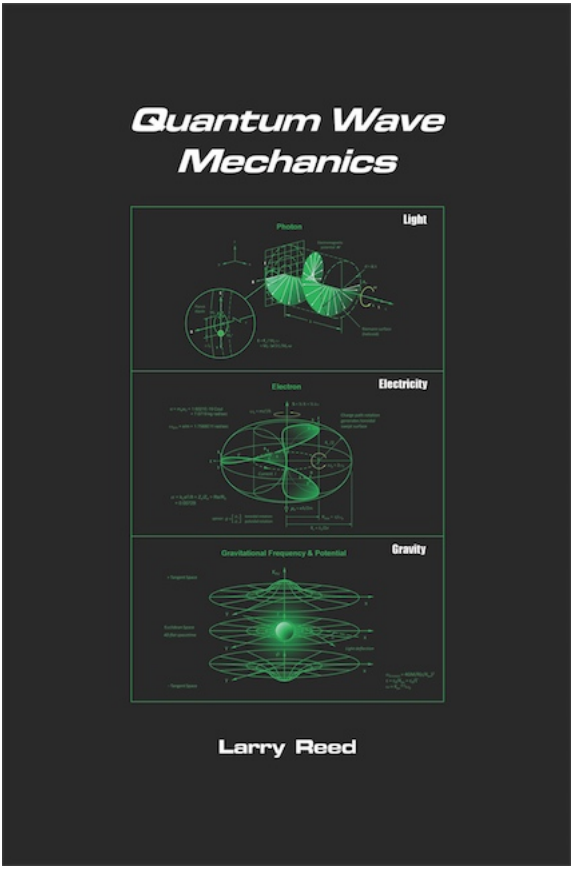
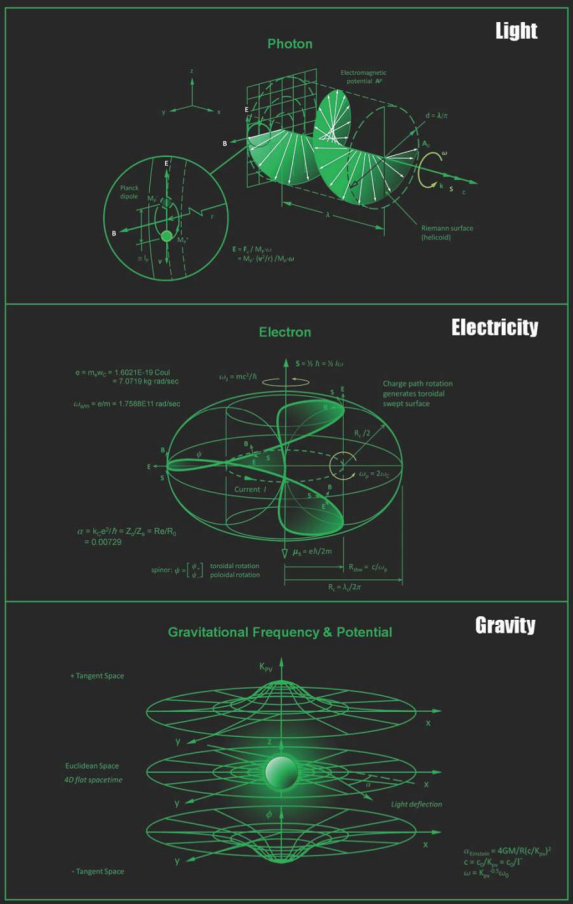


Geometrical description of photons, electrons and composite particles. Dimensional analysis of electrical charge. Quantum gravity, gravitational frequency spectrum, mass oscillator synchronization, spectral energy density modulation and phase conjugation. Origin of charge, fine structure constant and inertia. Prospects for wave-based EM propulsion.

Quantum Wave Mechanics

by Larry Reed

Quantum Wave Mechanics



Larry Reed

To my parents who never knew the result of their great experiment

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SECTION 3 – GRAVITY

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Preface

This book attempts an explanation and geometrical description of a quantum field theory of light, electric charge, and gravity. Understanding the fundamental nature and interactions of such quantum fields is facilitated with knowledge of wave phenomena and physical properties of the vacuum that enable wave propagation. All light and matter is composed of quanta that share a fundamental characteristic in that they are composed of quanta that spin and with spin angular momentum of only certain discrete multiples of Planck's quantum constant h (integer spin bosons and half-interger spin fermions). Why does this manifest, highly localized, quantized spin wave effect occur and how does it result in concentrated energy in the form of matter? The estimated quantum mechanical energy content of the vacuum (10^{113} J/m^3) is vastly larger by ~122 orders of magnitude than the energy contained in the observable universe (10^{-9} J/m^3) composed of fermions and bosons. What accounts for this incredible mismatch in the minute fraction of energy in that we can directly perceive and experience (i.e., quanta with spin) and vacuum energy (fluctuations without spin) that which is inaccessible to observation? Just what are photons, electrons, and gravitons? How are they created from the seeming void of the vacuum, and how do they interact? Why is the speed limit of the universe set at a certain finite velocity of light? What exactly is electric charge? What is mass? How does mass interaction result in gravitational attraction? We seek an *explanation* for such phenomena, not just an ad hoc label description without visualization. Several interrelated themes are developed in terms of wave phenomena, energy density gradients, spin waves, and quantum effects in a physical vacuum. The subject matter and concepts discussed are necessarily speculative but are founded on known wave-mechanics principles. Major themes addressed include the following:

Light. A freely propagating photon wavetrain or light quanta in empty space is described as a helical traveling electromagnetic wave of quantized spin angular momentum moving at the velocity of light *semper et ubique*. Photons are classified as integer spin bosons. The physical vacuum as a polarizable medium enables wave propagation and appears ultimately to be quantized at the Planck scale. In the Winterberg Planck aether hypothesis, the vacuum is a Bose-Einstein condensate (BEC) superfluid composed of positive and negative Planck mass dipoles. Fundamental particles such as the photon and the electron are viewed as polarized quasi-particle wave excitations of much smaller Planck particles. Electromagnetic waves are conjectured to consist of spin density waves of Planck dipoles enabling formation of kink or antikink solitons. Similar to the exotic properties of supercooled $_3$He BEC liquid helium superfluid, spin waves are not tolerated by the vacuum but quickly become localized and isolated quantized vortices. A BEC condenstate represents a fifth state of matter in which particles collectively act in coherent waves oscillating in phase at the same frequency. The formation of electric charge q, magnetic vector potential **A**, electric field intensity **E**, and magnetic field intensity **H** in a vacuum devoid of matter may be understood in terms of the spatial and temporal density fluctuations and motion of Planck dipoles. The speed of light is a function of the Planck energy density of a polarizable vacuum characterized by the variable index of refraction K_{PV}.

Photons and electrons/positrons may be directly interconverted in high-energy processes of pair production and annihilation. Any viable model of the photon or electron must account for this interconvertability. Oscillation of electrons generates electromagnetic waves. Electrons can resonantly couple with electromagnetic waves. Photons and electrons can interact, for example, as plasmonic waves of free electrons in a metal surface, in secondary emission of electrons due to the photoelectric effect as in a photomultiplier, in an

ionized plasma as plasmons (quanta of electron waves), in a vacuum as in free-electron lasers, magnetrons, photomultipliers, etc., in photonic-excited condensed matter excitons, and in absorption of photons in photo-sensitive semiconductor P-N diodes or photon emission in laser diodes. Absorption of energy of a photon in a semiconductor can be transferred to an electron as potential energy. Photon emission occurs when the electron loses potential energy when electron-hole pairs recombine. P-N-P junctions of quantum dimensions can provide a storage medium for electrons as quantum mechanical standing wave traps. Photonic devices enable conversion of photons into an electron current and vice versa to generate an electrical signal or photo signal. Photon interaction with electrons can result in motion of matter as, for example, in particles suspended in an EM tractor beam by photophoretic forces in an optical trap.

In addition to frequency and spin, a photon traveling wave disturbance may be described in terms of curvature and torsion. The straight line motion of a photon in a gravity-free, zero-curvature vacuum reflects a balance in electric and magnetic energy. A change in torsion of a photon in an optically dense medium is associated with effective mass. The processes of electron/positron pair production and annihilation are described in terms of the geometry of a photon helicoid. During electron/positron pair creation, the increased curvature k and decreased torsion τ of a helical wave train due to Faraday rotation and Levi-Civita effects results in formation of two counter-rotating loops of opposite topological charge. Each loop contains two spinors corresponding to poloidal and toroidal rotation of a toroidal electron and positron spin wave. Electric charge is related to topological charge associated with precessional rotation and is quantized as a result of quantization of spin angular momentum described by Planck's constant $\hbar$ (= 2πh).

Mass. Mass is a fundamental, intrinsic property of matter attributed to the interaction of electromagnetic quantum fields, i.e., a wave interference effect. In the Einstein relation, mass $m = E/c^2$ where E is energy and c = the celerity of light. Energy is a measure of wavefront curvature. Mass is associated with retardation of energy flow and resultant time dilation. Wave energy packets are separated by nodes which obstruct energy flow restricting propagation. Mass corresponds to wave periodicity and is a measure of EM wave volumetric nodal density. Rest mass is observed only in fundamental particles with electric charge and is a ratio of charge to Compton angular frequency. Fundamental particles are viewed as standing wave resonant structures and not point-like objects. Travelling waves such as light and neutrinos acquire effective mass during propagation in regions of higher EM density. Standing waves acquire mass and inertia as a result of confinement of travelling waves as demonstrated in work by Jennison and Drinkwater. The self-referral dynamics of radiation trapped in a phase-locked cavity accounts for Newton's First Law of Motion, i.e., every object in a state of uniform motion tends to remain in motion unless an external force is applied to it. Hence, there is no need to attribute inertia to instantaneous interaction with the rest of the matter in the universe according to the Mach hypothesis. Mass and inertia are local phenomena. Mass may be understood as an interaction of electromagnetic fields resulting in accelerative wavefront curvature without recourse to the hypothetical, vaguely described Higgs field with unexplained mechanism for imparting mass to massless particles. The confinement of light, consisting of massless photons, in a fixed reference frame of a cavity resonator results in the creation of mass and inertia. At a sufficiently high energy level corresponding to the rest mass of the electron, the imbalance of electrostatic and magnetostatic fields results in topological confinement of a photon within a fixed volume of Compton radius R_C. Hence, fermions may be interpreted as spinning, phase-locked, topologically confined, standing wave resonant structures with electrons and positrons as the fundamental building blocks of matter.

In general, the motion of a push-pull phase-locked cavity resonator consists of an oscillatory sequenced series of accelerative jumps interspersed with coasting periods of constant velocity. In this respect, a cavity resonator is somewhat analogous to an inflated bouncing rubber ball alternately compressing and decompressing without internal dissipative losses. The rhythmic pulsation of a phase-locked resonator in motion generates longitudinal and transverse EM waves with frequency which varies with the cavity velocity. For matter (composed of resonant EM standing waves) in motion, the Lorentz contraction is interpreted as a physical wavelength compression due to variation in EM field energy density as measured by vacuum refractive index K_{PV}. A phase-locked resonator in motion exhibits an oscillatory, pulsing compression and expansion emitting dipole radiation transverse to the direction of motion. Interaction of these radiated waves with nearby electrons via the electromagnetic vector potential $\mathbf{A}^{\mu}$ results in coupling of N number of electrons increasing their effective collective inertia as N^2.

The Lorentz transformations of motion in terms of velocity ratios compared with Ivanov-LaFreniere standing wave transformations in terms of standing wave ratios are shown to be equivalent. Ivanov and LaFreniere have shown that standing waves undergo wavelength (nodal) contraction in the direction of motion. An object in motion relative to a fixed observer undergoes a Lorentz contraction (wavelength compression) in the direction of motion and a Lorentz Doppler shift in frequency (reduction). The wavelength compression is a physical result of an increase in the vacuum energy density. Moving clocks which are made of standing matter waves undergo time dilation as a result. This is in keeping with de Broglie and Schrödinger's view that matter waves are real physical waves and not merely particle location probability amplitudes described in the Born interpretation. The EM wavelength contraction and frequency shift in a polarizable vacuum accounts for mass in motion and gravitational effects, including the energy change, deflection of light, gravitational frequency shift, and clock slowing. The speed of light *c* appears invariant in all inertial frames due to Lorentz contraction of the measurement apparatus and a concomitant Lorentz Doppler frequency shift. Spacetime remains Euclidean over scales comparable to wavelength. The apparent Lorentz space contraction and time dilation are the result of contraction of the nodal distance of the standing wave(s) which constitute the length of measurement. Time dilation is equivalent to a change in the size of the units of measurement which are undetectable to an observer as both the object and the comoving measurement apparatus undergo Lorentz transformation.

Fundamental particles of matter exhibit properties of standing EM waves trapped in a phase-locked resonator including Doppler frequency shifts in motion, inertia (resistance to motion) and de Broglie waves. Matter in motion relative to an observer exhibits de Broglie 'matter' waves as a modulated moving standing wave. The inverse effect of self-induced motion of matter may potentially be realized utilizing synthesized red- and blue-shifted Lorentz Doppler waves parametrically amplified in a phase conjugate phase-locked resonator. Energy of motion results from conversion of energy of the pump waves to the contracted moving standing wave formed from the signal wave and its counterpropagating phase conjugate wave within the resonator. Velocity of the resonator wave system is proportional to the wave phase difference while acceleration is proportional to the frequency difference. Synthesized matter waves would provide means for inertia modification and control as well as self-induced motion of matter. Such technology would enable EM wave-based propulsion without wheels, friction, reaction or expulsion mass. Inverse effects are not without precedent as, for example, inverse Doppler effect, inverse Sagnac effect, inverse Faraday effect, inverse Compton effect, inverse spin Hall effect, inverse Cherenkov effect, inverse Raman effect, inverse Cotton-Mouton effect, inverse Barnett effect (Einstein de Haas effect) and inverse piezoelectric effect, etc.

Electric charge. Traditionally, electric charge has been opaquely described as a separate dimension without geometrical description or explanation of its origin. In this book, a description of electric charge is detailed relating it to dimensions of mass, rotation rate and time which is interpreted as a rate of precession of closed loop standing waves and described by the fine structure constant. Spin momenta is associated with loop closure failure defects or dislocations in spacetime and resultant torsion stresses. The electron is described as a helical toroid standing wave formed from an energetic photon travelling wave with a full twist looped into a circle of a radius equal to the Compton wavelength. The photon helicoid may be envisioned as a twisted ribbon spinning around its longitudinal axis. The electron toroid geometry may be described in a twisted ribbon analogy as a spinning closed-loop Hopf strip – the simplest form of topological knot. The torus geometry is formed by a rotating charge path in the shape of a Hopf link with toroidal and poloidal components. The ½-spin characteristic of the electron arises as a result of a toroidal spin component of Compton frequency ω_C and a poloidal spin component of Zitterbewegung frequency equal to $2\omega_C$. The imbalance of the electrostatic and magnetostatic energy gives rise to the fine structure constant α. The charge-to-mass e/m ratio corresponds to a precession frequency equal to $\omega_{e/m}$. The whirl number is found equal to the inverse fine structure constant α^{-1}. Electric charge has mechanical dimensions of MLT^{-1} and represents an angular precession of ~1/137 ($\simeq$ 0.007) radians/sec. Spin angular precession creates wave function interference obstructing energy flow resulting in electron mass. Charge represents an angular torsion deficit angle and is correlated with a mass deficit angle.

Gravity. All matter is composed of quantum oscillators emitting electromagnetic waves over the entire EM frequency spectrum. Gravity is viewed as a standing wave interaction between coupled oscillators interacting via EM traveling waves (e.g., bosons). Inertia and mass are the result of standing electromagnetic waves generated by an isolated oscillator within a phase-locked resonator (e.g., fermions). Electromagnetic resonant wave interactions in a polarizable vacuum (PV) model in Euclidean space exhibit geometrical spacetime curvature consonant with Einstein SR/GR. Acceleration of gravity is the result of a spectral energy density gradient and corresponds to the rate of change of rapidity. Inertial mass of matter in motion and gravitational mass of matter in a gravitational field are equivalent as both arise from acceleration into regions of increased EM flux energy density and nonlinear frequency dependent alterations in vacuum dielectric constant.

Gravitation in the Einstein General Theory of Relativity (GR) is ascribed to a curvature of space and time in an abstract mathematical representation. However, the GR theory metaphysical description of gravitation does not describe the physical mechanism for how matter induces curvature or how spacetime curvature influences motion of matter. It is argued that space and time are not physical objects but are merely the mathematical ordering of location of points in space and events in time. Time represents the flow of energy. In an optical theory of gravity, the deflection of light in a gravitational field is the result of variation in the vacuum refractive index K_{PV} which is a measure of the electromagnetic field energy density. Gravitation is equivalent to a dielectric gradient force in a polarizable vacuum as a result of local Fresnel zone variation in electromagnetic (EM) flux density and vacuum refractive index K_{PV}. The gravitational force $\mathbf{F}_g$ is proportional to the gradient of K_{PV}^2 ($\mathbf{F}_g \propto m\nabla K_{PV}^2$). Interference of electromagnetic waves from coupled oscillators produce Moiré patterns and Fresnel zones. EM wave front interference creates a Fresnel zone effect between coupled mass source oscillators concentrating the local flux density and increasing the electric permittivity gradient. Gravitons are illustrated as wave interference of counterpropagating phase conjugate photons reflected from Fresnel zone boundaries. Wavefront curvature provides an accelerative force indistinguishable from

gravity. The observed contraction of wavelength nodal distances is responsible for the perceived Lorentz spatial contraction and time dilation effects. The metric of curved spacetime corresponds to the wave front interference node metric. Hence, the gravitational field becomes quantized and spacetime remains Euclidean. The quantized gravitation field may be understood as purely an electromagnetic phenomena. As such, gravitational fields may be subject to modification by alteration of the local electromagnetic field density to check the propensity to fall or neutralize weight. Ability to effect at will modification of the gravitational spectral energy density gradient and concomitant neutralization of the local gravitational frequency shift differential will mark a significant technological achievement and prove a benchmark of human intellect.

