Kron Cube Negative Mass Generation

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08/21/2007

This paper describes the relationship between mass and transmission line electromagnetic wave propagation. I suggest an experiment to validate the theory and propose a way to generate negative mass with a Kron Cube.

INTRODUCTION:

Theory predicts a transmission line wave exhibits mass as a by-product of its energy. Kyriakos[1] and others have suggested an electromagnetic wave confined within a finite volume emulates matter as a self-captured photon (i.e. electron/positron pair production). The captured photon transcends from field behavior to particle behavior resulting in charge and mass. A transmission line wave emulates this concept and allows manipulation with physical geometry and propagation environmental properties. This paper takes the concept one-step further by selecting anisotropic meta-material transmission line geometry with negative relative permittivity (dielectric constant) and positive magnetic permeability resulting in negative mass emulation.

Grbic[2] has experimented with altered lumped transmission line geometries with successful results in the microwave region. The isotropic meta-material devices swap the lumped inductor and capacitor connections resulting in a line "reversed" from conventional theory. Space waves experience a negative index of refraction when encountering the device. This paper uses an anisotropic variation to produce negative mass from the energy contained within the device. In addition, reducing wave phase velocity increases mass in the classical sense of $m=E/v_p^{\ 2}$. Electrically generated measurable positive mass from confined EM waves with reduced phase velocity is presented to experientially verify the theory.

NEGATIVE MASS ATTRIBUTES

Bondi and Forward[3] described particle properties of negative mass assuming all concepts of mass are equivalent. The result is a system where negative masses are attracted to positive masses but positive masses are repelled from negative masses. Bondi suggests the combined system of positive and negative mass particles will accelerate indefinitely without any additional input into the system. Negative mass behavior is unusual in that it is completely inconsistent with normal observation. However, it is mathematically consistent and introduces no contradictions when analyzed by physics.

Consider a spherical spacecraft with a cube of negative mass attached to its outer surface:

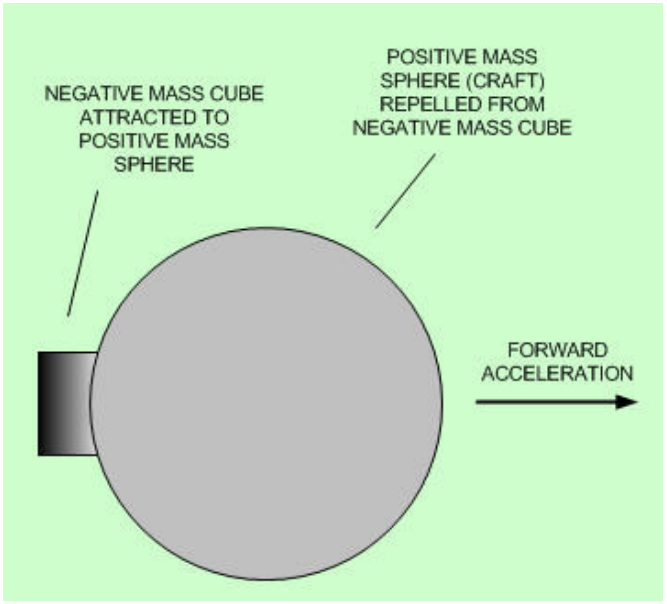

Figure 1 - Negative mass cube attached to positive mass craft results in forward acceleration.

The sphere is repelled from the cube and a repulsion force results. The cube is also repelled from the sphere but since the cube mass is negative, the cube repulsion force is opposite so the cube moves toward the sphere. Summing the forces, the sphere accelerates (forever) along a single vector trajectory path without violating conservation of energy. Moving the cube to another position on the sphere surface slows or steers the craft.

