three-dimensional continuum.

A pendulum is described by the pendulum equation

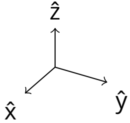
$$\frac{\partial^2 \theta}{\partial t^2} + \frac{g}{l} = 0$$

is not a wave and cannot described a soliton even if it is Lorentz boosted, *e.g.* taking the pendulum on a journey in an aeroplane. A pendulum equation does not, and will never describe *displacement* motion.

1 Dudley H. Towne. *Wave phenomena*. New York: Dover Publications, 1988.

Slide 3: Three orthogonal vectors in an Euclidean reference system

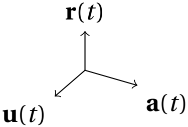
The reference system whose axis are the unit vectors $\hat{x}, \hat{y}$ and $\hat{z}$



is defined by:

$$\hat{x}\cdot\hat{y}=0 \qquad \hat{y}\cdot\hat{z}=0 \qquad \hat{z}\cdot\hat{x}=0$$
$$\hat{x}\times\hat{y}=\hat{z} \qquad \hat{y}\times\hat{z}=\hat{x} \qquad \hat{z}\times\hat{x}=\hat{y}$$

Consider three orthogonal vectors of function of time



gives:

$$\mathbf{u}\cdot\mathbf{a}=0 \qquad \mathbf{a}\cdot\mathbf{r}=0 \qquad \mathbf{r}\cdot\mathbf{u}=0$$
$$\mathbf{u}\times\mathbf{a}=\mathbf{r} \qquad \mathbf{a}\times\mathbf{r}=\mathbf{u} \qquad \mathbf{r}\times\mathbf{u}=\mathbf{a}$$

Next consider the indefinite series

$$\mathbf{z}_1=\mathbf{u}_0\times\mathbf{a}_0,\ \mathbf{u}_1=\mathbf{a}_0\times\mathbf{r}_1,\ \mathbf{a}_1=\mathbf{r}_1\times\mathbf{u}_1,\ \mathbf{r}_2=\mathbf{u}_1\times\mathbf{a}_1\ \ldots\ \mathbf{r}_n=\mathbf{u}_{n-1}\times\mathbf{a}_{n-1}\ \ldots\ \ldots$$

and what needs to be done so that $\mathbf{u}_0=\mathbf{u}_n,\ \mathbf{a}_0=\mathbf{a}_n,\ \mathbf{r}_0=\mathbf{r}_n$ to give us a simultaneous vector cross product equation set which has defined solutions?

Slide 4: Theorem: The Soliton Equation System

We introduce normalisation: $\mathbf{u} = \dfrac{1}{\|\mathbf{a}\|^2}\mathbf{a}\times\mathbf{r}, \quad \mathbf{a} = \dfrac{1}{\|\mathbf{u}\|^2}\mathbf{r}\times\mathbf{u}, \quad \mathbf{r} = \mathbf{u}\times\mathbf{a}$

Theorem 1: The soliton equation system. *In a space $\mathbb{C}^3$ the system of simultaneous equations*

$$\mathcal{M}(\mathbf{u},\mathbf{a},\mathbf{r}) \xrightarrow{\textit{defines}} \left\{\mathbf{u} = \frac{1}{\mathbf{a}\cdot\mathbf{a}^*}\mathbf{a}\times\mathbf{r}, \quad \mathbf{a} = \frac{1}{\mathbf{u}\cdot\mathbf{u}^*}\mathbf{r}\times\mathbf{u}, \quad \mathbf{r} = \mathbf{u}\times\mathbf{a}\right\}$$

defines the motion of a soliton characterised by a velocity vector $\mathbf{u}(t)$ and two co-orthogonal vectors $\mathbf{a}(t)$ and $\mathbf{r}(t)$ that describe the disturbance in a homogenous and isotropic medium.

Here the vector quantities $\mathbf{u}$, $\mathbf{a}$ and $\mathbf{r}$ are complex vectors, for example
$\mathbf{a} = \hat{x}\,a_x e^{i\alpha_x} + \hat{y}\,a_y e^{i\alpha_y} + \hat{z}\,a_z e^{i\alpha_z} \qquad \mathbf{a}^* = \hat{x}\,a_x e^{-i\alpha_x} + \hat{y}\,a_y e^{-i\alpha_y} + \hat{z}\,a_z e^{-i\alpha_z}$
therefore $\mathbf{a}\cdot\mathbf{a}^* = a_x^2 + a_y^2 + a_z^2 = a^2 = \|\mathbf{a}\|^2$

Slide 5: Proof: $\left\{\mathbf{u}=\mathbf{a}\times\mathbf{r}/\mathbf{a}\cdot\mathbf{a}^*, \quad \mathbf{a}=\mathbf{r}\times\mathbf{u}/\mathbf{u}\cdot\mathbf{u}^*, \quad \mathbf{r}=\mathbf{u}\times\mathbf{a}\right\}$ describes a soliton.