A conundrum of modern physics is the apparent incompatibility between quantum mechanics and general relativity, each of which have had considerable success in describing aspects of the physical universe. It is asserted that the mathematical construct of spacetime curvature as represented in Einstein's GR applies not to spacetime itself but rather to wavefront curvature and nodal contraction of electromagnetic waves in spacetime. Based on investigations by Michael Faraday, the existence of electromagnetic waves theorized by James Clerk Maxwell was experimentally demonstrated by Heinrich Hertz, Nikola Tesla and others. The exact nature of just what is doing the 'waving' in electromagnetic waves has remained a mystery. What constitutes Faraday's invisible electric and magnetic field lines of force? What Planck scale vacuum elements are in contact to enable transmission of force? What accounts for the apparent tension and pressure? The vacuum is calculated to have enormous energy density and is characterized by quantum oscillators with zero point energy. What is the nature of such oscillators that support propagation of electromagnetic and gravitational wave disturbances? In this book, *Quantum Wave Mechanics*, electromagnetic fields and waves are conjectured to be disturbances in the physical vacuum composed of rotating quantized Planck dipoles consisting of coupled positive and negative Planck mass with net zero mass and angular momenta. Electric and magnetic field lines are manifestations of temporal and spatial spin alignments of groupings of adjacent Planck dipoles. The Planck vacuum is represented as an exceedingly dense energetic medium composed of Planck mass dipoles with characteristic Planck impedance and under symmetry breaking, easily induced to spin. Bosonic and fermionic fields correspond to resonant spin wave interactions between such dipoles. Bosons represent traveling waves while fermions represent standing wave structures both of which are electromagnetic. The spacetime metric is a mathematical overlay description of electromagnetic interactions characterizing the relative positioning of objects in space and ordering of events in time. The quantum vacuum may be understood as a foam of postive and negative curvature and mass. Planck masses are the underlying quintessence or "stuff" of the vacuum and are thought to arise spontaneously as a result of vacuum instability from a state of nothingness. Dark energy represents quantum wave function dissonance driving universe expansion.

Concept and inspiration is the aegis of design and invention. Knowledge and understanding of quantum wave mechanics effects in the physical vacuum is a *conditio sine qua non* for future theoretical development of funamental physics and may lead to new technological developments such as wave-based propulsion, enhanced energy conversion, vacuum engineering, programmable quantum dot nanostructures or artificial atoms and force field effects. The relation and interconversion of fundamental and derived dimensions of physical quantities and geometrical interpretations illustrated herein are intended to relate previous discoveries and provide new sources of insight and ideas as to the nature of physical reality and the universe in which we live.

Section 1 - Light

1. Photon Model

There is no greater mystery to me than that of light travelling through darkness. – Alexander Volkov

I happen to have discovered a direct relation between magnetism and light, also electricity and light, and the field it opens is so large and I think rich. – Michael Faraday

We can scarcely avoid the inference that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena. – James Clerk Maxwell

For the rest of my life, I will reflect on what light is. – Albert Einstein

Light consists of photons, the quanta of electromagnetic fields. A freely-propagating photon in empty space (gravity-free, zero curvature vacuum) is represented as a helical, self-sustaining, traveling electromagnetic wavepacket of quantized spin angular momentum moving at the velocity of light. An electromagnetic (EM) wavefront consists of a multitude of in-phase photon torsional wave trains each of an ordered sequence of photon wave packets. The photon is categorized as a stable, massless boson having no electrical charge with spin angular momentum $s = \pm\hbar$. The photon is right-circularly polarized if $s_z = \hbar$ and left-circularly polarized if $s_z = -\hbar$. In the ansatz model described, the photon is posited to consist of a spin density wave disturbance in a quantum vacuum composed of positive and negative Planck mass dipoles. The spin field forms a kink or antikink soliton defined in terms of the spin direction. Like a soliton, a photon may be regarded as a local confinement of the energy of a wave field with particle-like behavior and may propagate without dissipation or change of form. The spin axis **s** is aligned with the direction of propagation vector **k** in either the forward or the backward direction depending on helicity. An individual photon may be either right or left circularly polarized represented as polar opposites on a Poincaré sphere. Linear polarization requires a superposition of an even number of photons of opposite spin. In a coherent wave, wave packets overlap and are in the same direction, in-phase and of the same frequency.

A conceptual helicoid model of the photon as a quantized wave packet of a single wavelength is illustrated in Fig. 1-1. A helicoid describes a minimal surface generated by a space curve which simultaneously rotates about an axis and translates parallel to that axis such that the ratio of the rotational velocity to the translational velocity is constant. A minimal surface has positive curvature in one principal direction and negative curvature in the orthogonal direction with zero mean curvature. See Fig. 1-2. Photon models consisting of transverse **EM** plane wavefronts composed of rotating orthogonal **EHV** dreibein (triad) have been proposed by Hunter *et al* [1] and Funaro[2, 3, 4] and expressed in tetrad formalism by Evans[5, 6]. The **EM** potential is defined by the dreibein $\mathbf{A}_{\boldsymbol{\mu}}^{\ a}$ where superscript a = 1, 2, 3 represents the tangent space and subscript μ the base manifold. The internal index **e** in O(3) electromagnetics, represents an orthonormal tangential space defined by unit vectors $\mathbf{e}^1$, $\mathbf{e}^2$, $\mathbf{e}^3$ (complex circle basis) to the base manifold. The rotating **EHV** dreibein describes a helical geodesic propagation path (circular helix, constant curvature, constant torsion) which may be represented as a space curve in terms of the Frenet-Serret equations. A unit speed curve corresponds to arc length *s*. Curvature (departure from linearity) corresponds to the change in direction of the tangent vector ***t*** per unit arc length while the torsion (departure from planarity) corresponds to the change in direction of the binormal vector ***b*** (= ***t*** x ***n***) which is orthonormal to the osculating plane defined by the curvature (radial) vector ***n*** and tangential vector ***t***. The charge path trajectory describes a geodesic on a cylinder. Zero axial velocity (zero torsion) corresponds to a circle. Infinite velocity (infinite

torsion) corresponds to a line. In geometric terms, motion of an inextensible curve of constant torsion (= 1/r) and constant curvature k = ω_u associated with the sine-Gordon equation ($\omega_{uv} = 1/\rho^2 \sin\omega$) traces out a single-soliton Bianchi surface as it moves where at each instant will be an asymptotic line on the surface. The sine-Gordon equation in this representation includes one spatial and one temporal independent variable. The spatial motion of curves of constant torsion and curvature such as the Sine-Gordon curve are geometrically linked with soliton theory of nondispersive, solitary waves such as described by the Korteweg–de Vries (KdV) nonlinear wave equation.

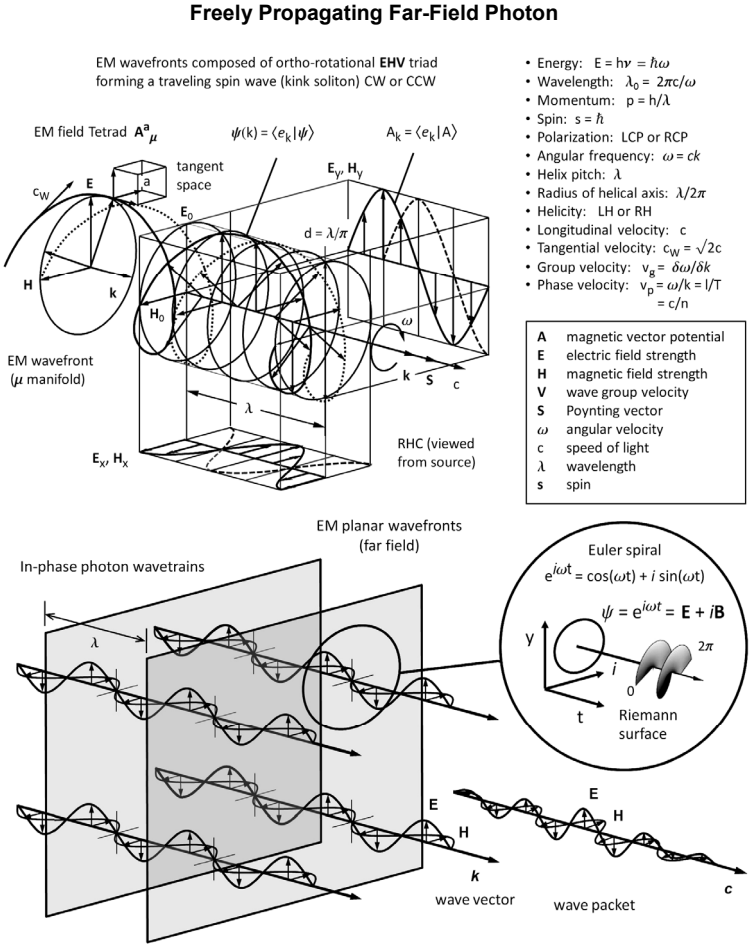
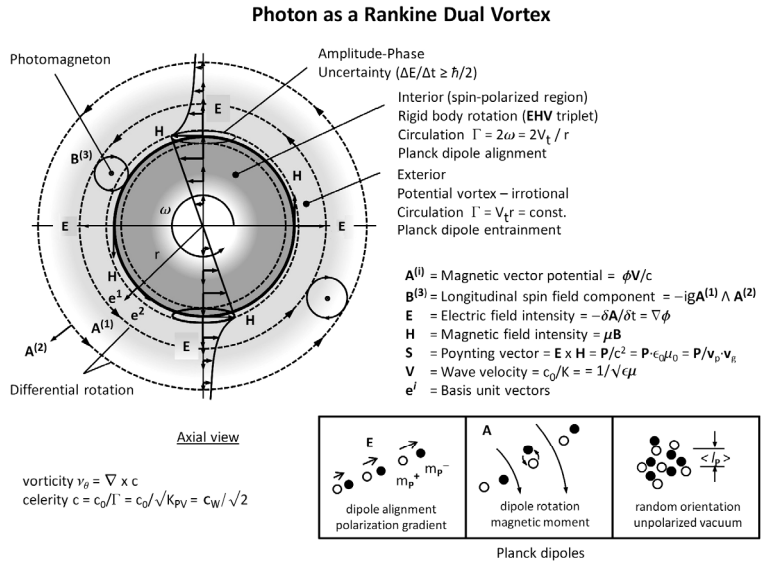


Fig. 1-1. Illustration of a monochromatic single-wave length photon represented as a torsional wave and a EM wavefront composed of photon wavetrains remote from source quantum harmonic oscillator. Photons are elementary excitations of the normal modes of the electromagnetic field with quantized energy $\hbar\omega_\lambda$ and represent quantization of Maxwell's equations. Energy flow is in the direction of the Poynting vector **S** (= **E** x **H**).



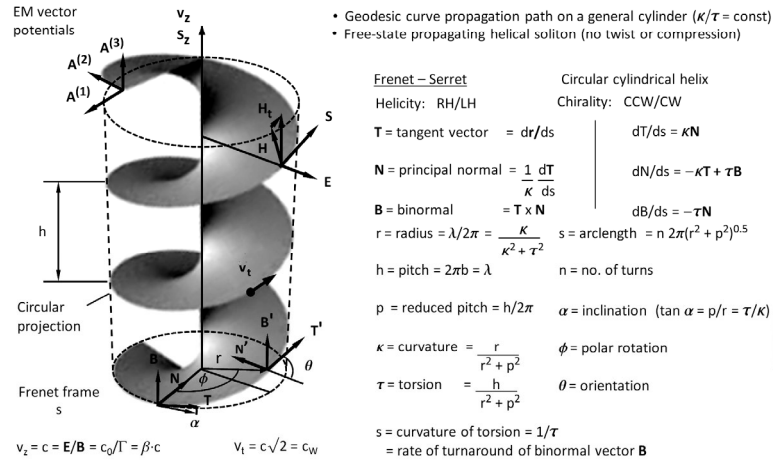


Fig. 1-2. Photon model detail illustrating electric and magnetic field component relationship to helical curvature and torsion. The motion of the Frenet frame along the unit speed curve is described by the Frenet-Serret formulas. The contravariant vector **T** is tangent to the parametized curve. Right-hand (RH) circular polarization is shown.

Ordinary photons do have spin, they have a notion of helicity so they spin around their direction of motion. – Roger Penrose

Electrons behave in exactly the same way as photons; they are both screwy. – Richard Feynman

1. Photon Model

A wave group consists of consecutive energy packets separated by nodes. Energy trapped between consecutive nodes cannot escape, hence, wave energy travels at the group velocity $\mathbf{v}_g$ (= dx/dt = d$\boldsymbol{\omega}$/d$\boldsymbol{k}$) in the direction of propagation denoted by the wave vector $\boldsymbol{k}$. In a vacuum, the wave vector is given by $\boldsymbol{k} = \boldsymbol{\omega}/c$. In a material medium, the wave vector $\boldsymbol{k} = \boldsymbol{\omega}n/c = \boldsymbol{k}_0/\sqrt{(1-\beta^2)}$ where n is the refractive index. An increase in the refractive index lowers the phase velocity. The refractive index of a zero curvature vacuum equals one. For a metamaterial with refractive index equal zero, the phase velocity and wavelength become infinite. An increase in the energy density of the medium acts to slow the group velocity compressing the wavetrain resulting in frequency up chirp. Conversely, a decrease in energy density of the medium results in frequency down chirp. This effect is illustrated in Fig. 1-3.

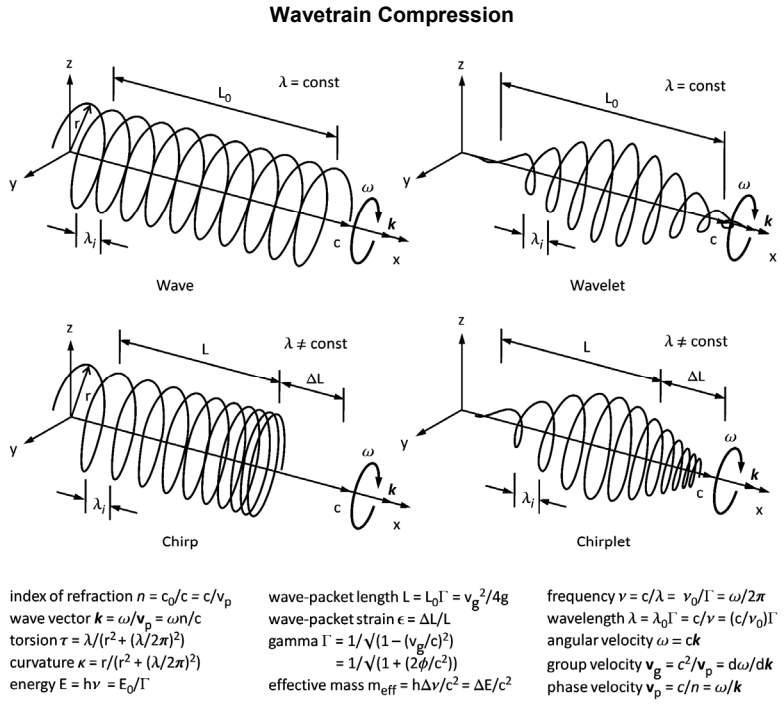


Fig. 1-3. Wave pulse compression results in high frequency chirp. Increase in frequency is produced as a result of increase in refractive index n (= $c_0/c = c/v_p$) of the propagation medium which is a measure of EM energy density. Up chirp corresponds to an increase in frequency and torsion while down chirp corresponds to decrease in frequency and torsion. A complex-valued EM wavefunction ψ (= $\mathbf{E} + i\mathbf{B}$) $\rightarrow e^{i\theta}\psi$ can be represented as a complex-valued wavelet time-frequency transform. Wavelet compression (i.e., change in scale factor α) corresponds to a chirplet transform commonly used in signal processing.

I therefore take the liberty of proposing…the name photon. – Gilbert N. Lewis

Near an oscillating dipole source in the near field evanescent region of the radiation pattern, the electric **E** and magnetic **H** fields are out-of-phase and the Poynting vector **S** (= **E** x **H**) has transverse components. This can result in unusual effects exploited in plasmonic devices, metamaterial magnetic mirrors and the like. The field intensities in the near field fall more steeply as $1/r^3$ than $1/r^2$ as in the far field region. Electromagnetic field propagation from an oscillating dipole antenna illustrating amplitude and phase change in electric **E**-field and magnetic **H**-field with distance from source generator is illustrated in Fig. 1-4. Wave impedance is reactive close to the antenna with transverse and longitudinal **E**-field components in the near-field. In the far-field, the transverse **E**-field and **H**-field are perpendicular to the direction of wave propagation in phase quadrature with the wavefront approximating a plane wave. The transition to a radiative field is marked by detachment of flux lines from the antenna and self-closure.