TRANSMISSION LINE WAVE MASS:

Consider a traveling wave having both Ex and Ey components[4]. Superposition of the two waves result in electric and magnetic fields described as:

$$E = (u_x E_{ox} + u_y E_{oy}) e^{-jkz}$$

$$H = \frac{1}{\eta}\left(-u_x E_{oy} + u_y E_{ox}\right) e^{-jkz}$$

Where ux, uy are unit vectors in the x and y axis directions.

$$k = \omega\sqrt{\mu_0 \mu_r \varepsilon_0 \varepsilon_r}$$

$$\eta = \sqrt{\frac{\mu_0 \mu_r}{\varepsilon_0 \varepsilon_r}}$$

If E_y is equal in magnitude to E_x but quadrature phased, a circular polarized "corkscrew" wave results.

$$E = (u_x - ju_y) E_o e^{-jkz}$$

$$H = \frac{1}{\eta}\left(u_x - ju_y\right) jE_o e^{-jkz}$$

Selecting this circular polarized waved results in no change in energy or power density with time or space yielding steady power flow. This is analogous to two-phase circuit theory power transmission so energy to mass analysis is simplified. Wave energy per volume *w* is:

$$w_e = \varepsilon E_0^2$$

$$w_m = \varepsilon E_0^2$$

Parallel plate transmission lines will produce similar to the above wave. Transmission line physical representation is:

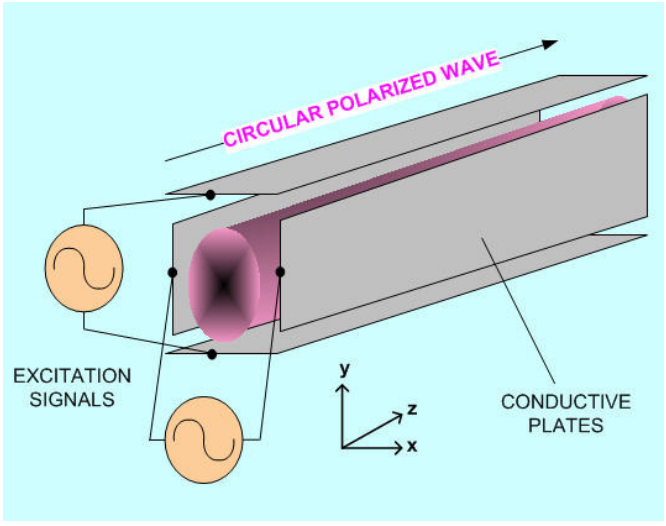

Figure 2 - XY plane parallel plate transmission lines with quadrature phasing propagating Z plane circular polarized wave.

MASS EMULATION:

In the classical sense, the wave energy adds additional mass to the transmission lines. The additional wave mass from energy $E=mc^2$ is small since electrical conductive transmission lines propagate with a typical phase velocity only slightly less than c with the reduction due to the propagation medium relative permittivity.

For the above circular polarized case, total wave energy is:

$$W_T = w_e + w_m = 2\varepsilon E_0^2$$

Additional wave mass is:

$$m = \frac{2\varepsilon_r \varepsilon_0 V_0^2}{c^2} Vol$$

Where *Vo* is the excitation voltage and *Vol* is the transmission line volume (as a first order approximation).

Assuming an input of $100V_{pp}$ at 1 MHz with plate separation of 0.01 meter and a line length of 1 meter in air, additional wave mass is on the order of m = 1E-28 Kgm (not measurable).

From Maxwell's field equations, phase velocity of a non-vacuum medium is:

$$v_p = \left[\frac{\varepsilon_0 \varepsilon_r \mu_0 \mu_r}{2}\left(\sqrt{1+\left(\frac{\sigma}{\omega \varepsilon_o \varepsilon_r}\right)^2} + 1\right)\right]^{-\frac{1}{2}} = f\lambda$$

Where
v_p = field phase velocity (real component),
εo = permittivity of free space,
εr = coaxial medium permittivity,
μo = permeability of free space,
μr = coaxial medium permeability,
σ = coaxial medium conductivity,
f = signal frequency,
λ = transmission line reduced wavelength,
ω = 2πf

Substituting above propagation velocity for c, wave mass is:

$$m = \frac{2\varepsilon_r \varepsilon_0 V_0^2}{v_p^2} Vol$$

Constructing the transmission line geometry with copper plate conductors filled with a slightly conductive medium of distilled water (dielectric constant εr = 80) with NaCl added to produce a conductivity of 100S/m effects larger mass. Driving this line with $100V_{p\text{-}p}$ 10milliHz, (0.01Hz) quadrature sine waves produces an added mass of the order 1E-12Kgm, within existing measurement technology. A slightly conductive medium with high relative permeability increases mass to the order 1E-10Kgm. An experiment is now possible to test the wave mass contribution to the total gravitational mass. Note if v_p could be slowed to near zero while preserving field intensity, theory predicts line mass would become large without bound (singularity). Possible application is a "closed time curve" time travel machine.