Performing a 'left and right side' curl operation on the second and third equations of the equation-set gives

$$\nabla\times\mathbf{a}=\frac{1}{\mathbf{u}\cdot\mathbf{u}^*}\nabla\times(\mathbf{r}\times\mathbf{u}) \quad \text{and} \quad \nabla\times\mathbf{r}=\nabla\times(\mathbf{u}\times\mathbf{a}) \tag{1}$$

and to evaluate the vector triple products we use general vector analytic methods to give

$$\nabla\times(\mathbf{r}\times\mathbf{u})=\mathbf{r}(\nabla\cdot\mathbf{u})-\mathbf{u}(\nabla\cdot\mathbf{r})+(\mathbf{u}\cdot\nabla)\mathbf{r}-(\mathbf{r}\cdot\nabla)\mathbf{u}$$
$$\nabla\times(\mathbf{u}\times\mathbf{a})=\mathbf{u}(\nabla\cdot\mathbf{a})-\mathbf{a}(\nabla\cdot\mathbf{u})+(\mathbf{a}\cdot\nabla)\mathbf{u}-(\mathbf{u}\cdot\nabla)\mathbf{a}.$$

Because the vectors **a** and **r** are position independent (from theorem: vectors $\mathbf{a}(t)$ and $\mathbf{r}(t)$ describe the disturbance in a homogenous and isotropic medium., therefore we have

$$\nabla\cdot\mathbf{a}=0 \quad \text{and} \quad \nabla\cdot\mathbf{r}=0. \tag{2}$$

Slide 6: Proof: $\{\mathbf{u} = \mathbf{a}\times\mathbf{r}/\mathbf{a}\cdot\mathbf{a}^*,\quad \mathbf{a}=\mathbf{r}\times\mathbf{u}/\mathbf{u}\cdot\mathbf{u}^*,\quad \mathbf{r}=\mathbf{u}\times\mathbf{a}\}$ describes a soliton.

$$\nabla\times(\mathbf{r}\times\mathbf{u}) = \mathbf{r}(\nabla\cdot\mathbf{u}) - \cancel{\mathbf{u}(\nabla\cdot\mathbf{r})} + (\mathbf{u}\cdot\nabla)\mathbf{r} - (\mathbf{r}\cdot\nabla)\mathbf{u}$$

$$\nabla\times(\mathbf{u}\times\mathbf{a}) = \cancel{\mathbf{u}(\nabla\cdot\mathbf{a})} - \mathbf{a}(\nabla\cdot\mathbf{u}) + (\mathbf{a}\cdot\nabla)\mathbf{u} - (\mathbf{u}\cdot\nabla)\mathbf{a}.$$

Evaluating the terms containing $\mathbf{u} = \hat{x}\,\partial x/\partial t + \hat{y}\,\partial y/\partial t + \hat{z}\,\partial z/\partial t$ we obtain

$$\mathbf{u}\cdot\nabla = \nabla\cdot\mathbf{u} = \frac{\partial x}{\partial t}\frac{\partial}{\partial x} + \frac{\partial y}{\partial t}\frac{\partial}{\partial y} + \frac{\partial z}{\partial t}\frac{\partial}{\partial z} = \frac{\partial}{\partial t}$$

Because $\mathbf{a}(\mathbf{u}\cdot\nabla) = \mathbf{a}\,\partial 1/\partial t = 0$, we are left with

$$\nabla\times(\mathbf{u}\times\mathbf{a}) = -\frac{\partial\mathbf{a}}{\partial t} \quad\text{and}\quad \nabla\times(\mathbf{r}\times\mathbf{u}) = \frac{\partial\mathbf{r}}{\partial t}.$$

Therefore, the ‘left and right side’ curl operations (1) generate the new relations:

$$\nabla\times\mathbf{a} = \frac{1}{u^2}\frac{\partial\mathbf{r}}{\partial t} \quad\text{and}\quad \nabla\times\mathbf{r} = -\frac{\partial\mathbf{a}}{\partial t} \tag{3}$$

Slide 7: Proof: $\left\{\mathbf{u} = \mathbf{a}\times\mathbf{r}/\mathbf{a}\cdot\mathbf{a}^*, \quad \mathbf{a} = \mathbf{r}\times\mathbf{u}/\mathbf{u}\cdot\mathbf{u}^*, \quad \mathbf{r} = \mathbf{u}\times\mathbf{a}\right\}$ describes a soliton.