Emission of energy from a harmonic oscillator occurs during the first quarter period of oscillation and temporarily stored in the reactive field. Energy is radiated or reabsorbed by the dipole antenna during the next quarter period. The magnetic field appears initially to propagate at infinite velocity before slowing down to the speed of light within about a quarter wavelength. The electromagnetic field energy $E = \frac{1}{2}[\mathbf{E}^2 - c^2\mathbf{B}^2]$. In the near field, a dipole antenna field energy is primarily electric while a loop antenna field energy is largely magnetic. The average energy velocity of propagation equals the speed of light. The free-space impedance Z_0 (radiation resistance) of the vacuum to EM wave propagation is illustrated in Fig. 1-5 and depicts the mode transition from near- to far-field. Far-field impedance $Z_0 = 120\pi\ \Omega \simeq 376.7\ \Omega$. The Planck impedance Z_P is shown for comparison. In circa 350 BC, Aristotle declared the famous dictum *horror vacui* (Nature abhors a vacuum) based on the deduction that in a complete vacuum infinite speed would be possible because motion would encounter no resistance. Hence, if infinite speed was impossible, so to is a complete vacuum. The finite velocity of light in vacuo is a measure of impedance of wave energy flow ($c = 1/Z_P 4\pi\epsilon_0$). A complete vacuum devoid of a Planckian substructure as hypothesized would not support propagation of a photonic spin wave disturbance.

Light itself is a revelation. – James Turrell

If I pursue a beam of light with velocity c, I should observe such a beam of light as an electromagnetic field at rest though spatially oscillating. – Albert Einstein

Nothing is more practical than a good theory. – Ludwig Boltzmann

The ether undulates athwart the path of the wave's advance. – Robert Gascoyne-Cecil

But without a medium how can the propagation of light be explained? – Albert Michelson

The vacuum was characterized by Dirac as a state with an infinite number of zero energy and zero momentum quanta. Photon emission was considered as a transition from this vacuum state to a state of a single photon with finite momentum and energy; photon absorption consisted of the reversed transition. Schrödinger, on the other hand, in his formulation of quantum mechanics, conceived the idea of a "wave function" ψ as representing some kind of wave, and he interpreted the squared modulus $|\psi|^2$ as the density of electronic matter. For him, following de Broglie, waves were the fundamental entities. – Silvan S. Schweber

The same entity, light, was at once a wave and a particle. How could one possibly imagine its proper size and shape? To produce interference it must be spread out, but to bounce off electrons it must be minutely localized. This was a fundamental dilemma, and the stalemate in the wave-photon battle meant that it must remain an enigma to trouble the soul of every true physicist. It was intolerable that light should be two such contradictory things… – Banesh Hoffman

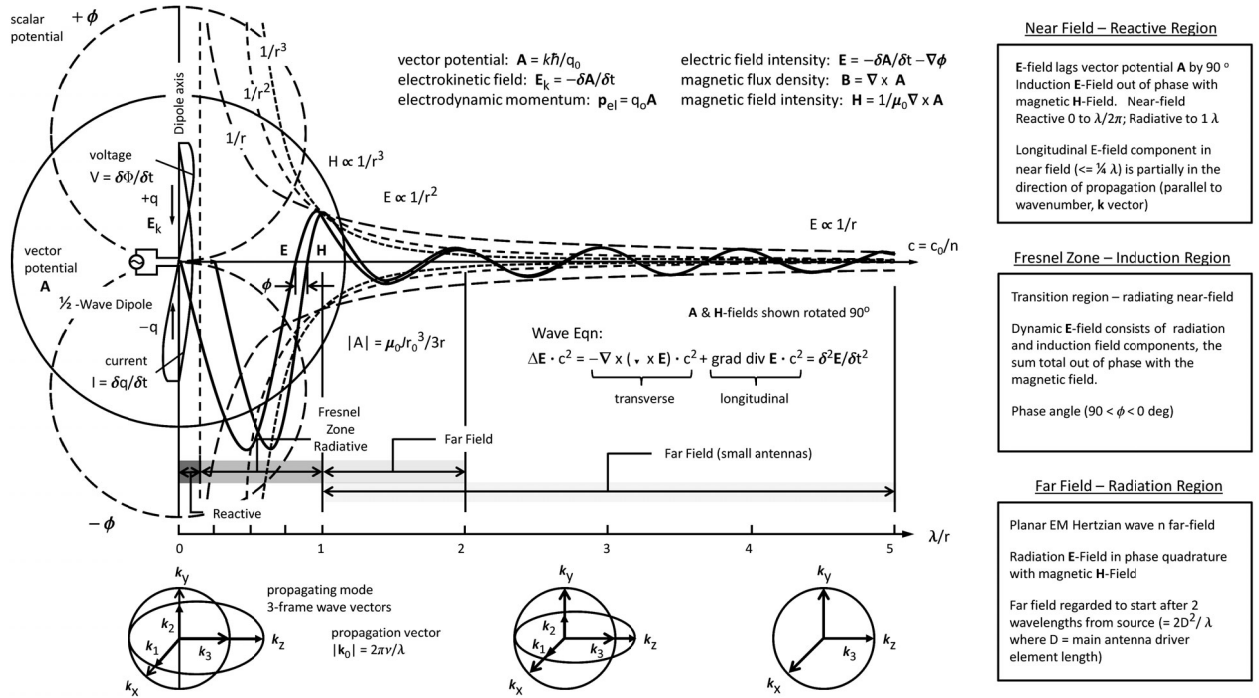


Fig. 1-4. Oscillating dipole electromagnetic wave propagation (½ wave dipole antenna at rest relative to an observer).

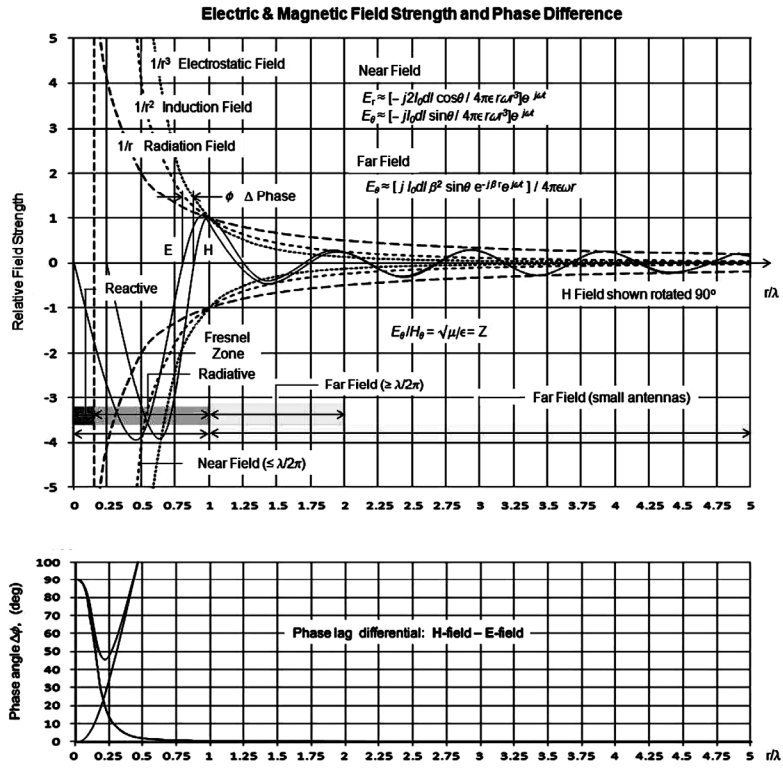


Fig. 1-5. **E** and **H** field phase lag is illustrated as a function of distance from the emitter. The phase difference falls to zero in the far field closed-loop region.

As shown in Fig. 1-6, the wave impedance ($Z_0 = |\mathbf{E}|/|\mathbf{H}|$) of electric and magnetic fields in the near field vary with frequency. The velocity of propagation becomes independent of frequency for a wave frequency much greater than the cutoff frequency ($\nu >> \nu_c$). In the transverse electromagnetic mode (TEM), the free wavelength is much greater than the cutoff wavelength ($\lambda >> \lambda_c$) and, in a dispersionless medium, the phase velocity equals the group velocity ($v_p = v_g$) for plane waves. In a waveguide at the cutoff frequency, the phase velocity is infinite and the group velocity is zero. The cutoff wavelength of the vacuum is taken as the Planck wavelength ($l_P = \sqrt{c^5/\hbar G/c^3} = 1.616 \times 10^{-35}$ m). For comparison, the impedance of an orbital electron in the 1st orbital of a hydrogen atom is given as $Z_0/\alpha = 51{,}649\ \Omega$ where α = the electron fine structure constant ($\alpha = Z_0/Z_e = v_e/c$) which reflects the ratio of the tangential speed of the electron velocity to the velocity of light. The Planck impedance is given by $Z_P = V_P/I_P = \hbar/\theta_P^2 = 1/4\pi\epsilon_0 c$ and is a quantized expression of the opposition to a change in flow of Planck charge q_P ($= e/\sqrt{\alpha}$). The Z_0/Z_P ratio ($= 4\pi$) implies a corresponding ratio of Planck mass tangential velocity to the velocity of light.

The speed of light is a constant of measure and not a constant of nature. – Konstantin Meyl

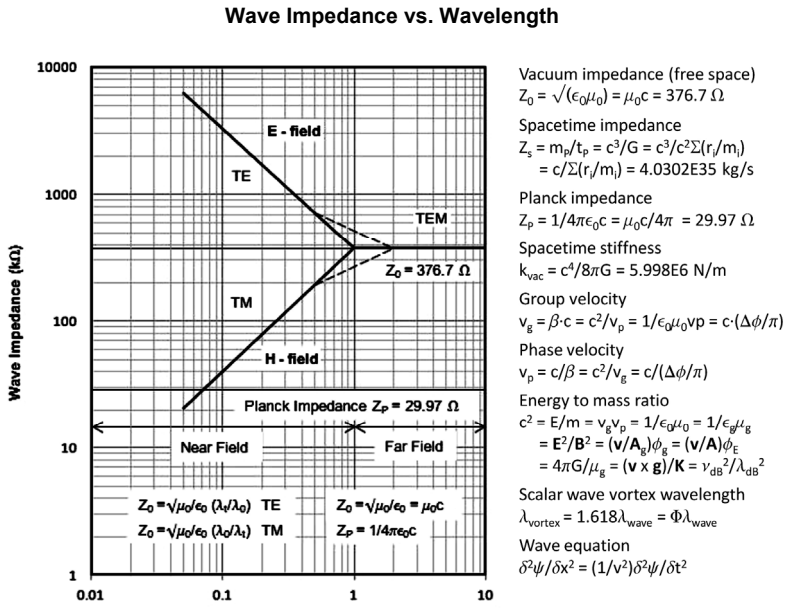


Fig. 1-6. Wave impedance (Z_0) of electric and magnetic fields in near and far fields in free-space. Wave propagation in waveguides is described by the Transverse Electric (TE), Transverse Magnetic (TM) or Transverse Electromagnetic (TEM) modes as determined by the longitudinal component. Antenna impedance at resonance equals radiation resistance.

Illustration of variation in wave vector (**k**) direction in relation to energy flow direction represented by the Poynting vector (**S**) in different types of media is shown in Fig. 1-7. In an ordinary wave, vectors **k** and **S** are aligned whereas in an extraordinary ray, the **k** and **S** vectors are not aligned. The group velocity $\mathbf{v}_g$ (the velocity of the wave group modulation envelope) is in the direction of propagation. The phase velocity $\mathbf{v}_p$ (the velocity of a point on the smaller constituent waves, e.g., zero-crossing or wave crest) is in the direction of momentum transfer. A travelling wave has a standing wave ratio SWR = 1 (no reflection) while a standing wave has an SWR > 1. In a material medium, the phase velocity v_p (= $1/\sqrt{\epsilon_0\mu_0}$) is a function of permittivity and permeability. Man-made metamaterials, such as split-ring resonators (SSRs), complimentary split-ring resonators (SCRRs), exhibit simultaneous negative permeability ϵ and permeability μ. Left-hand materials (LHMs) or negative index materials (NIMs) exhibit negative index of refraction resulting in opposed phase and group velocities. For LHMs, EM waves propagate towards the source, opposite to the direction of energy flow. A similar reverse effect occurs as well for Cherenkov radiation such as emitted when an electron passes through a dielectric medium of periodic structure comparable to the wavelength at a speed in excess of the phase velocity of light. Optical tractor beams make use of such effects to produce a negative radiation pressure pulling an illuminated object towards the source. With a zero-index material (ZRM), the phase velocity $v_p = \infty$ and the group velocity $v_g = 0$, such that no light propagates. A ZRM may be constructed, for example, by stacked layers of metamaterial with alternating positive and negative permittivity with effective zero permittivity resulting in phase velocity and wavelengths approaching infinity.

In a nondispersive medium, such as a vacuum below the Planck cutoff frequency ω_P, the group velocity equals the phase velocity ($v_g = v_p$). Non-dispersive waves (e.g., light, sound, shallow water tension waves, solitons) retain their envelope shape while their energy, momentum, and phase speed remains constant ($\omega = ck$). In a dispersive medium, waves of different wavelength travel with different speeds resulting in chromatic dispersion effects such as prismatic rainbows. In a bulk medium, chromatic dispersion results from a variation in refractive index with frequency. The phase velocity in a dispersive medium varies with frequency. For a normal dispersive medium, higher frequency components travel slower than low frequency components resulting in up-chirp. For a dispersive medium, such as water, the group velocity is greater than the phase velocity ($v_g > v_p$). Dispersive waves (e.g., deep water gravity waves, capillary waves) broaden as they propagate. The group velocity of the wave is usually the observed velocity and is the velocity at which energy is transmitted. Zero dispersion can occur when the material and waveguide dispersion cancel, an effect significant in fiber optics. Pulse broadening may also occur as a result of modal dispersion in waveguides.

For a light pulse propagating in an anomalous dispersive medium (ADM), higher frequency wave components travel faster than slower components producing down-chirp. The velocity of light is not necessarily *semper et ubique* a fixed upper limit. In a medium with anomalous dispersion, under some circumstances, the group velocity of a narrow-band pulse may exceed the velocity of light ($v_g > c$). This apparent contradiction with relativity theory is explained as causality is preserved as it is the signal front velocity v_f that is limited to the speed of light c and it is the signal wave front that conveys information, not necessarily the wave peak. Anomalous dispersion occurs when the frequency of incident light is approximately equal to the absorption resonance frequency of the medium. In a non-linear optical medium, an AC Kerr effect can give rise a self-induced phase modulation and frequency shift produced by change in the refractive medium by the electric field of the light wave. For a narrow-band pulse in a anomalous dispersive medium, the pulse peak becomes shifted towards the signal front as the pulse propagates. As a result, the peak of the pulse envelope described by the group velocity becomes larger than front velocity ($v_g > v_f$) which propagates at c. Under resonance conditions, the group velocity v_g may be positive or negative, subluminal or superluminal. Pulse propagation in non-dispersive, dispersive and anomalous dispersive medium are compared in Fig. 1-8.

Polarization of light, by convention, refers to the direction of the transverse vibration plane of the electric field. For unpolarized light, there is no preferred transverse direction. Polarized light may be linear, elliptical or circularly polarized depending on the rotation and amplitude of the electric field vector. A superposition of left- and right- hand circularly polarized photons can give rise to a light wave with linear polarization such that there is no net angular rotation. A circularly polarized beam exhibits a constant angular rotation as viewed along the axis of propagation with constant amplitude. A circularized polarized beam may be realized by out-of-phase superposition of two circularly polarized waves. If the amplitude varies with rotation, the beam is elliptically polarized. Polarization states of an electromagnetic wave may be described by a two-dimension complex (Jones) vector or represented on a Poincaré sphere such as shown in Fig. 1-9. For fully polarized light, the polarization state point lies on the surface; partially polarized states lie within the sphere.