TRANSMISSION LINE META-MATERIAL:

Eleftheriades[2] has experimented with transmission line meta-material exhibiting negative relative permeability and/or permittivity for incident EM waves. Simply, the transmission line lumped element equivalent capacitance and inductance is "swapped" resulting in a negative μr and εr as shown by Figure 3. The effects realizes for incident waves as well as traveling waves on the line since both shares the common geometric environment and are influenced by the swapped L/C passive components.

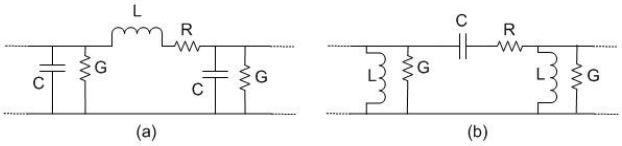

Figure 3 - Line (a) represents a transmission line lumped equivalent circuit. Line (b) has L and C reversed.

In 1943, Kron[5] suggested a three-dimensional network consistent with Maxwell's equations in a charge free medium. By swapping the L/C terminations, Grbic[2] experimentally showed the cube acted on incident waves with a negative index of refraction (negative μr and εr).

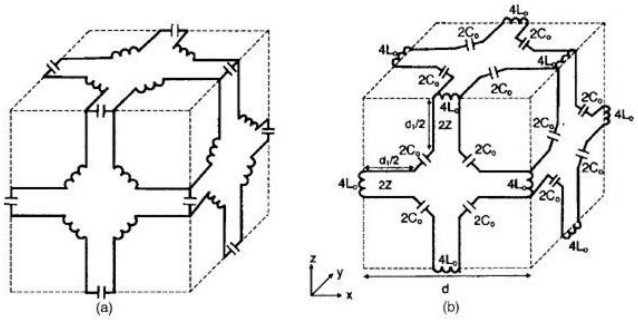

Figure 4 - Kron Cube equivalent circuit (a) and L/C reversed circuit (b).

Virtual electric walls form at the cube faces and virtual magnetic walls form along the planes. The entire cube volume becomes the meta-material confining the fields to within the cube dimensions. Stacking cubes will increase total volume and therefore wave mass.

The cube physical construction is simplified using parallel conductive strips along the outer edges of intersecting planes:

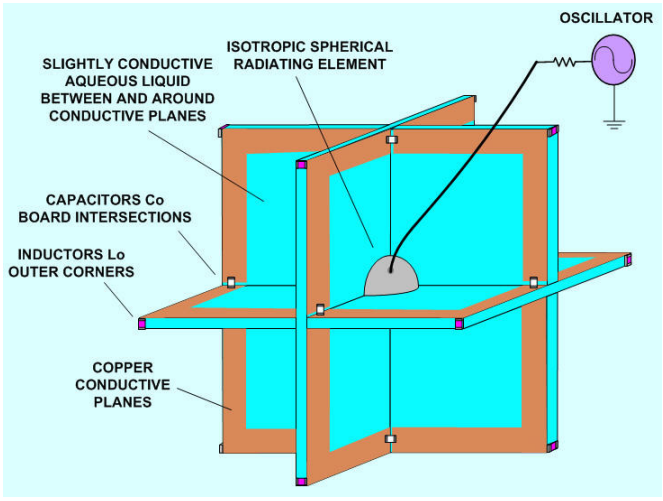

Figure 5 - Constructed Kron Cube from three intersecting copper conductor strip planes excited by an internal spherical isotropic radiator.

Excitation with radiated waves is possible using a radiator located at the cube center. Since power density is small, an alternative approach is to apply excitation directly:

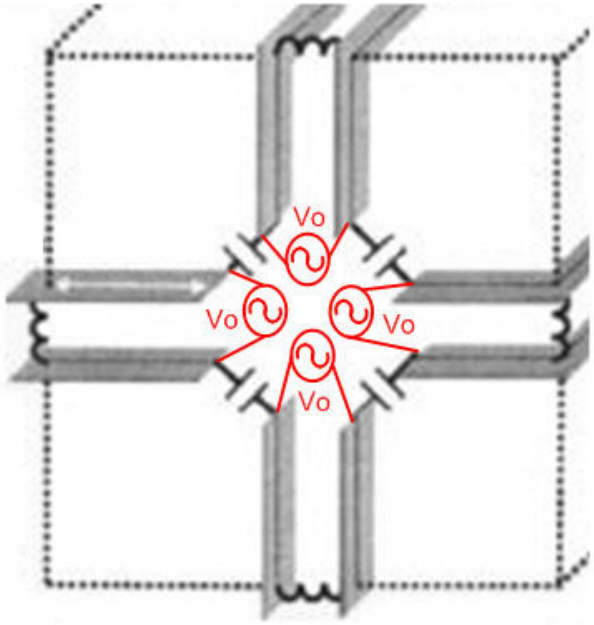

Figure 6 - Kron Cube excitation by differential signals applied to each parallel plane strip.

Theory predicts direct excitation with larger power results in larger wave mass. Electronic excitation with parallel differential drivers and matching circuits sharing a common oscillator is ideal:

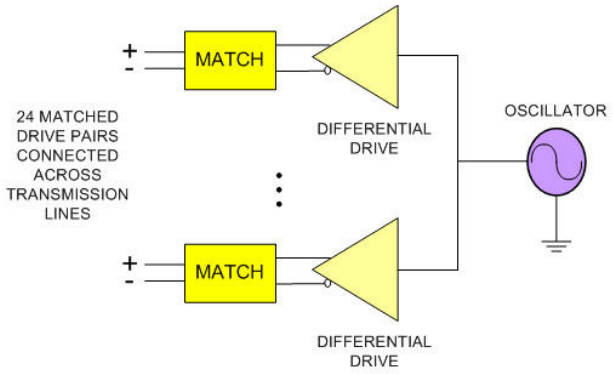

Figure 7 - Electronic excitation circuit block diagram.

NEGATIVE MASS:

For negative mass, a negative relative permittivity (dielectric constant) is required. Constructing the transmission lines of Figure 5 as the geometry of Figure 2, the mass equation becomes:

$$m = \frac{2(-\varepsilon_{rKC})\varepsilon_0 V_0^2}{v_p^2} Vol_{KC}$$

Where
ε_{rKC} = effected relative permittivity of the Kron Cube geometry,
VOL_{KC} = the Kron Cube volume.

Cube wave impedance is:

$$\eta = \sqrt{\frac{\mu}{\varepsilon}} = \sqrt{\frac{\left(\frac{2Cd_1}{d}\right) - \left(\frac{1}{\omega^2 L_o d}\right)}{\left(\frac{2Ld_1}{d}\right) - \left(\frac{1}{\omega^2 C_o d}\right)}}$$

Where
C = transmission line capacitance
Co = termination capacitance
L = transmission line inductance
Lo = termination inductance
d = cube dimension
d1 = transmission line dimension (see Figure 4)

Note the numerator is permeability and the denominator is permittivity. In addition, each term determines sign. Since a positive permeability and negative permittivity is required for anisotropic operation, the design target is:

$$2\omega C > \frac{1}{\omega L_o d_1} \quad \text{And} \quad 2\omega L < \frac{1}{\omega C_o d_1}$$

For practical operation, the cube operating frequency will be at minimal reflective coefficient (S11 null). In addition, cube dimension d must be small compared to the excitation wavelength. Slowing phase velocity results in a larger operating cube dimension.

CONCLUSION:

Theory suggests EM wave energy present on a transmission line results in increased line mass. Slowing wave phase velocity increases wave mass for a given wave energy present. Swapping L/C lumped components on an electrically short line effects negative relative permeability and/or permittivity. Constructing the lines into a Kron Cube and adjusting parameters, an anisotropic meta-material medium volume results (negative μr and/or εr). Theory suggests the anisotropic medium volume with negative εr emulates negative mass from the line wave energy.

REFERENCES:

1. A. Kyriakos, On Calculations Of Elementary Particles Masses, http://arxiv.org/ftp/physics/papers/0604/0604063.pdf

2. A. Grbic, G. Eleftheriades, An isotropic three-dimensional negative-refractive-index transmission-line metamaterial, JRNL App Phy. 98, 043106, (2005)
link

3. Exotic Matter, Wikipedia,
http://en.wikipedia.org/wiki/Exotic_matter

4. Time Harmonic Electromagnetic Fields, R. Harrington, McGraw-Hill, (1961)

5. G. Kron, Phsy Rev. 64, 126, (1943)