Therefore, the ‘left and right side’ curl operations generate the new relations:

$$\nabla\times\mathbf{a} = \frac{1}{u^2}\frac{\partial\mathbf{r}}{\partial t} \quad \text{and} \quad \nabla\times\mathbf{r} = -\frac{\partial\mathbf{a}}{\partial t} \tag{3}$$

A further ‘left and right side’ curl operation on (3) gives

$$\nabla\times\nabla\times\mathbf{r} = -\frac{\partial(\nabla\times\mathbf{a})}{\partial t} \quad \text{and} \quad \nabla\times\nabla\times\mathbf{a} = \frac{1}{u^2}\frac{\partial(\nabla\times\mathbf{r})}{\partial t}$$

and because $\nabla\times\nabla\times\mathbf{r} = \nabla(\nabla\cdot\mathbf{r}) - \nabla^2\mathbf{r}$ we recover the d’Alembert wave equations

$$\nabla^2\mathbf{r} - \frac{1}{u^2}\frac{\partial^2\mathbf{r}}{\partial t^2} = 0 \quad \text{and} \quad \nabla^2\mathbf{a} - \frac{1}{u^2}\frac{\partial^2\mathbf{a}}{\partial t^2} = 0. \tag{4}$$

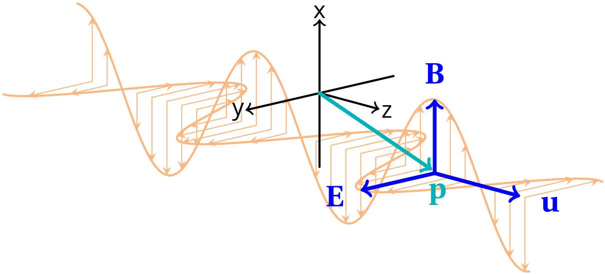
This concludes the proof that the three vector algebraic equations of $\mathcal{M}$ give rise to the d’Alembert wave equations (4). Therefore, the equation set $\mathcal{M}$ is a generic bimodal-transverse soliton equation system. □

Slide 8: One Plane of an Electromagnetic Wave

$\mathcal{M}(\mathbf{u},\mathbf{B},\mathbf{E})$ recovers the Maxwell equations in vacuum

from (2): $\nabla\cdot\mathbf{B}=0$ $\qquad$ $\nabla\cdot\mathbf{E}=0$

from (3): $\nabla\times\mathbf{B}=\dfrac{1}{c^2}\dfrac{\partial\mathbf{E}}{\partial t}$ $\qquad$ $\nabla\times\mathbf{E}=-\dfrac{\partial\mathbf{B}}{\partial t}$



$$\left\{\ \mathbf{E}=\mathbf{u}\times\mathbf{B},\quad \mathbf{u}=\frac{1}{\|\mathbf{B}\|^2}\mathbf{B}\times\mathbf{E},\quad \mathbf{B}=\frac{1}{\|\mathbf{u}\|^2}\mathbf{E}\times\mathbf{u}\ \right\}\qquad \mathbf{p}=\int\mathbf{u}\,\mathrm{d}t$$

Remark 1: Electrostatic *versus* Electromotive. I intentionally distinguish between

- the elementary electrostatic charge e (represented by e in italic serif font) and
- the electromotive charge $\mathscr{e}$ (represented by $\mathscr{e}$ in script font)

In the conventional interpretation of electromagnetic theory, both charges are considered equal in magnitude and are measured in units of coulombs.

Remark 2: Defining the *emflux*. As a consequence of above, we must distinguish between

- the magnetic flux ϕ (slanted ϕ) and
- the elementary magnetic momentum $\upphi$ (upright $\upphi$)

The elementary magnetic momentum $\upphi$ or its vector form $\boldsymbol{\upphi}$, which will henceforth be referred to as a magnetic emflux (magnetic electromotive flux)

Slide 10: Theorem: Elementary Electromagnetic Soliton

The equation system $\mathcal{M}$ defines a purely mathematical and a purely generical Maxwell equation system allowing us to formulate new Maxwellian like system.