All the fifty years of conscious brooding have brought me no closer to the question, "What are light quanta?" Of course today every rascal thinks he knows the answer, but he is deluding himself. – Albert Einstein

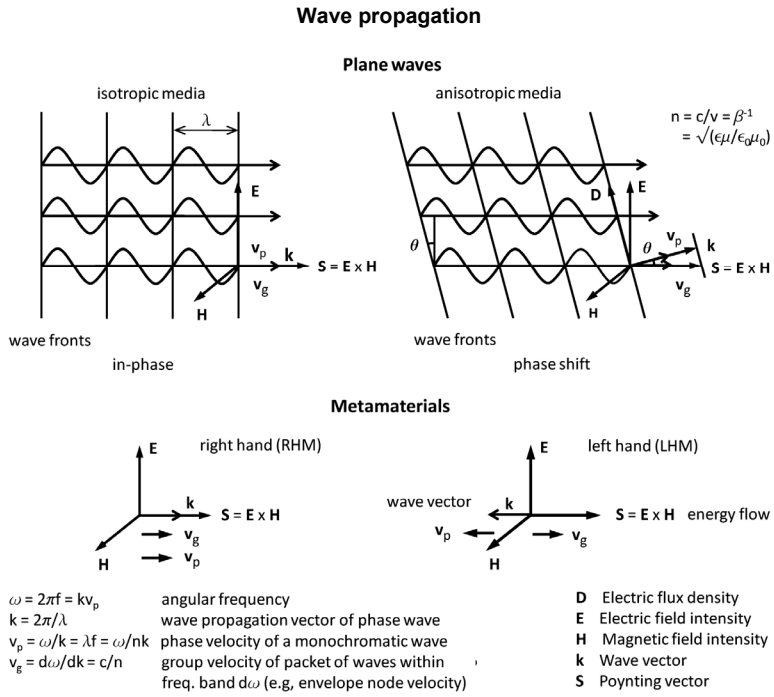


Fig. 1-7. Wave vector **k** defining the direction of planes of constant phase is, in general, not in the same direction as the energy flow vector **S** direction and depends on the type of media. Plane waves in isotropic media which are in-phase have wavefronts perpendicular to the direction of propagation. In anisotropic media, plane waves which are phase shifted have wavefronts that are inclined to the direction of propagation. Unlike right-hand metamaterials, left-hand metamaterials exhibit wave vectors opposite to the direction of energy flow. Chiral metamaterials allow for torsional deformation. A plane wave of definite wave vector **k** and polarization s has no localization in space or time and, hence, may be regarded as a one-photon state distributed over spacetime. A photon may be approximately localized in the form of a wave packet centered at a given location at a given time. A quantum mechanical n-photon Fock state $|n\rangle$ corresponds to a discrete number of field excitations $|\mathbf{k}_1 s_1, \mathbf{k}_2 s_2 \ldots \mathbf{k}_n s_n\rangle$ where $\mathbf{k}_i$ is the wave vector and s_i the polarization for a given mode generated by repeated action of creation operators $\hat{a}^\dagger$ on the ground state $|\psi_0\rangle$.

I insist upon the view that 'all is waves' – Erwin Schrödinger

The Schrödinger equation came as a great relief, now we no longer had to learn the strange mathematics of matrices. – George Uhlenbeck

If I were there I would, as in the case of the Zeeman effect, plead for a formal dualistic theory; everything must be describable both in terms of the wave theory and in terms of light quanta. – Werner Heisenberg

There are only three basic actions needed to produce all of the phenomena associated with light and electricity. – R. P. Feynmann

17. Electron Model

The electron can no longer be conceived as a single, small granule of electricity; it must be associated with a wave, and this wave is no myth; its wavelength can be measured and its interferences predicted. – Louis de Broglie

There was a time when we wanted to be told what an electron is. The question was never answered. No familiar conceptions can be woven around the electron; it belongs to the waiting list. – Arthur Eddington

We can therefore say that we have now reached a theoretical understanding of the existence of the electron, but in no way that of its constitution. – Pascual Jordan

The magnetic cleavage of the spectral lines is dependent on the size of the charge of the electron, or, more accurately, on the ratio between the mass and charge of the electron. – Pieter Zeeman

The bridge between the electron and other elementary particles is provided by the fine structure constant, $\alpha \sim 1/137$, as manifested in the factor-of-137 spacings between the classical electron radius, electron Compton radius, and the Bohr radius… – Malcolm H. MacGregor

A number of torus ring electron models have been previously proposed including those by Compton[44], Allen[45], Thomas[46], Jennison[47], Bergman/Wesley[48,49], Hestenes[50], Williamson / van der Mark[51], Kanarev[52,53], Winterberg[7], Ginzburg[54], Carroll[55], Heaston[56], Lucas[57], Rivas[58], Gauthier[59], Klyushin[60] and others in addition to a variety of disc and spherical wave models by Crane, Macken, Wolf, Haselhurst, Tomes, Cabala, LaFreniere, MacGregor, Tewari, Ghosh, etc. In superstring theory, the electron is represented as a closed loop with size on the order of the Planck scale with no explanation of electric charge. What discriminators may be applied to determine which of the proposed models best represents the observed reality? The ability to account for pair production and annihilation presents a critical test. It is experimentally observed that energetic photon(s) and electrons/positrons may be interconverted in pair production/annihilation processes. The geometrical transformation of an energetic photon into an electron/positron pair must be mathematically demonstrable. Likewise, the emission of a pair of photons with opposite momenta resulting from the annihilation of an electron and positron must be shown to be geometrically possible for a plausible model. The creation of electric charge and rest mass during electron/positron formation must be explained and calculable. The observed physical properties of the photon, electron and positron must be accounted for and quantified.

A photon wave-train is described as a helicoid in a twisted ribbon travelling wave geometrical model. A closed-loop double loop Hopf strip may be formed from a ribbon with a full twist. An eccentric hula-hoop motion of a Hopf strip generates a swept volume toroidal envelope corresponding to a closed-loop sanding wave. See Fig. 17-1. An example of a torus ring model is depicted in Fig. 17-2 illustrating an electron consisting of two orthogonal spinors generated by a rotating Hopf link corresponding to a poloidal and toroidal current loop. The charge trajectory is described by a precessing Hopf link, the simplest form of knot, embedded in a torus manifold created by eccentric motion.

It has to do with electrons. You know, the little things that whirl in space.
Never heard of them. – Dr. Stanton (Riders to the Stars)

You know, it would be sufficient to really understand the electron. – Albert Einstein

Electron-positron pair production requires electric fields greater than the Schwinger field critical value $E_{cr} = m^2c^3/e\hbar \cong 1.3 \times 10^{18}$ V/m sufficient to provide the required rest mass energy. Pair production occurs by decay of a sufficiently energetic photon near an atomic nucleus $\gamma \rightarrow e^- + e^+$ or through photon-photon interaction via Breit-Wheeler decay $\gamma\gamma \rightarrow e^+e^-$ such as a probe photon propagating through a polarized short-pulsed electromagnetic field. Photons (gamma rays) may be generated in a reverse annihilation process by collision of an electron and positron $e^+e^- \rightarrow \gamma\gamma$. An inelastic collision of a photon with a free electron results in Compton scattering with a result momentum transfer altering the photon wavelength. Acceleration or deceleration of an electron results in photon emission such as EM radio wave emission at low energy or Bremsstrahlung emission, synchrotron radiation, or Cherenkov radiation at high energy with photon energy proportional to frequency.

The classical electron radius r_e also known as the Thompson scattering length is derived by assuming the electron is a sphere with uniform charge density and equating the potential energy of charged sphere $E_p = c^2/\pi c_0 r^2$ with the electron's rest mass energy $E = m_0c^2$ and solving for radius r. The resultant value of this estimate is 2.8179×10^{-15}m. For comparison, the calculated Compton wavelength λ_C of 2.4263×10^{-12}m as determined from scattering experiments yields a reduced Compton radius R_C ($= \lambda_C/2\pi$) of 3.8616×10^{-13}m.

Remarkably, an electron, a spin ½$\hbar$ fermion with quantized electric charge (e^-) and positive rest mass ($m_e = 0.511$ MeV/c^2), may be created from an energetic photon, a spin ±1 $\hbar$ boson with no electric charge or rest mass. A toroid configuration of the electron has long been posited to account for the observed physical properties such as quantized electric charge, magnetic moment, g-factor, spin angular momentum, etc. The electron's wavefunction ψ may be represented as consisting of two spinor components one with right-hand and one with left-hand helicity. An example of a model electron formed from a single wavelength helical photon topologically confined into a torus configuration is shown in Figs. 17-3 through 17-9. In this model, the helical path of a photon is in the form of Hopf link which under rotation traces out a trajectory path of toroidal geometry. The electron has a magnetic dipole moment $\boldsymbol{\mu}_s$ as a result of its intrinsic spin angular momentum **S** ($= \hbar[½(½ + 1)]^{½}$). In the ansatz model considered here, the electron has both a toroidal spin and poloidal spin component. If there were no spin-spin interaction of the toroidal spin angular momenta S_o and the poloidal spin angular momentum S_r, the orientation of one vector would be independent of the other.

The electron in the toroid model illustrated has both toroidal rotation and poloidal rotation such that the **EHV** triplet charge path develops two internal rotations for each toroidal rotation. The toroidal radius corresponds to the reduced Compton radius ($R_C = \lambda_C/2\pi$). The tangential velocity of rotation v_t equals the velocity of light c ($v_t = R_C\omega_C$). Due to the increased magnetic field, the orbital charge velocity internally varies from superluminal at the orbital periphery to sublight velocity at the spin center. The ½$\hbar$ spin characteristic of the electron arises from the ratio of the Compton and Zitterbewegung rotational frequencies ($\omega_C/\omega_{zbw} = ½$) resulting in the observed net spin in a reference frame at rest with the observer.

The fundamental fact of electron theory, the existence of discrete electrical particles, thus manifests itself as a characteristic quantum phenomena, namely as equivalent to the fact matter waves only appear in discrete quantized states. – Pasqual Jordan

Nobody has ever seen an electron. Nor a thought. – Robert A. Heinlein

Zitterbewegung: what happens when you take too much coffee. – Prof. Rabindra Mohapatra

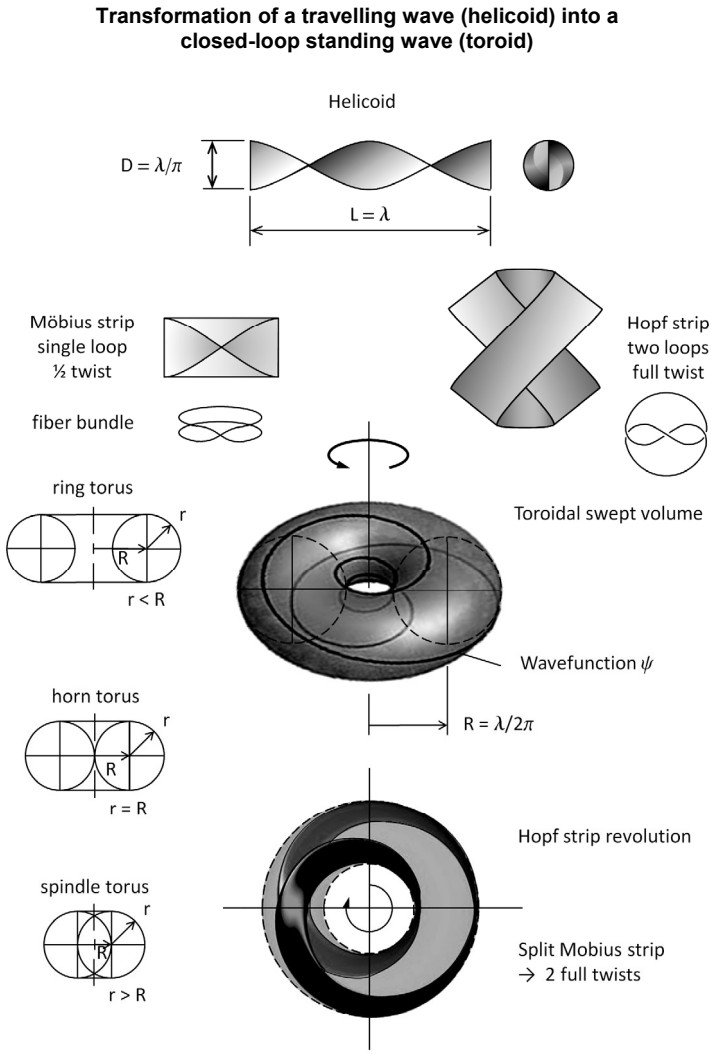
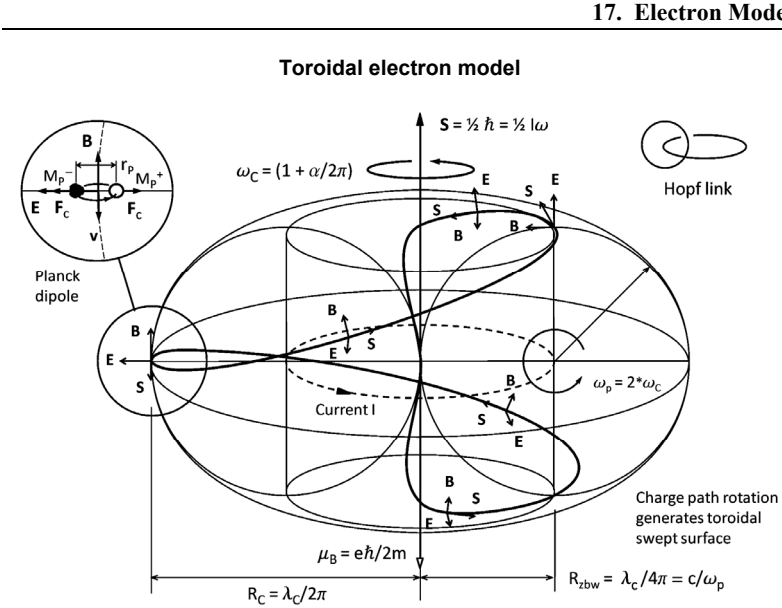


Fig. 17-1. Illustration of a rotating closed-loop Hopf link formed from a twisted ribbon (helicoid) embedded in a torus of revolution. Such a geometry exhibits a ½ spin characteristic, i.e., a 720° rotation is required to return to the starting position. Similarly, a spin 1 photon (a travelling wave of helical geometry) may be transformed into a spin ½ electron (a closed-loop standing wave of toroidal geometry). Electric charge (spin precession) corresponds to a torsion field dislocation defect (loop closure failure).

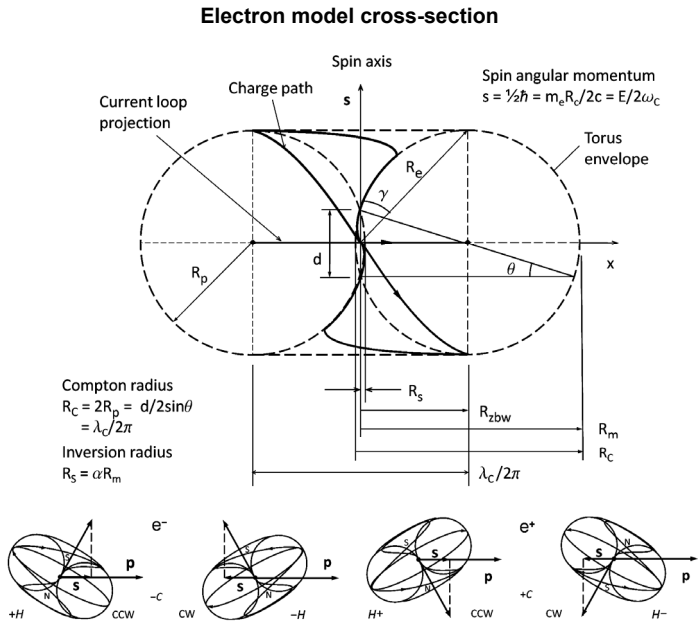
The only thing you can say about the reality of the electron is to cite its mathematical properties. – Martin Gardner

As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain they do not refer to reality. – Albert Einstein



Parameter	Symbol	Relation	Value	Units
Electric charge	e	$= \mathbf{F}/\mathbf{E} = \mathbf{F}_k/\mathbf{E}_k = \hbar\mathbf{k}/\mathbf{A} =$ $= E/V = \mathbf{p}/\mathbf{k}\cdot\mathbf{A} = \sqrt{(\alpha q_P^2)}$ $= m(\omega_C + \omega_p) \simeq m\omega_C$	1.60217E-19 7.019E-10	Coul kg·rad/s
Mass	m_e	$= E/c^2 = \hbar/c\cdot R_C = \lvert V\cdot q\rvert/c^2$ $= \hbar\mathbf{k}/\mathbf{v} = e/(\omega_C+\omega_p) \simeq e/\omega_C$	9.10938E-31	kg
Compton wavelength	λ_C	$= h/mc = h/p$	2.4263E-12	m
Compton frequency	f_C	$= mc^2/h = c/\lambda_C = \omega_C/2\pi$	1.2355E20	Hz
Compton radius:	R_C	$= \lambda_C/2\pi = \alpha a_0 = \sqrt{(E/m\omega^2)}$	3.8616E-13	m
Compton angular frequency	ω_C	$= c/R_C = mc^2/\hbar \simeq e/m$	7.7634E20	rad/s
Zitterbewegung angular frequency	ω_{zbw}	$= 2\omega_C$	1.5527E21	rad/s
Precession frequency	ω_p	$= \omega_{e/m} = q/m = \alpha\omega_C$	1.7588E11	rad/s
Spin angular momentum	**s**	$= ½\hbar = i\boldsymbol{\omega} = ½m_eR_C^2\boldsymbol{\omega}$	5.2725E-5	J·s
Bohr magneton	$\boldsymbol{\mu_B}$	$= e\hbar/2m$	9.274E-24	J/T
Rest Energy	E	$= \hbar c/R_C = m_0c^2 = m\phi$	8.187E-14	J

Fig. 17-2. Toroidal electron is formed by a topologically confined photon inside the Compton radius as a result of imbalance of electrostatic and magnetostatic energy. The charge path represents a spin wave phase alignment of entrained Planck dipoles, the rotation of which generates a toroidal form. The propagation of the rotating spin wave describes a current loop of radius equal to one half the Compton radius.