Theorem 2: Elementary Electromagnetic Soliton. *There exists an elementary length denoted as* l_o *and an elementary time denoted as* t_o *defining the speed of light* c *such that* $l_o = c\,t_o.$ *Additionally, an elementary magnetic emflux* ϕ_o *represents a quantum of magnetic momentum. Furthermore, an elementary* EM*-soliton, defined by* $\mathcal{M}(\mathbf{u}, \boldsymbol{\phi}_o, \boldsymbol{\Upsilon}_o)$*, carries an elementary electromotive charge denoted as* $\mathscr{e}$ *and has action* $h,$ *whilst propagating at the speed of light.*

Here $\boldsymbol{\Upsilon}_o$ is the electric electromotive flux.

Slide 11: Proof: Elementary Electromagnetic Soliton

The proof is structured by demonstrating that the set of simultaneous equations

$$\mathcal{M}(\mathbf{u}, \boldsymbol{\phi}_o, \boldsymbol{\Upsilon}_o) \xrightarrow{\text{defines}} \left\{ \mathbf{u} = \frac{1}{\|\boldsymbol{\phi}_o\|^2} \boldsymbol{\phi}_o \times \boldsymbol{\Upsilon}_o,\ \ \boldsymbol{\phi}_o = \frac{1}{\|\mathbf{u}\|^2} \boldsymbol{\Upsilon}_o \times \mathbf{u},\ \ \boldsymbol{\Upsilon}_o = \mathbf{u} \times \boldsymbol{\phi}_o \right\}$$

together with the theorem's assertions demands the presence of ϵ_0 and μ_0 in their known forms.

Assuming that $\boldsymbol{\phi}_o \times \boldsymbol{\Upsilon}_o$ represents wave action, we multiply the equation $\mathbf{u} = (\boldsymbol{\phi}_o \times \boldsymbol{\Upsilon}_o)\|\boldsymbol{\phi}_o\|^{-2}$ by h and evaluate its norm, yielding

$$\|h\mathbf{u}\| = \left\| \frac{h}{\|\boldsymbol{\phi}_o^2\|} \boldsymbol{\phi}_o \times \boldsymbol{\Upsilon}_o \right\| \qquad \text{to give}$$

$$h = \left[\frac{h}{c\phi_o^2} \right] \Big(\|\boldsymbol{\phi}_o\| \, \|\boldsymbol{\Upsilon}_o\| \Big) \tag{5}$$

where the square brackets indicate the development of a constant.

Slide 12: Proof: Electromagnetic action

- We define the elementary EM-action as $h_e = \varrho h$, where $\varrho = 1$ C/kg
- Theorem 2 demands that e is transported at a velocity c
- Action is momentum times distance, we consider the elementary distance l_o

therefore

$$h_e = \varrho h = \kappa e c l_o \tag{6}$$

where κ is a dimensionless proportionality constant of unknown value, scaling $e c l_o$ to the EM-action h_e.

Also, Theorem 2 states that ϕ represents a quantum of magnetic momentum. Consequently, EM-action is also proportional to the product of ϕ and the distance travelled:

$$\varrho h = \chi \|\phi_o\| l_o \quad \text{combining with (6)} \quad \|\phi_o\| = \kappa e c \chi^{-1} \tag{7}$$

where χ is a physical quantity with units and scaling to be determined.

Slide 13: Proof: Permittivity and Permeability

Repeating equation (5): $h = \left[h/c\phi_o^2\right]\left(\|\boldsymbol{\phi}_o\|\,\|\boldsymbol{\Upsilon}_o\|\right)$ which we now rewrite, using $\|\boldsymbol{\phi}_o\| = \kappa e c \chi^{-1}$ and the relationship $\boldsymbol{\Upsilon}_o = \mathbf{u} \times \boldsymbol{\phi}_o$ (or $\|\boldsymbol{\Upsilon}_o\| = c\|\boldsymbol{\phi}_o\|$) giving:

$$h = \left[\frac{h}{c\phi_o^2}\right]\left[\frac{1}{\chi}\right] c^2 \kappa e \phi_o$$

We are now in a position to define the expression for $\phi_o = \dfrac{h}{\kappa e}$ but only if

$$1 = \left[\frac{h}{c\phi_o^2}\right]\left[\frac{1}{\chi}\right] c^2$$ and replacing ϕ_o gives

$$1 = \left[\frac{\kappa^2 e^2}{ch}\right]\left[\frac{1}{\chi}\right] c^2$$ which requires $\dfrac{1}{\chi} = \dfrac{h}{\kappa^2 e^2 c}$, hence

$$1 = \left[\frac{\kappa^2 e^2}{ch}\right]\left[\frac{h}{\kappa^2 e^2 c}\right] c^2 \tag{8}$$

Slide 14: Proof: Permittivity and Permeability

Equation (8), that is $1 = \left[\frac{\kappa^2 \mathscr{e}^2}{ch}\right]\left[\frac{h}{\kappa^2 \mathscr{e}^2 c}\right] c^2$ defines, purely mathematical the permittivity and permeability of the medium. These are the two constants developed mathematically and enclosed in the square brackets.

$$\epsilon_o = \frac{\kappa^2 \mathscr{e}^2}{hc} \qquad \text{and} \qquad \mu_o = \frac{h}{\kappa^2 \mathscr{e}^2 c}$$

and mapping $e \mapsto \mathscr{e}$ and setting $\kappa^{-2} = 2\alpha$ gives the accustomed

$$\epsilon_0 = \frac{e^2}{2\alpha hc} \qquad \text{and} \qquad \mu_0 = \frac{2\alpha h}{e^2 c}$$

Slide 15: The Mass Gap

Recalling $\varrho h = \kappa e l_o c$, *i.e.* (6); we are now in the position to calculate the numeric values for the elementary length and time, using $\kappa^{-2} = 2\alpha$, $\varrho = 1$ C/kg, and the 2018 CODATA values:

$\kappa = 8.277\,559\,999\,29(62)$	which I name the Heaviside constant
$l_o = 1.666\,566\,299\,11(12) \times 10^{-24}$	elementary length in metres
$t_o = 5.559\,066\,796\,49(42) \times 10^{-33}$	elementary time in seconds
$\Delta_0 = 3.683\,476\,656\,21(18) \times 10^{-66}$	mass gap in joules

where $\Delta_0 = h t_o$ is the least energy gap from a vacuum to the next lowest energy state.

Historic note: In the late 19th century Oliver Heaviside developed vector calculus, and rewrote the Maxwell works into the form commonly used today. The Heaviside constant κ is a coupling constant relating the electric charge momentum to mechanical momentum.

Slide 16: Syntax for describing solutions of $\mathcal{M}$

Introducing a new mathematical syntax, utilising a row-by-row matrix product operator $\diamond$, defined as follows:

$$\begin{pmatrix} Pa_{1,1} & Pa_{1,2} \\ Qa_{2,1} & Qa_{2,2} \end{pmatrix} = \begin{pmatrix} P \\ Q \end{pmatrix} \diamond \begin{pmatrix} a_{1,1} & a_{1,2} \\ a_{2,1} & a_{2,2} \end{pmatrix}$$

A wave or soliton ξ that is a solution of $\mathcal{M}$ is precisely defined by the three vectors $\mathbf{u}$, $\boldsymbol{\phi}_o$, and $\boldsymbol{\Upsilon}_o$, expressed in matrix form as

$$\xi \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} \mathbf{u} \\ \boldsymbol{\phi}_o \\ \boldsymbol{\Upsilon}_o \end{pmatrix} = \begin{pmatrix} c \\ \phi_o \\ c\phi_o \end{pmatrix} \diamond \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix} \begin{pmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \end{pmatrix}$$

This expression can be further simplified by considering only the parameters of interest:

$$\xi \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{pmatrix}$$

Slide 17: Solutions of $\mathcal{M}(\mathbf{u},\mathbf{a},\mathbf{r}) \xrightarrow{\text{defines}} \{\mathbf{u}=\mathbf{a}\times\mathbf{r}/\mathbf{a}\cdot\mathbf{a}^*, \quad \mathbf{a}=\mathbf{r}\times\mathbf{u}/\mathbf{u}\cdot\mathbf{u}^*, \quad \mathbf{r}=\mathbf{u}\times\mathbf{a}\}$