Parameter	Symbol	Relation	Value	Units
Charge radius	R_e	$= \sqrt{(2\lambda_C/4\pi)} = R_{zbw}/\sin\gamma$	2.7305E-13	m
Classical electron radius	R_0	$= (1/4\pi\epsilon_0)\ e^2/m_e c^2$ $= k_e(e^2/m_e c^2)$	2.8179E-15	m
Compton radius	R_C	$= \lambda_C/2\pi = \alpha a_0 = h/2\pi mc$	3.8616E-13	m
EM radius	R_{em}	$= \hbar/mc^2 = R_m$	1.2880E-21	m
Helix radius	R_{photon}	$= R_{helix} = \lambda_C/2\pi$ $= \sqrt{(E/m_e{\cdot}\omega^2)}$	3.8616E-13	m
Mass radius (max)	R_m	$= \hbar c/E = \hbar/mc$	3.8613E-13	m
Poloidal radius	R_p	$= R_m/2$	1.9308E-13	m
Spindle (inversion) radius	R_S	$= R_C - R_m = \alpha R_m$	2.6983E-17	m
Toroidal radius	R_t	$= R_C(1 + \alpha/2\pi)$	3.8616E-13	m
Zitterbewegung radius	R_{zbw}	$= \langle R_m \rangle = \lambda_C/4\pi = \hbar/2mc$ $= c/2\omega_C = R_e \sin\gamma$	1.9308E-13	m

Fig. 17-3. Characteristic dimensions of electron torus model. The toroidal circumference corresponds to the Compton wavelength λ_C of the confined photon. The electron Compton radius is $R_C = \lambda_C/2\pi = (\lambda_C/\alpha^{-1})/\theta_{137}$. Electron charge (a torsion defect due to loop closure failure) is a result of a slight spin precession with whirl no. $= \alpha^{-1}$ where α = fine structure constant. Electron mass results from wave function interference due to spin precession.

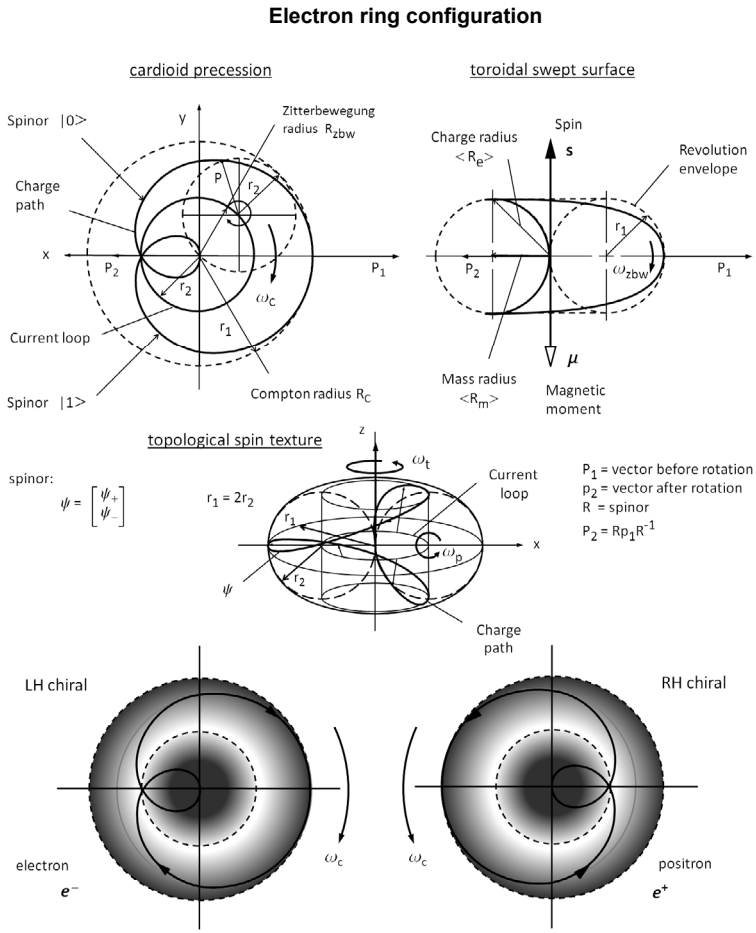


Fig. 17-4. Electron depicted as precessing epitrochoid charge path composed of two orthogonal spinors describing a rotating Hopf link with toroidal and poloidal current loop components of 2:1 rotary octave. Rotation of the charge path generates the torus geometry. The spin ratio of the Compton angular frequency ω_C and the Zitterbewegung angular frequency ω_{zbw} (= $2\omega_C$) corresponds to observed spin of ½. Precession induces an internal magnetic field that is stronger by a factor of α^{-1} than the spin induced magnetic field external to the Compton radius aligned along the spin direction.

How electrons are made has not yet been determined. – Oliver Heaviside

To the electron…May it never be of any use to anybody. – J. J. Thomson (Cavendish Lab toast)

I now believe in the idea of the self-rotating electron. – Wolfgang Pauli

How can one look happy when he is contemplating the anomalous Zeeman effect? – Wolfgang Pauli

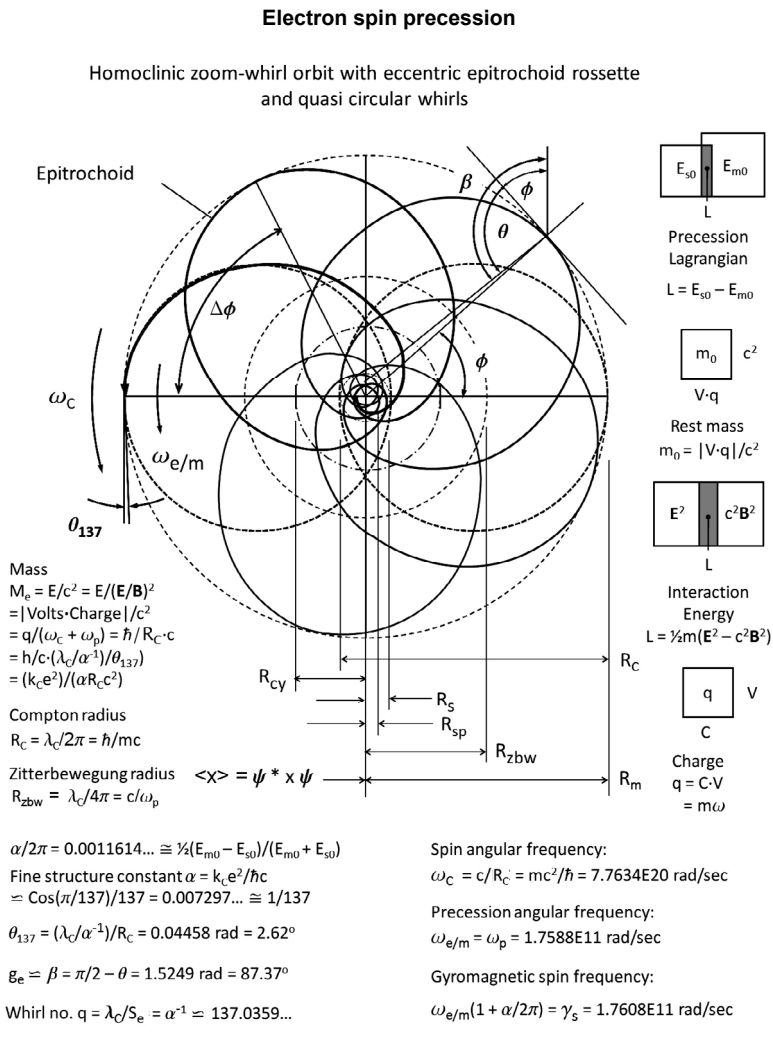


Fig. 17-5. In the electron model illustrated, electron spin precession $\omega_{e/m}$ is due primarily to imbalance of electrostatic and magnetostatic energy resulting in an eccentric whirl orbit of the charge path about the spin axis. The precession follows a zoom-orbit whirl with a periapsis advance θ_{137} that is a function of the fine structure constant α and the Compton radius R_C. Synchronization occurs every α^{-1} revolutions. The Thomas precession frequency ω_T is approximately equal in magnitude to Compton angular frequency ω_C. Electron rest mass m_0 equals E/c^2 ($= |V \cdot q|/c^2 \simeq \hbar/a_0 ca = e/\omega_C$). Electric charge $q = \hbar\mathbf{k}/\mathbf{A} = C \cdot V = \mathbf{p}/\mathbf{k} \cdot \mathbf{A}$ where $\mathbf{k}$ = wave no., $\mathbf{A}$ = vector potential, C = capacitance, V = voltage, $\mathbf{p}$ = momentum.

In quantum theory, mass corresponds to the periodicity of waves. – Arthur Eddington

The rigid electron is no working hypothesis, but a working hindrance. – Hermann Minkowski

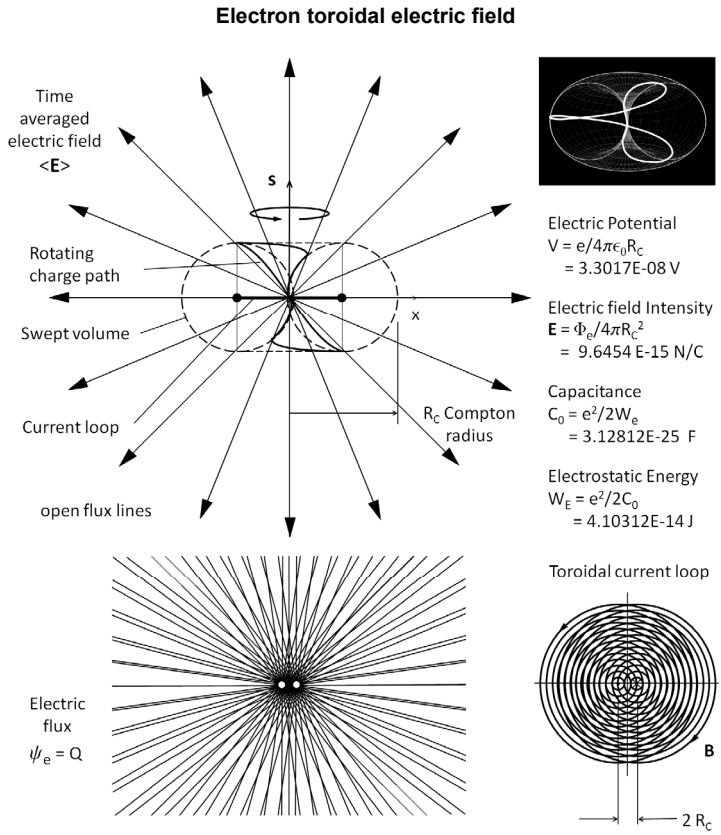


Fig. 17-6. Electrostatic **E**-field of the electron shown time-averaged over one rotation period. For a positron, the electric flux lines ψ are directed radially inward. At distances greater than the Compton radius R_C, the electric flux distribution is spherically symmetric equivalent to a point charge for an electron in an inertial reference frame. The instantaneous electric field **E** vector is represented as a Hopf strip embedded in a torus. The toroidal surface is generated by rotation of the Hopf link formed of poloidal and toroidal currents. For a physical vacuum composed of Planck dipoles, the electric flux lines of the **E**-field represent momentary synchronous alignment of positive M_P^+ and negative M_P^- Planck masses.

Charge is certainly a well-characterized attribute, but the question: "What is charge?" is presently unanswerable. – Riccardo C. Storti

A full theory of the dynamics of the electron depends upon assumptions concerning its structure, an unsolved problem. – William Berkson

I believe that the development of the theory along the correct lines will then lead to a numerical value of the fine-structure constant $\alpha = e^2/\hbar c = 1/137$, and to an explanation of the fact that arbitrarily high masses do not appear concentrated in a given region of space region in nature. – Wolfgang Pauli

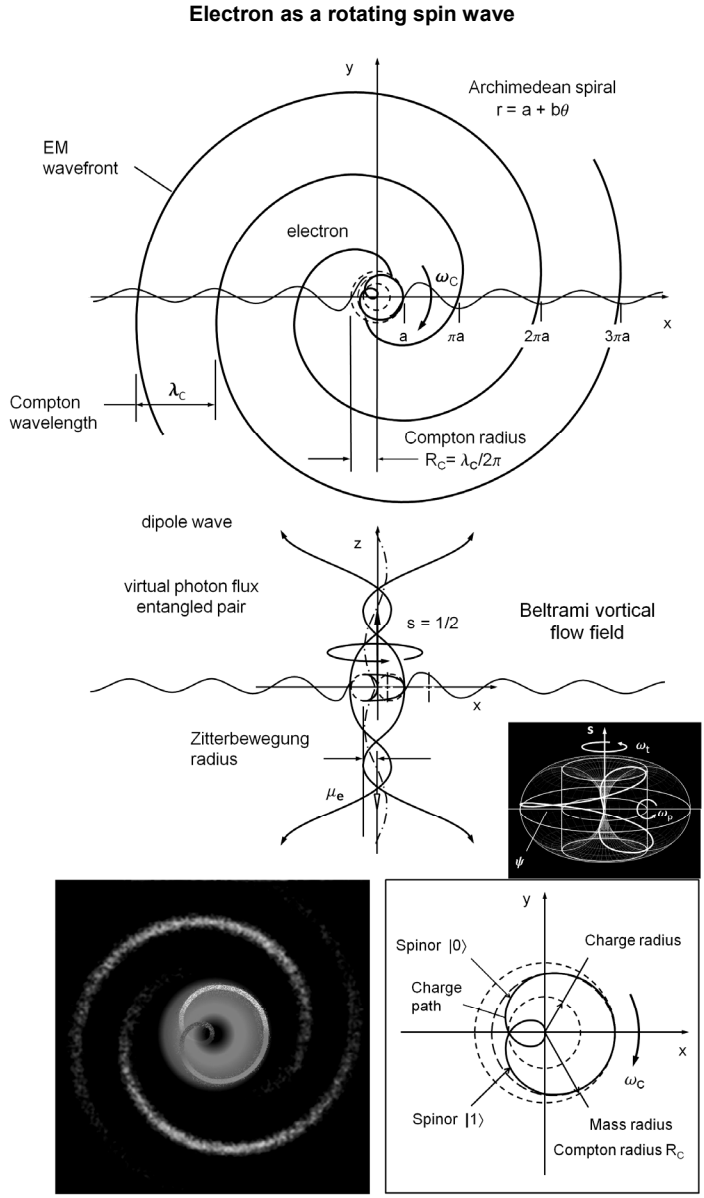


Fig. 17-7. The electron continuously generates a dipolar spin wave at the Compton frequency f_C (= mc^2/h = 1.236E20 Hz). The electron acts as a spinning dipole antenna with virtual radiation emission of a pair of entangled wavefronts along the spin axis. Viewed along the spin axis, the dipole waves describe an Archimedean spiral. Virtual photons are continuously emitted and absorbed and, like unobservable Cheshire cats, appear to wink in and out of existence – but have a measurable zero point energy effect en masse.

Electric field of an oscillating electron

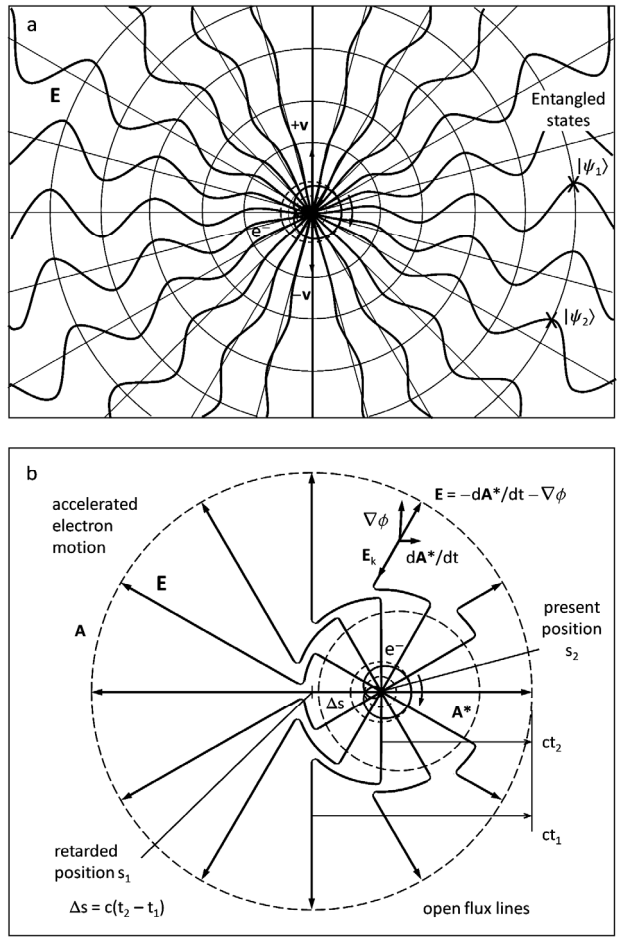


Fig. 17-8. Oscillation of the electron at frequencies less than the Compton frequency f_C in response to an external electromagnetic field results in generation of observed EM waves in synchronicity with the imposed frequency. In a) is depicted vertical sinusoidal oscillation. Horizontal acceleration over an interval Δt is illustrated In b) showing a propagating spherical disturbance with farfield flux pointing in the direction of the retarded initial starting position. Entangled states represent different points on the same wavefront and, hence, share properties of energy, momentum and polarization. Measurements of particle states are thus correlated as they are sampling the same wavefront. Hence, no superluminal influence or "spooky action at a distance" is involved in perceived entanglement. An 'observer' is simply an interacting object being acted upon – No consciousness is required.