Electromagnetic solitons of interest are described generically:

$$\left.\begin{array}{l}
\xi_1 \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta\sin\vartheta & \cos\theta\sin\vartheta & \cos\vartheta \\ \sin\theta\cos\vartheta & -\cos\theta\cos\vartheta & \sin\vartheta \end{pmatrix} \\
\text{or} \\
\xi_2 \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} \sin\theta\cos\vartheta & -\cos\theta\cos\vartheta & \sin\vartheta \\ \cos\theta & \sin\theta & 0 \\ -\sin\theta\sin\vartheta & \cos\theta\sin\vartheta & \cos\vartheta \end{pmatrix} \\
\text{or} \\
\xi_3 \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} -\sin\theta\sin\vartheta & \cos\theta\sin\vartheta & \cos\vartheta \\ \sin\theta\cos\vartheta & -\cos\theta\cos\vartheta & \sin\vartheta \\ \cos\theta & \sin\theta & 0 \end{pmatrix}
\end{array}\right\} \text{ where } \left\{\begin{array}{l}
\theta = sn\omega_o t \\
\vartheta = \mathsf{r_z} m\omega_o t \\
\mathsf{s_a} \in \{1/2, 1, 3/2, \ldots\} \\
\mathsf{r_a} \in \{-1, 0, 1\} \\
s = \mathsf{s_a}\mathsf{r_a} \\
\mathsf{r_z} \in \{-1, 0, 1\} \\
n \in \mathbb{Q} \geq 0 \\
m \in \mathbb{Q} \geq 0
\end{array}\right.$$

Slide 18: Rotating flux vectors

We are working with rotating emflux vectors. For instance, $\boldsymbol{\phi}_\mathrm{o}$ represents a rotating vector, which we define as the source of a north-pointing elementary magnetic emflux, denoted as $\phi_\mathrm{o} = l_\mathrm{o}^2 \phi_\mathrm{o}$. Consequently, $-\boldsymbol{\phi}_\mathrm{o}$ still acts as a source of a north-pointing emflux but in the opposite direction. We are now required to introduce $\overline{\boldsymbol{\phi}}_\mathrm{o}$ as the magnetic field vector that absorbs a north-pointing emflux. This implies that $\boldsymbol{\phi}_\mathrm{o} + \overline{\boldsymbol{\phi}}_\mathrm{o} \equiv 0$, and $\boldsymbol{\phi}_\mathrm{o} - \overline{\boldsymbol{\phi}}_\mathrm{o} \equiv 2\boldsymbol{\phi}_\mathrm{o}$ if and only if $\boldsymbol{\phi}_\mathrm{o} = \hat{\mathrm{p}}\phi_\mathrm{o}$ and $\overline{\boldsymbol{\phi}}_\mathrm{o} = \hat{\mathrm{p}}\bar{\phi}_\mathrm{o}$, where $\hat{\mathrm{p}}$ represents any unit vector. Below is a visual representation of this concept where the symbol Ⓢ signifies the source or the sink:

$$\boldsymbol{\phi}_\mathrm{o} \mapsto \mathtt{S}\text{Ⓢ}\!\longrightarrow\!\mathtt{N} \quad \text{and} \quad -\boldsymbol{\phi}_\mathrm{o} \mapsto \mathtt{N}\!\longleftarrow\!\text{Ⓢ}\mathtt{S}$$
$$\overline{\boldsymbol{\phi}}_\mathrm{o} \mapsto \mathtt{N}\text{Ⓢ}\!\longleftarrow\!\mathtt{S} \quad \text{and} \quad -\overline{\boldsymbol{\phi}}_\mathrm{o} \mapsto \mathtt{S}\!\longrightarrow\!\text{Ⓢ}\mathtt{N}$$

Slide 19: Elementary EM-solitons, the *emtron*

$$\mathcal{m}_o \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \text{and} \quad \overline{\mathcal{m}}_o \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \bar{\phi}_o \\ \bar{\Upsilon}_o \end{pmatrix} \diamond \begin{pmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$\underset{\cdot}{\mathcal{m}}_o \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{pmatrix} \quad \text{and} \quad \underset{\cdot}{\overline{\mathcal{m}}}_o \xrightarrow[\text{by}]{\text{par}} \begin{pmatrix} c \\ \bar{\phi}_o \\ \bar{\Upsilon}_o \end{pmatrix} \diamond \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

The overaccented bar represents an 'anti' (where the source becomes an absorber), while the underaccented dot signifies 'contra' (indicating a 180-degree rotation). At creation the recoil reactions are:

			$\mathcal{E}$	p	ϕ_o	Υ_o
a)	$\mathcal{m}_o + \overline{\mathcal{m}}_o + \underset{\cdot}{\mathcal{m}}_o + \underset{\cdot}{\overline{\mathcal{m}}}_o$	$\Rightarrow$	4	0	0	0
b)	$\mathcal{m}_o + \overline{\mathcal{m}}_o$	$\Rightarrow$	2	0	0	2
c)	$\mathcal{m}_o + \underset{\cdot}{\overline{\mathcal{m}}}_o$	$\Rightarrow$	2	0	2	0
d)	$\mathcal{m}_o + \underset{\cdot}{\mathcal{m}}_o$	$\Rightarrow$	2	2	0	0
e)	$\overline{\mathcal{m}}_o + \underset{\cdot}{\overline{\mathcal{m}}}_o$	$\Rightarrow$	2	−2	0	0