All matter is simply undulations in the fabric of space. – William Clifford

All forces are consequences of geometry. – Timothy Ferris

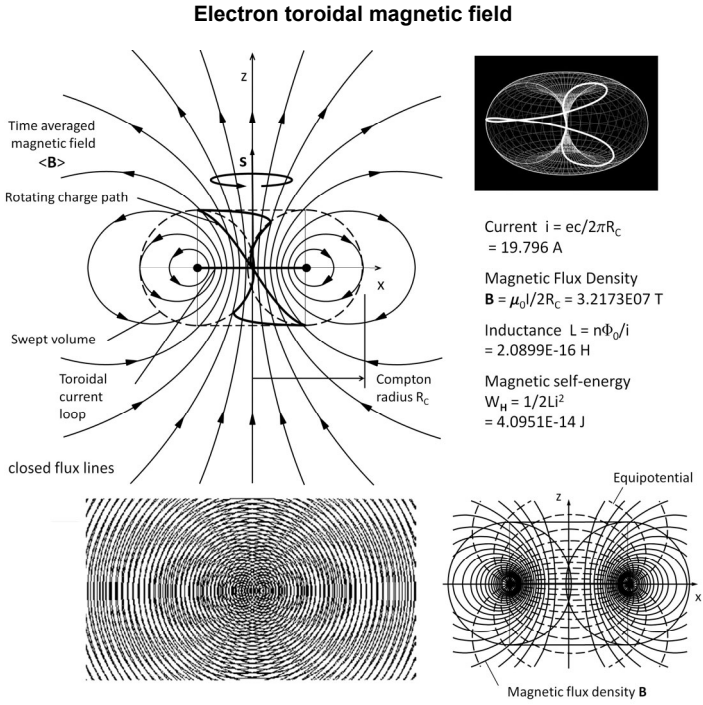


Fig. 17-9. Magnetostatic **B**-field of the electron is shown time-averaged over one rotation period. The external magnetic field flux configuration is toroidal while the internal magnetic field is poloidal. Magnetic flux is concentrated in a pinch zone in the central region creating a concentration of potential magnetic energy density. The magnetic flux lines represent filaments of vortical rotation of Planck dipoles of the physical vacuum. The external magnetic field corresponds to the interference pattern of the current loop magnetic flux. Spin precession results in wave field interference and generation of mass.

The electron, in a sense, may be considered as a form of a primitive electrical machine consisting of an electric circuit linked with a magnetic circuit similar to a transformer or electric motor. See Fig. 17-10. The electromotive force (e.m.f.) in an electric circuit equals current x resistance. The magnetomotive force (m.m.f.) in a magnetic circuit equals flux x reluctance which is proportional to the product of current and number of turns or ampere-turns. Electrical power produced in the electric current loop is the product of electromotive force ($\mathcal{E}$ = e.m.f.) and current (I). In an electron, the estimated electrical power (P = V·I) is $\cong$ 5.1096 x10^5 watts. As shown by Macken[20], the circulating electrical power ($P_c = E_i\omega_C = \omega_C^2 \cdot \hbar$) in an electron is $\cong$ 6.355 x 10^7 watts. Maximum current induced by the magnetic flux for a given e.m.f. occurs when electric circuit resistance (R) and magnetic circuit reluctance ($\mathcal{R}$) are both minimized. Maximum magnetic flux (ϕ_B) is realized for a given current (I) with minimal reluctance. The electric current I (= dQ/dt) or equivalently, the magnetic vector potential **A,** represents mass motion of Planck dipoles in a spin density wave. Electric charge e [Q] is dimensional equivalent to mass•radians/unit time [$M\Phi T^{-1}$].

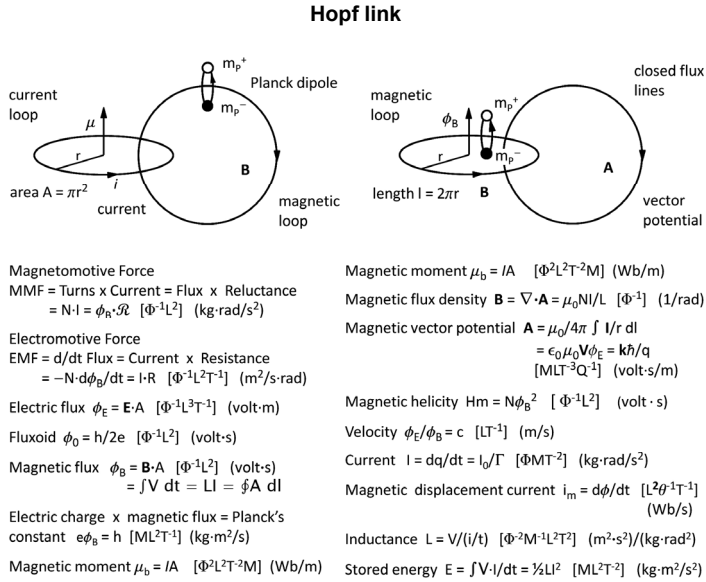


Fig. 17-10. An electron represented schematically as a primitive electrical machine linking a super-conducting electric circuit with a magnetic circuit resembles a transformer. Two interconnected loops (fiber bundles) form a Hopf link. The magnetic flux density **B** (= $-\nabla\phi_B = \nabla\cdot\mathbf{A}$), the gradient of the magnetic scalar potential ϕ_B (= LI = $\int V dt = \oint \mathbf{A}\cdot d\boldsymbol{l}$), represents vortical motion of spin chains of Planck dipoles with dimension of inverse radians [Φ^{-1}]. Broken magnetic flux lines reconnect to form closed loops.

A single electron represents a vast store of internal energy with a rest energy of 0.511 MeV/c^2, an electric current of 19.7 Amperes and an electric power estimated at 5.109E05 Watts. The electron shrinks in size with increasing kinetic energy and, thus, appears as a point object when probed at high energy. The change in poloidal diameter is a measure of the individual temperature of an electron[61]. With spin-oriented electrons trapped in metamaterial quantum wells, might it be possible to synthesize an electron-like artificial spin wave with an excess of magnetostatic energy over electrostatic energy that precesses to generate electric charge? For example, if a surfeit of electrons is confined in a superlattice of oriented, layered graphene sheets and subjected to rotation, an expanding and contracting Moiré pattern results changing the energy density in a periodic fashion. The diffraction patterns form an adjustable fractal antenna allowing coupling to external photonic fields. Connected to an external resonant LC circuit, the electron oscillations may be converted to EM waves or conversely, as in a dielectric, electrons may be excited in resonance with incident EM waves. To reproduce Maxwell's results of electrical disturbances in dielectrics producing transverse waves, Helmholtz deduced that the vacuum must be polarizable electrically and magnetically. If there were any resistance to vacuum polarization, longitudinal waves would result in addition to transverse waves. In a material dielectric, the movement of electrons result in self-induction interaction and magnetic interference thus decreasing the local velocity of light and increasing the index of refraction.

The size and energy content of the electron varies with motion as a function of the Lorentz factor γ. As illustrated in Fig. 17-11, the electron represented as a standing wave resonator undergoes a Lorentz contraction in the direction of motion. An electron shrinks in size as energy of motion increases as a function of the Lorentz factor γ $(= 1/\sqrt{(1 - (v/c)^2)})$. The electric permittivity ϵ $(= \epsilon_0/\sqrt{g_{00}})$ and magnetic permeability μ $(= \mu_0/\sqrt{g_{00}})$ vary with the GR metric coefficient g_{00}. In a gravitational field, an equivalent relation holds as the gravitational gamma $\Gamma = dt/d\tau = 1/\sqrt{(1 - (2GM/c^2R))} = 1/\sqrt{g_{00}} = 1/\sqrt{(1 - (v_e/c)^2)}$ where t = coordinate time (stationary metric), τ = proper time, R = radial distance and v_e is the escape velocity of the central mass M. The EM energy density in a polarizable vacuum may be represented by a scalar vacuum index of refraction index K_{PV} $(= \Gamma^2 = 1/g_{00})$.

The mechanism for storage of energy and re-radiation by an electron under acceleration is elucidated in a theory of forces developed by Bergman[48]. To briefly summarize, the electric field amplitude during acceleration undergoes relativistic contraction and the electron decreases in size (radius $R = R_0/\gamma$) as energy acquired increases ($E = \gamma E_0$). Magnetic induction ($E = -\phi/dt$) stores energy in the surrounding electromagnetic radiation field. See Fig. 17-12. The radiation field corresponds to the induced EM field asymmetry under acceleration. A measure of the local field distortion is represented by the non-orthogonality of the **E** and **H** vectors. The magnetic energy E_m, electrostatic energy E_s, inductance L and magnetic flux ϕ_m increase by the Lorentz γ factor. The increase in magnetic energy density is equivalent to an increase in magnetostatic pressure acting to reduce the size of the electron. The change in electron radius, mass, flux, inductance, capacitance and energy as a function of velocity ratio β and Lorentz factor γ is shown in Figs. 17-13 through 17-18. The Schwinger correction[61] for spinning mass is given by $m_s = m(1 - \alpha/2\pi)$ in which the electromagnetic mass $\Delta m = m \cdot \alpha/2\pi$ where α is the fine structure constant. In the toroid electron model illustrated, the additional mass due to the magnetic field ($\Delta m = m_e\alpha/2\pi$) results in a reduced Compton radius ($R_C' = \alpha R_C = \alpha\hbar/mc$). The magnetostatic energy E_{m0} is reduced $E_{m0}' = E_{mo}(1 - \alpha/2\pi)$ while the electrostatic energy is increased $E_{s0}' = E_{s0}(1 + \alpha/2\pi)$. Langragian energy $L = E_{s0}(1 + \alpha/2\pi) - E_{m0}(1 - \alpha/2\pi)$.

The combined matter wave of a coupled pair of electrons (superconducting Cooper pairs) corresponds to a partially overlapping superposition of wave functions with length and peak amplitude greater that that of a single electron in isolation. This effect enables tunneling of pairs of electrons through an insulating barrier of a few nanometers thick between two superconducting wires that would otherwise impede current flow of single electrons. This effect is utilized in a Josephson junction superconducting tunneling current switch. On-off current flow is electromagnetically controlled via an external magnetic field in an adjacent control wire enabling very fast switching speeds of up to ~10 terahz (THZ).

De Broglie's ideas were for a free electron by itself, and Schrödinger extended them to apply to an electron moving in an electromagnetic field. – P.A.M. Dirac

Einstein suggested that mass might be an interrelation between electromagnetic and gravitational fields. – A.R. Weyl

No, It's quite impossible for the electron to have spin. – Hendrik Lorentz

I would rather know what an electron is. – Albert Einstein

Light travels with the velocity of light. That's a nice sentence. – Prof. Rabindra Mohapatra

Time reversal goes with inversion of energy and mass. Consequently, there are two kinds of antimatter of opposite mass. – Jean-Pierre Petit

33. Gravitation

Sir Isaac Newton when asked how he discovered the law of gravity is said to have replied "By thinking about it all the time." – Isaac Newton

I consider it quite possible that physics cannot be based on the field concept, i.e., on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics. – Albert Einstein

If you have built castles in the air, your work need not be lost; there is where they should be. Now build your foundations under them. – Henry D. Thoreau

33.1 Gravity of the matter

Gravitation in a quantum gravity theory is a result of resonant electromagnetic (EM) wave interactions in a polarizable vacuum (PV) with a variable refractive index. Unlike the geometric spacetime curvature assumed in the Einstein Theory of General Relativity (GR), gravitation in the Puthoff *et al* PV model[29,30] is described instead by variation in EM wave energy and density due to local variation in the vacuum refractive index K_{PV}. The PV theory was proposed by H. Wilson[27] in 1921 and later developed by R.H. Dicke[28] in 1957, Puthoff[30] and Krogh[32]. The refractive index n is a ratio of the phase velocity v in a medium to velocity of light c in a gravity-free, zero curvature vacuum (n = c/v). Variable vacuum electric permittivity and magnetic permeability results in a variation in the speed of light providing an explanation of bending of light and gravitational attraction in terms of local scalar ϵ and μ fields. Einstein, in 1911, initially proposed a gravitation theory with a variable speed of light as a function of potential, but later in 1916, settled for a purely mathematical GR metric description[35] in which particles move along geodesics without a defined causal physical mechanism for means by which mass-energy curves spacetime. This metaphysical theory, further refined in 1918, uses a metric tensor field to describe both spacetime geometry and gravitation without a physical explanation. In lieu of an unexplained mechanism for assumed "bending" of spacetime (e.g., alteration in space (contraction) and time (dilation) in accelerated inertial frames), the Lorentz contraction in the Ivanov-LaFreniere wave model[36,37,38] refers instead to a physical EM wavelength contraction (compression of the nodal distance) and frequency reduction of a standing matter waves in motion. 4D spacetime remains invariant. A variation in the vacuum dielectric constant K_{PV} provides the mechanism for alteration in wavelength which occurs in quantized multiples of wavelength. The EM wavelength contraction and frequency shift in a polarizable vacuum accounts for mass in motion and gravitational effects including the energy change, deflection of light, gravitational frequency shift and clock slowing.

The gravitational attraction between masses modeled as EM oscillators, as shown by Ivanov, is the result of an arrhythmia (frequency pulling effect) due to a difference in frequencies. Mass represents a resistance to frequency change. An energy flow occurs from the oscillator with higher frequency to the lower frequency oscillator as a clock synchronization effect between coupled oscillators. The energy flow between masses is transmitted via electromagnetic waves in a standing wave interaction (mode-locking) between coupled oscillators. The acceleration of gravity is developed within each mass in response to the frequency differential to reduce the overall energy level. The energy flow is modulated by a Fresnel zone effect increasing the local EM flux density between coupled masses. The increased EM flux density (**D**, **B**) increases the local K_{PV} (r,ω,M) dielectric constant and gradient with a resultant increase in an associated gradient force of attraction

($\mathbf{F}_g \propto \nabla K_{PV}^2$) proportional to the gradient of K_{PV}^2 and, hence, is always attractive. The family of ellipsoidal Fresnel zones encapsulate the coupled masses forming in effect a graded dielectric lens with the center of masses at the ellipse focii. Photons emitted from each oscillator mass are reflected at the Fresnel zones boundaries towards the opposite foci. The augmented gradient produces a force of attraction substantially greater than the radiation pressure imbalance from a long range Casimir force. The variation in EM flux energy density produces a nonlinear variation in ϵ_0 and μ_0 of the interacting mass altering the local speed of light. The alteration of ϵ_0 and μ_0 results in local variation of the EM energy density as measured by the vacuum refractive index K_{PV} and provides a mechanism for EM wave contraction effects.

A comparison of physical constants and units of measure in a spacetime GR model in terms of the gravitational Γ with physical parameters as a function of the vacuum dielectric constant K_{PV} may be shown illustrating an exact one-for-one correspondence as does the γ factor in SR. The equivalence between gravitational mass and inertial mass has a common origin – acceleration into a region of increased EM energy density i.e., increased dielectric constant K_{PV}.

According to the Ivanov 'Rhythmodynamics' model of gravitation[37,38], matter consists of packages of standing waves of collectively synchronized elements linked by wave fields – in effect, an assembly of standing wave resonators formed of fermions. An electron/positron as a fermion constitutes an elementary standing wave resonator. In the presence of a gravitational field, the mass oscillators undergo a phase shift. Displacement of potential holes (standing wave minima) is triggered by a phase shift. Wave system velocity v_g is proportional to phase difference ($v_g = \Delta\phi \cdot c/\pi = \beta \cdot c$). Accumulation of phase displacement between moving elements makes the system self-accelerate. Gravitational acceleration $\mathbf{g}$ is proportional to the net frequency difference ($= 2c \cdot \Delta\nu \cdot \mathbf{r}_u$) which is a function of the gradient in EM energy density ($= \nabla\nu$) and, hence, may be subject to control as discussed in subsequent sections.

The fall of an object under a gravitational field involves a conversion of potential energy into kinetic energy according to conservation of energy. The kinetic energy resides with the falling object. Where is the potential energy stored? In the physical aether model, the potential energy represents kinetic energy of Planck scale dipoles composed of positive and negative Planck masses which make up the vacuum and matter fields. Jefimenko[16] notes that the process by which this interchange takes place may be explained as a consequence of influx of gravitational-cogravitational field energy via a gravitational Poynting vector. The self-induced gravito-magnetic field $\mathbf{B}_g$ of a falling object induces a circumferential field surrounding the object due to a mass current similar to a magnetic field B induced by an electrical current. The net gravitational acceleration acting on a falling object is the sum of the Earth's external field $\mathbf{g}$, the gravitational self-generated gravitational field $\mathbf{g}_c$ and the self-induced motional gravito-magnetic field $\mathbf{B}_g$. The gravito-magnetic Poynting field $\mathbf{S}_g$ ($= \mathbf{E}_g \times \mathbf{H}_g$) is radially inward directed whereas the gravito-magnetic field $\mathbf{B}_g$ is a circular field oriented perpendicular to the direction of motion in alignment with $\mathbf{g}$ and directed according to the left-hand rule relative to the mass current direction.

The introduction of the "cosmological member" into the equations of gravity, though possible from the point of view of relativity, is to be rejected from the point of view of logical economy. – Albert Einstein

The key difference between GR and EGM is that EGM explicitly describes why spacetime physically becomes refractive in the presence of matter; GR does not. – Ricardo C. Storti

33.2 Newton's law of gravitation

Halley and Wren, in 1684, speculated that the force of gravity must be inversely related to separation distance based on a study of planetary orbits as had Hooke, Bullialdus and Newton previously. At Halley's urging, Isaac Newton published the *Philosophiæ Naturalis Principia Mathematica* in 1687 which included a derivation of force of attraction in accordance with Galileo's and Kepler's laws of motion that diminished with the square of distance. The Newtonian gravitational coupling force of attraction between two idealized point masses in scalar notation is given by

$$F_g = GmM/r^2 = \mu m/r^2 \qquad (33\text{-}1)$$

where:

F_g	Force of gravity		
	Value: Varies	Units: N [= kg(m/sec^2)]	Dimensions: MLT^{-2}
G	Universal gravitation constant (= $G_0/\Gamma^3 = c^2R_{univ}/M_{univ} = 1/4\pi\epsilon_g = c^3/Z_s$)		
	Value: 6.67384 x 10^{-11} (measured)	Units: N·m^2/kg^2 [= m^3/kg·sec^2]	Dimensions: L^3/MT^{-2}
m	Orbital (passive) mass		
	Value: Varies	Units: kg	Dimensions: M
M	Central (active) mass		
	Value: Varies	Units: kg	Dimensions: M
μ	Standard gravitational parameter = GM = ϕ·r		
	Value: Varies	Units: m^3s^{-2}	Dimensions: M^3T^{-2}
r	Radius vector r(t) = instantaneous distance between mass centers		
	Value: Varies	Units: m	Dimensions: L

In vector notation, the above may be written as $\mathbf{F}_g = -(GmM/r^2)\mathbf{r}_u$ where $\mathbf{r}_u$ is the unit vector. The Gravitational constant G in terms of Planck units becomes $G_P = 2\pi G = c^3t_P/m_P = c^3/Z_S = l_P^3/m_Pt_P^2$ = 4.2005E-10 m^3/s^2·kg where Z_S = spacetime impedance (= $m_P/t_P = c^3/G$), t_P = Planck time, m_P = Planck mass, l_P = Planck length and c = velocity of light = l_P/t_P.

The variation of force with the inverse square of distance in Newton's law of gravitation is illustrated in Fig. 33-1 for a pair of spherical masses. Newton's law of gravitation is independent of time and describes instantaneous action at a distance without description of causal mechanism. Newton observes in a letter to Bentley "Tis inconceivable that inanimate brute matter should (without the mediation of something else which is not material) operate upon & affect other matter without mutual contact….That gravity should be innate & {essential} to matter so that one body may act on another at a distance through a vacuum without the mediation of anything else by & through which their action or force {may} be conveyed from one to another is to me so great an absurdity that I believe no man who has in philosophical matters any competent faculty can ever fall into it." In an essay included in the second edition to the *Principia* (1713), Newton famously remarks "Hypotheses non fingo". In modern translation, "I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses".

Nature uses as little as possible of anything. – Johannes Kepler

The gravitational force F_1 experienced by mass m_1 equals the gravitational force F_2 experienced by mass m_2

$$F_1 = |F_2| = G(m_1 \text{ x } m_2)/r^2 \tag{33-2}$$

The gravitational charge of active mass M acting on a passive mass m generates an acceleration $g = GM/r^2$. The force exerted on another mass m is equal to mass x acceleration

$$F = mg = (m) \text{ x } GM/r^2 = GMm/r^2 \tag{33-3}$$

The gravitational parameter GM expresses the relationship of gravitational potential $\phi(r)$ and mass radius R: $\phi = -GM/R$ and the acceleration due to gravity: $g = GM/R^2$. The mass of a central body M and the period P of an orbiting mass m with velocity V in a circular orbit are related by the gravitational parameter: $GM = 3\pi V/P^2$. In terms of escape velocity V_e, $GM = V_e^2R/2$. The GM parameter is also directly related to the Schwarzschild radius r_S of an event horizon: $GM = c^2r_S/2$.

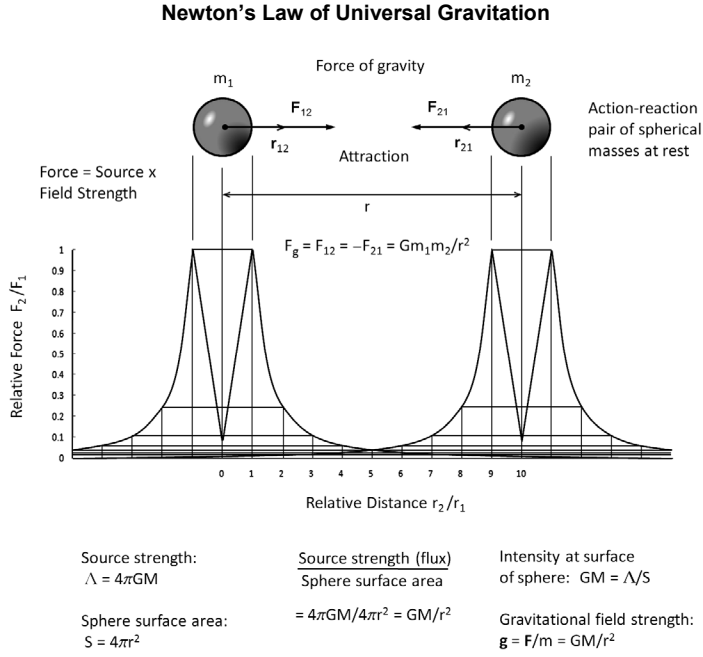


Fig. 33-1. The Newtonian gravitational force equation describes a static field configuration with instantaneous, inverse square, action-at-a-distance gravitational force between a pair of spherical mass objects represented as idealized points. The gravitational force is always attractive and varies as $1/r^2$. Velocity dependent effects are not included, hence, Newton's equation is not relativistic.

It is better to be approximately correct rather than very precisely wrong. – Ricardo C. Storti

33.3 Gravitational flux intensity

In the non-relativistic Newtonian theory of gravity, the magnitude of force depends only on the separation distance, and not on the velocity or acceleration of the masses – gravity is assumed to act instantaneously. The theory describes action at a distance without explanation for the means of force transmission or causal mechanism. The given expression for gravitational force is described in terms of the coordinates of an unaccelerated inertial frame of reference. The inverse square law relation is scale invariant and independent of time with an implicit assumption of absolute space and time with instantaneous velocity of propagation. Gravitational waves are inconsistent with the concept of instantaneous action. As such, the Newtonian relation represents a static, non-relativistic approximation. Newton's law of universal gravitation is not in accordance with Einstein's principle of covariance postulate in Special Relativity (SR) for a time dependent, causal relationship independent of reference coordinate system (Lorentz frame). The inverse square relation is illustrated in Fig. 33-2.

The gravitational flux intensity variation for a pair of point masses in the non-relativistic Newtonian theory of gravity is illustrated in Fig. 33-3. As shown, the radial flux overlap results in a dipolar Moiré fringe pattern of constructive and destructive interference.

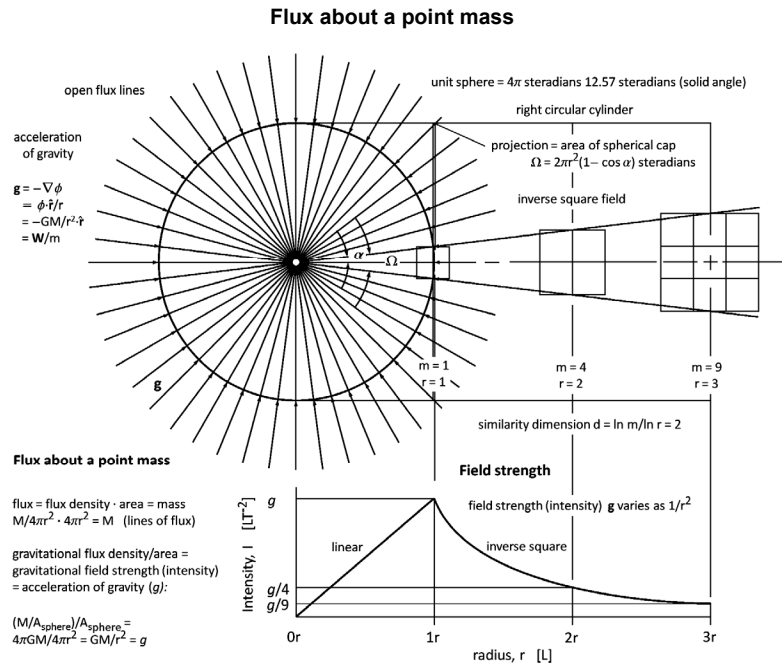


Fig. 33-2. Gravitational flux intensity from a point mass varies as $1/r^2$ in 3D space.

I had not thought of this regular decrease in gravity, namely that it is as the inverse square of the distance; this is a new and highly remarkable property of gravity. – Christiaan Huygens

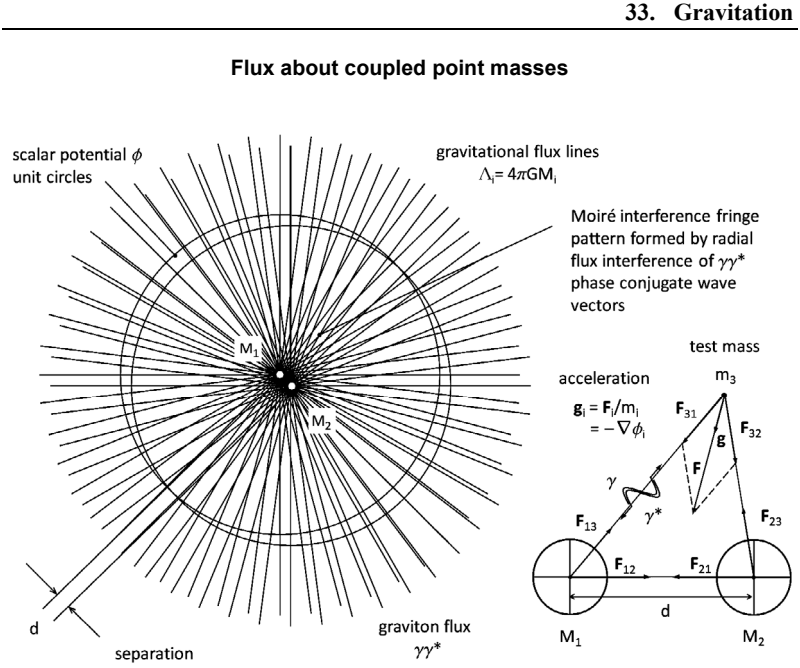


Fig. 33-3. Gravitational flux of two interacting masses produces Moiré pattern of constructive and destructive interference of narrowband polarized (PV) spectrum surrounding each mass or equivalently as broadband Electro-Gravi-Magnetic (EGM) paired conjugate wavefunctions (gravitons) with momentary overlap and zero group velocity.

33.4 Comparison of gravity and electricity

The force of gravity between static masses given by Newton's law is similar to Coulomb's law for the electrostatic force between static electric charges both varying as $1/r^2$. Based on this similarity, Maxwell speculated if gravitational attraction like electrostatic attraction was 'not also traceable to the action of the surrounding medium' A comparison of fundamental equations for each in terms of scalar potentials is summarized in Table 33-1. In a sufficiently small localized region where the field gradient is low (i.e., linear), the field is approximately uniform. The force of gravity is attractive only wheras electric force is attractive or repulsive. The force of gravity is weaker than electrostatic force by a factor of $\sim 10^{42}$ ($F_{elec}/F_{grav} = q^2/G\epsilon_0 m^2 = 4.17 \times 10^{42}$) as gravity is an acceleration field while an electrical field is a mass velocity dependent force field. The Newtonian Gravitational constant G is assumed always positive. Gravitational fields change velocity of EM waves while electromagnetic fields change EM direction. Based on Riemannian geometry of curved manifolds, Clifford suggested that the force of gravity like electromagnetic forces was the result of variation in curvature of higher-dimensional spaces. Static potentials resemble dimples; waves resemble ripples; and particles resemble knots. Analogous to electrostatic attraction, masses attract other masses via the "gravitoelectric" field – a scalar potential effect. Similarly, moving masses attract each other via the "gravitomagnetic" field – a vector potential effect. The Lense-Thirring effect represents an example of gravitational drag anaologous to the electrokinetic effect.

33. Gravitation

The analogy between gravitation and electromagnetism has been developed extensively in a gravitoelectro-magnetic description of Newton's law with a gravitomagnetic field due to a mass current. Theories advanced include gravitoelectromagnetism (GEM), Lorentz-invariant theory of gravitation (LITG) and covariant theory of gravity (CTG). Similar to Weber's modification of Coulomb's law, Holtzmüller (1870) and Tisserand (1872) modified Newton's law to include a force term as a function of relative velocity of the attracting masses. Gerber (1898) proposed that the gravitational potential velocity of transmission varies with relative velocity. Heaviside (1893) and Poincaré (1905) proposed gravitation has two components, a gravitational field **g** proportional to the vector distance between masses and a gravimagnetic or cogravitational field **k** which is a function of the relative velocities. Jefimenko (1991) proposed a generalized Newton's theory of gravitation to include time-dependent interactions which satisfy the conservation of momentum, principle of causality and principle of relativity. Weber's electrodynamic force between moving charges with time retardation yields wave equations for electric scalar and magnetic vector potentials. Assis (1992) proposed a non-relativistic derivation of gravitation from generalized Weber electrodynamics force between neutral dipoles including terms of fourth and higher orders of $\dot{r}_{12}/c$ in which electrostatics is a zeroth-order effect, magnetism and Faraday's induction as a second-order effect, gravitation as a fourth-order effect and inertia and perhelion precession as a sixth-order electromagnetic effect. Analogous parameters in Maxwell's electromagnetic equations in a vacuum and gravitational equations are summarized in Table 33-2. The dimensionless electron fine structure constant α (= $e^2/\hbar c \cong 0.007297$) has an analogous gravitational fine structure constant α_G (= $GH^2/\hbar c = (t_P\omega_C)^2 \cong$1.7518E-45) where H = mass of a nucleon, t_P = Planck time, ω_C = Compton angular frequency of the electron. Expressed in so-called 'natural' units ($4\pi G = c = \hbar = \epsilon_0 = 1$), the ratio α/α_G (= $(e/m_e)^2 \approx 10^{-39}$) is a measure of the relative strength of the electrostatic and gravitational forces between electrons.

The gravitomagnetic field $\mathbf{H}_g$ of mass currents is the mechanism held responsible for frame-dragging or Lense-Thirring effect. These interactions are second order in v/c and very weak as a result. Generation and spin alignment of plasma jets along the spin axis of quasars and black hole nuclei is attributed to the gravitomagnetic field. Interaction with the gravitomagnetic field results in accretion disc precession and jet alignment (Bardeen-Petterson effect). The immense gravitomagnetic rotational energy of supermassive black holes and conversion to relativistic plasma jets is known as the Blandford-Znajek mechanism.