Slide 20: *Emtrons* in circular self-orbits: Spin=0

The notable finding is that the solutions to $\mathcal{M}$ permit circular self-orbits. As proven by Theorem 1, $\mathcal{M}$ leads to the Maxwell equations. Thus, circular and spherular self-orbits are intrinsic features of electromagnetic phenomena. Circular self-orbits are mathematically described by the following equations:

$$m_{\text{o}}^{\odot} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_{\text{o}} \\ \Upsilon_{\text{o}} \end{pmatrix} \diamond \begin{pmatrix} \cos\omega_{\text{o}}t & \sin\omega_{\text{o}}t & 0 \\ -\sin\omega_{\text{o}}t & \cos\omega_{\text{o}}t & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \hat{\text{x}} \\ \hat{\text{y}} \\ \hat{\text{z}} \end{pmatrix}$$

$$\underset{\cdot}{m}_{\text{o}}^{\odot} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_{\text{o}} \\ \Upsilon_{\text{o}} \end{pmatrix} \diamond \begin{pmatrix} \cos\omega_{\text{o}}t & \sin\omega_{\text{o}}t & 0 \\ 0 & 0 & 1 \\ \sin\omega_{\text{o}}t & -\cos\omega_{\text{o}}t & 0 \end{pmatrix} \begin{pmatrix} \hat{\text{x}} \\ \hat{\text{y}} \\ \hat{\text{z}} \end{pmatrix}$$

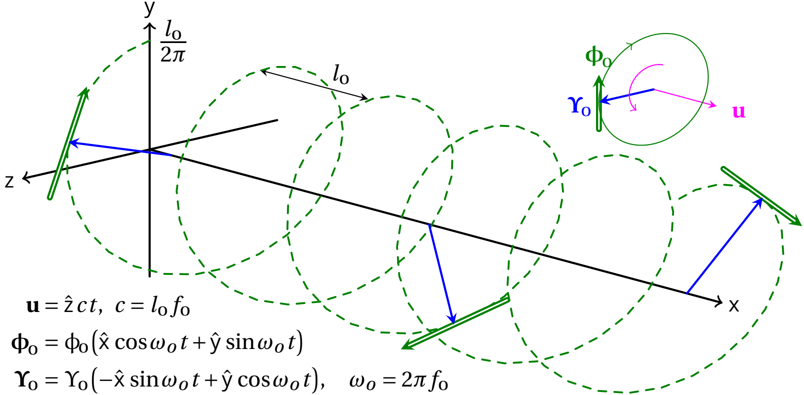
These emtrons are classified as spin-zero because either $\boldsymbol{\phi}_{\text{o}}$ or $\boldsymbol{\Upsilon}_{\text{o}}$ remains static.

These would be responsible for establishing the electromotive field between capacitor plates, or the electromotive magnetic fields of permanent magnets.

Slide 21: *Emtrons* with Rotation and Linear Motion; Spin=1

$$m^{\gamma} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_o \\ n\Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos \mathrm{r_a} n\omega_o t & \sin \mathrm{r_a} n\omega_o t \\ 0 & -\sin \mathrm{r_a} n\omega_o t & \cos \mathrm{r_a} n\omega_o t \end{pmatrix}$$

$$\underset{\cdot}{m}^{\gamma} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_o \\ n\Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} 1 & 0 & 0 \\ 0 & -\cos \mathrm{r_a} n\omega_o t & -\sin \mathrm{r_a} n\omega_o t \\ 0 & \sin \mathrm{r_a} n\omega_o t & -\cos \mathrm{r_a} n\omega_o t \end{pmatrix}$$



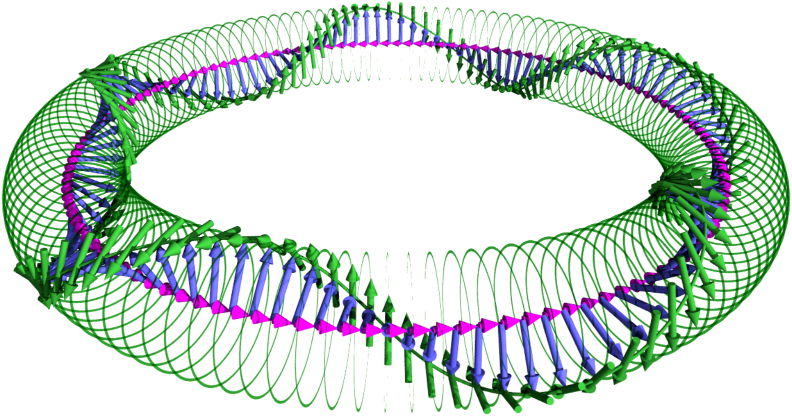
$\mathbf{u} = \hat{z}\, c t, \;\; c = l_o f_o$

$\boldsymbol{\phi}_o = \phi_o\left(\hat{x} \cos \omega_o t + \hat{y} \sin \omega_o t\right)$

$\boldsymbol{\Upsilon}_o = \Upsilon_o\left(-\hat{x} \sin \omega_o t + \hat{y} \cos \omega_o t\right), \quad \omega_o = 2\pi f_o$

Slide 22: Toroidal EM-eddy — Emtrons in Circular Self-Orbits: Spin=1

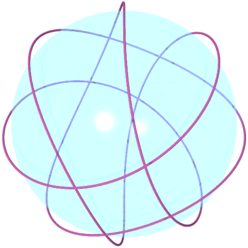
$$m^{\tau} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} \cos\omega_o t/_n & \sin\omega_o t/_n & 0 \\ -\cos\omega_o t/_n \sin\omega_o t/_n & \cos\omega_o t/_n \cos\omega_o t/_n & \sin\omega_o t/_n \\ \sin\omega_o t/_n \sin\omega_o t/_n & -\sin\omega_o t/_n \omega_o t/_n & \cos\omega_o t/_n \end{pmatrix}$$

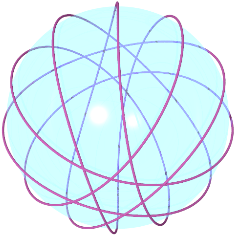


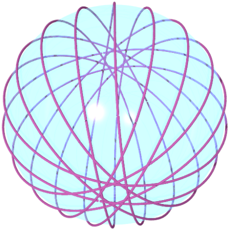
Slide 23: Particles as EM-Solitons — Emtrons in Spherular Orbits: Spin=1

$$m^{\oplus} \xrightarrow[\text{by}]{\text{def}} \begin{pmatrix} c \\ \phi_o \\ \Upsilon_o \end{pmatrix} \diamond \begin{pmatrix} \cos 2\omega_o t/m & -\sin 2\omega_o t/m \sin \omega_o t/mn & \sin 2\omega_o t/m \cos \omega_o t/mn \\ 0 & \cos \omega_o t/mn & \sin \omega_o t/mn \\ -\sin 2\omega_o t/m & -\cos 2\omega_o t/m \sin \omega_o t/mn & \cos 2\omega_o t/m \cos \omega_o t/mn \end{pmatrix}$$

where $n \in \{2, 3, 5, \ldots \text{prime}\}$, and m an integer scaling value. The integral $\mathbf{p} = \int \mathbf{u}\, \mathrm{d}t$ determines the path shape which has a length $2mnl_o$ and encloses a sphere of radius $r_s = ml_o/(2\pi)$.







Slide 24: Summary and Conclusion

Please refer to my full paper "A Novel Constructive Electromagnetic Quantum Theory describes the Origin of Mass and Unifies the Forces" available `https://hnp.onl/1882`

- Theorem 1 and 2 provide the mathematical framework to define electromagnetic solitons.
- We are required to separate the electrostatic fields from the electromotive fields. They are two different phenomena that combine into the electromagnetic phenomenon.
- The various solutions of $\mathcal{M}(\mathbf{u}, \boldsymbol{\phi}_o, \boldsymbol{\Upsilon}_o)$ give explanation to electric currents, photons and particles.
- The Origin of Mass is an EM-phenomenon, $E = mc^2$ is derived from energies of these solitons in $\mathbb{C}^3$
- The paper provides explanation to unify the forces.
- The paper provides explanation to all quantum phenomena
- The paper provides a method for algorithmic nucleus packing of all elements and their isotopes giving the correct atomic mass number.

Slide 25: Finale

Unfortunately Theorem 1 and 2 require $\mathbb{C}^3$ and will not work in the four dimensional space-time constructs. I predict that a paradigm revolution in physics is upon us.

Thank You

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Full paper: `https://hnp.onl/1882`