Half of science is putting forth the right questions. – Francis Bacon

Faraday's idea was that it might be possible to convert electricity into gravity, or vice versa. The grounds for his expectation were two theories he held, the unity of force and the conservation of force. – William Berkson

In 1914, a Finnish physicist named Gunnar Nordstrom found that all you had to do to unify gravity with electromagnetism was to increase the dimension of space by one. – Lee Smolin

It is known from oberved phenomena and established physics…that gravity, electromagnetism and spacetime are interelated phenomena. These ideas have led to questioning if gravitational or inertial forces can be created or modified using electromagnetism. – Marc Millis

Behind it all is surely an idea so simple, so beautiful, that when we grasp it - in a decade, a century, or millenium - we will all say to each other, how could it have been otherwise. – J. A. Wheeler

Table 33-1. Comparison of gravity and electricity under static conditions*

Parameter	Gravitation	Units	Electrostatics	Units
charge	m = mass = $\mathbf{F}/\mathbf{a} = E/\phi_g$ $= \hbar\mathbf{k}/\mathbf{v} = E/c^2 = \lvert V\cdot q\rvert/c^2$ $= m_0/\Gamma = (\phi_E\cdot q)/c^2$	kg	q = charge = $\mathbf{F}/\mathbf{E} = E/\phi_E$ $= \hbar\mathbf{k}/\mathbf{A} = E/V = mc^2/V$ $= m((\omega_C + \omega_{e/m})$	Coulombs
flux	$\Lambda = 4\pi GM$	$m^3 s^{-2}$	$\phi_E = q/\epsilon_0$	volt·meter
divergence of gradient	$\nabla^2\phi = -4\pi G\rho_m$ Poisson eqn $\nabla\cdot\mathbf{g} = -4\pi G\rho_m$	sec^{-2}	$\nabla^2\phi = -\rho_{mq}/\epsilon_0$ Poisson eqn $\nabla\cdot\mathbf{E} = -\rho_q/\epsilon_0$	$kg\cdot C^2/sec^2$
coupling constant	$G = \frac{1}{4\pi\epsilon_g} = 6.67262 \times 10^{-11}$ (Newton's gravitational constant)	$N\cdot m^2/kg^2$	$k_C = \frac{1}{4\pi\epsilon_0} = 8.987551 \times 10^9$ (Coulomb's constant)	$N\cdot m^2/C^2$
Uniform field				
Field strength	$\mathbf{g}$ = const. $= -\Delta\phi/\Delta x$ $= -\nabla\phi = -\nabla\phi_g$ (acceleration of gravity, gravitational field strength)	m/sec^2	$\mathbf{E}$ = const. $= -\Delta V/\Delta x$ $= -\nabla V = -\nabla\phi_E$ (electric field strength, voltage gradient)	volts/m
Force	$\mathbf{F} = W = m\mathbf{g} = -m\nabla\phi_g = \delta L/\delta x$ (Gravity force) $= d\mathbf{P}/dt$	$kg\cdot m/sec^2$ $= N$	$\mathbf{F} = q^+\mathbf{E} = q\mathbf{V}/r = -q\nabla\phi_E$ (Coulomb force)	$kg(m/sec^2)$ $= N$

cont

44. Quantum Gravity

General Theory of Relativity is as yet incomplete insofar as it has been able to apply the general principles of relativity satisfactorily only to gravitational fields. – A. Einstein

The quest for a quantum gravity is one of the greatest unsolved problems in all of science – Michio Kaku

Space is imagined as a lattice made of nodes connected by edges… A physicist working without a lattice is something like a trapeze artist working without a net. – Lee Smolin

44.1 Introduction

Quantum gravity theory purports to reconcile quantum theory describing elementary particles and atoms with Einstein's general theory of relativity describing events in curved spacetime under the influence of gravity. Gravitation in an optical gravity theory is a result of resonant electromagnetic (EM) wave interactions in a polarizable vacuum (PV) with a variable refractive index. Gravitation is described by variation in EM wave energy and density due to local variation in the vacuum refractive index $K_{PV}(r,\omega,M)$. Variation of the vacuum refractive index and corresponding variation in the speed of light and provides a mechanism for EM wave contraction effects. The electromagnetic field and photon/electron interactions in quantum electrodynamics theory (QED) are quantized and has provided a template for subsequent quantum field theories.

Two currently popular theoretical approaches to quantizing gravity are String/M-theory and Loop Quantum Gravity (LQG). In M-Theory, there are 10-dimensional strings in a membrane in an 11-dimensional supergravity hyperspace. A complex 6-dimensional Calibi-Yau manifold compactifies 6 of the 10 dimensions to a 4-D spacetime. 4D spacetime is regarded as a 'D-Brane' hypersurface in a 11-dimensional superspace. Particles represent vibrations of 1 dimensional Planck scale string objects in the Calibi-Yau manifold including the graviton. Quantum gravity is described in terms of dynamic intersecting, linking or knotting of loops. Particles of spin 1 and 2, i.e., the photon and graviton, are massless and correspond to zero frequencies of the string. Higher frequencies correspond to particles with mass in multiples of the Planck mass ($m_{Planck} = 10^{19}$ GeV). Electric charge is associated with open strings. Quarks are connected by open strings. String loops in 4-D may include twists or rotations in the extra six internal dimensions or degrees of freedom. In analogy with guitar strings, mass m may be associated with string tension T ($= m \cdot 4L^2f^2$) although what the source of the tension in string theory is undefined. The amplitude envelopes of closed strings form loops moving through spacetime. Vibrations of the closed loops allow different energy levels corresponding to different particles including boson/fermion supersymmetric partners. Despite intensive search, supersymmetric particles have not been observed. String theory proponents argue string theory is the only known way that includes gravity with other forces described by quantum theory. A graviton in string theory is described by a quadrapole excitation of a closed loop string. String theory comes in many different versions with various assumptions. What is the composition of a string or how formed is undefined. With an odd number of spatial dimensions and one temporal dimension, spacetime must be an even number. However, chirality arises only with an odd number of spatial dimensions, which appears to preclude a 11-D supergravity manifold. String theory, like brane theory, appears as a fanciful, metaphysical abstraction with little substance, an idea full of holes – a doily for the mind.

Gravitons in quantum field theory (QFT) are usually regarded as massless, spin-2 bosons propagating as perturbative quantum fluctuations (excitations) superimposed on a flat, Minkowski spacetime metric

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu} \tag{44-1}$$

where $g_{\mu\nu}$ is the resultant field metric, $\eta_{\mu\nu}$ is the background metric and $h_{\mu\nu}$ is the graviton field which is a measure of deviation from the flat Minkowski metric. However, there is no explanation for causal mechanism for variation in background metric such as gravity waves, how the graviton field is generated or how exactly does gravitational attraction occur via graviton exchange. In loop quantum gravity (LQG), space-time is quantized as a network in which quantum numbers are assigned to nodes and linkages. GR is expressed in terms of Ashtekar variables in which quantum areas are quantized.

In LQG, unlike M-Theory, higher dimensions are not required. Holonomy of curved space is described in terms of rotational transformations around a loop. LQG does not describe objects within spacetime unlike string theory and appears incompatible with requirements of SR absent the effects of gravity and the principal of general covariance. LQG as presently formulated does not include the graviton of QFT nor does it describe other forces. QFT was formulated for flat spacetime and does not incorporate curved spacetime of GR. Spin networks represent quantum states of the geometry of space. The edges of spin networks correspond to discrete units of area while network nodes correspond to quantized volumes in Planck units. The spin networks are relational objects said to generate space. The geometry of spin networks may be adjusted to match a given metric. A spin network represents causal linkages, however, the causal mechanism of gravity is unclear as is just what is it that is spinning or the cause of spin.

Similar to the GR mathematical theory, both approaches attempt to quantize space and time, ascribing physical properties to geometry rather than objects in spacetime. Neither of these approaches address the fundamental nature of the physical vacuum. There is neither explanation of the origin of electric charge, mass or spin nor are specific geometric models proposed with characteristics matching particle observables. The mathematics of the theories is complex and few verifiable predictions are advanced. Laboratory experimental verification of string theory or loop quantum gravity appears at best remote if at all even possible.

44.2 Quantum diagrams

A Feynman tree level vertex diagram representing the scattering of a pair of photons via graviton resonance interaction ($\gamma + \gamma^* \rightarrow \gamma\gamma^* \rightarrow \gamma^* + \gamma$) is shown in Fig. 44-1. Graviton $\gamma\gamma^*$ corresponds to the propagator. The 4-momentum conservation is maintained across each vertex and for the sum of inputs and outputs overall:

$$\mathbf{p}_g - \mathbf{p}_g^* = -\mathbf{p}_g^* + \mathbf{p}_g \tag{44-2}$$

The momentum for s-, t-, and u-channel scattering is described by Mandelstam variables s, t, and u.

$$s = (p_1 + p_2)^2 = (p_3 + p_4)^2 \tag{44-3}$$
$$t = (p_1 - p_3)^2 = (p_2 - p_4)^2 \tag{44-4}$$
$$u = (p_1 - p_4)^2 = (p_2 - p_3)^2 \tag{44-5}$$
$$s + t + u = m_1^2 + m_2^2 + m_3^2 + m_4^2 \tag{44-6}$$

The virtual graviton corresponding to the internal propagator is not directly observable. There are two different physical interpretations in the Veneziano's dual resonance model with equivalent results. In t-channel scattering, the graviton is an unstable resonance whereas in s-channel scattering, the graviton is viewed as an intermediate exchange particle. Energy and momentum are transferred to each photon. The massless graviton exists as a momentary resonance of phase conjugate photonic fields. The propagator is represented as the product of the amplitudes. The spin-2 field results in wavefront curvature and net acceleration transverse to the wavefront (spontaneous symmetry breaking) with eikonal scattering of interacting photons away from the interaction region center of rotation.

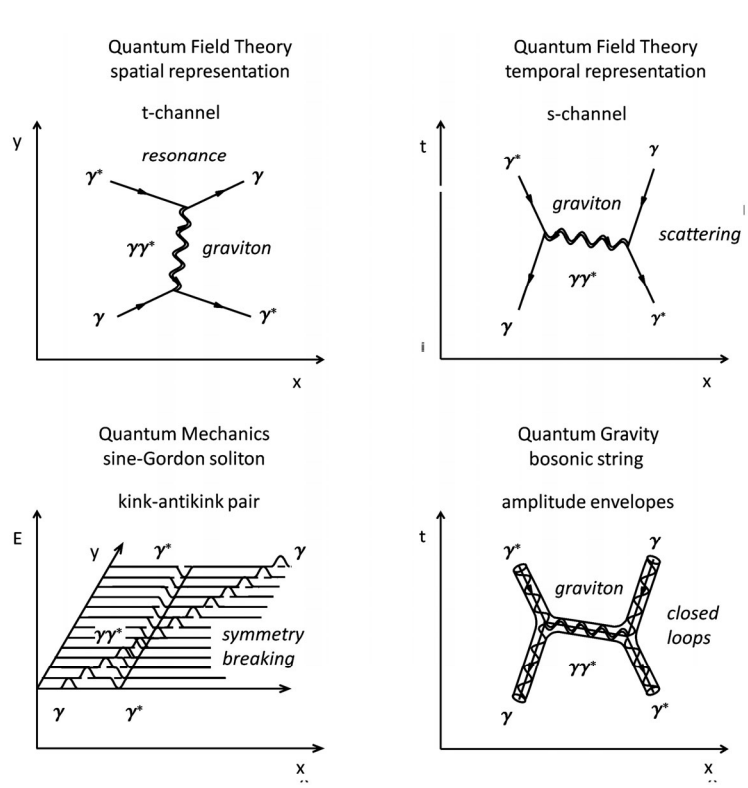


Fig. 44-1. Quantum vertex diagram illustrations of a massless spin-2 graviton $\gamma\gamma^*$ formed by interference of a pair of phase conjugate counter-propagating photons γ and γ^*. Spontaneous symmetry breaking from a false vacuum state results in resultant photon scattering.

What do you think about this? (Was meinen sie dazu)? – Wolfgang Pauli

Quantum Field Theory… is a beautiful but not very robust child. – Stephen Weinberg

Gravitons are represented in string theory as the first excited mode of a Planck scale one dimensional closed loop. In loop quantum gravity, spacetime is quantized in terms of spin networks embedded in a topological curved manifold. The spin network is formed from spinors with connecting lines representing allowable angular momentum ($n\hbar/2$). The spin network describes spin angular momentum exchange between particles independent of a specific coordinate system. The combination of loop variables in Planck units allows embedding in a curved manifold such as described by GR with QM quantization. Loop quantum gravity is nonperturbative and background independent. Supergravity attempts to relate interacting fields of bosons and fermions via supersymmetry. Representations of various quantum gravity approaches are illustrated in Fig. 44-2. The Barbero-Immirzi parameter $\gamma_0 = \ln(2)/\sqrt{3}\pi$ has been interpreted in loop quantum gravity as a normalized Newton's gravitational constant G although a geometrical derivation has not yet been achieved.

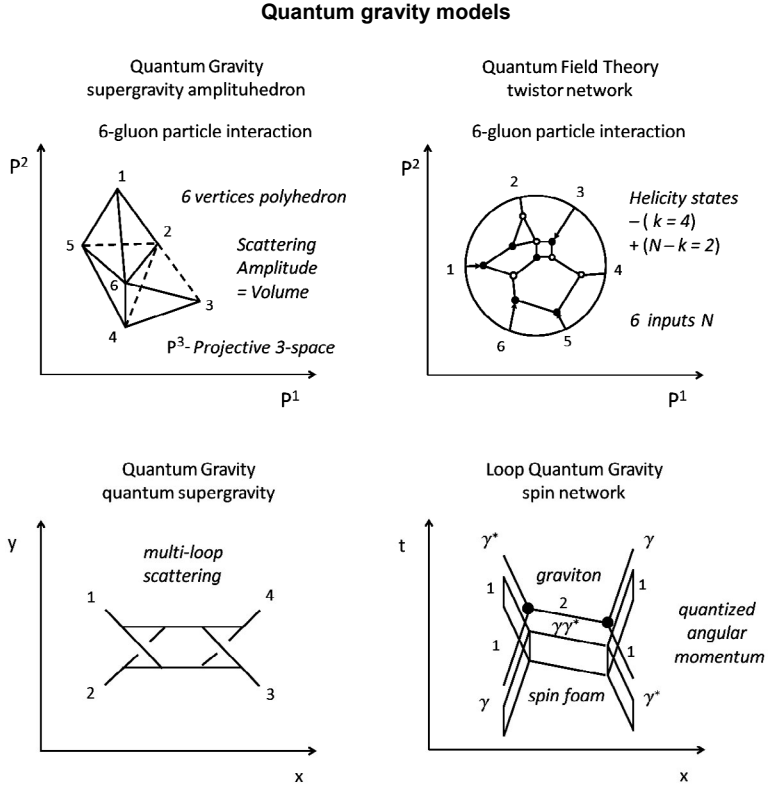


Fig. 44-2. Quantum diagram representations of symplectic structure spin loop networks. A curvilinear finite-element mesh model of a spin network with second-order triangular or tetrahedral elements requires six degrees of freedom (DOF) for each node with three DOF to describe translation along the x, y, and z axes and three DOF to describe rotation about the axes. A quantum scale representation corresponds to a reductionist viewpoint whereas thermodynamics and general relativity corresponds to a description of emergent phenomena as gravity becomes much weaker at length scales >> Planck scale ($l_P = t_P c = \sqrt{\hbar G/c^3}$).

The origin of mass in quantum field theory is represented as symmetry breaking from a symmetrical unstable vacuum state to an asymmetrical lower energy state. Various representations involving transitions from unstable symmetrical potential energy states into lower energy stable unsymmetrical states are illustrated in Fig. 44-3.

Quantum Field Symmetry Breaking

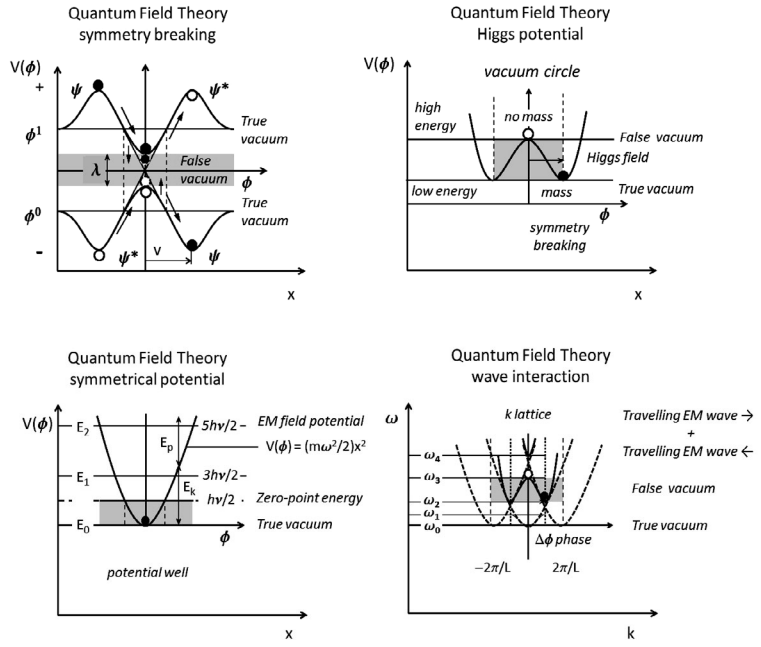


Fig. 44-3. Spontaneous gauge symmetry breaking from an unstable false vacuum state to a lower energy state. Eg., Origin of Planck mass $\pm m_P$: $S_0 = \{0\} \rightarrow S_1 = \{-m_P < 0 < +m_P\}$.

A soliton-soliton interaction in a spin network is illustrated in Fig. 44-4 representing a particle interaction. A plot of the harmonic mean of two independent variables produces a similar plot. Wave coupling occurs if the counter-propagating waves are close in frequency with the interaction zone corresponding to the coherence range. The line of impact corresponds to a decaying eigensolution (stable manifold) whereas the line of suppression corresponds to an increasing eigensolution (unstable manifold). A typical trajectory approaches the line of suppression as $t \rightarrow -\infty$ and approaches the line of impact as $t \rightarrow \infty$. A similar effect occurs in coupling of electromagnetic waves with polaritons exhibiting the quantum phenomenon of level repulsion obeying a non-crossing rule. In a system of two coupled oscillators of different natural frequencies, as the coupling strength increases the lower frequency decreases while the higher frequency increases – an apparent frequency repulsion effect.

Even the most sensible arguments for the existence of quantum gravity lack the gravitas of experimental facts. – Natalie Wolchova

Soliton-soliton interaction/particle collision

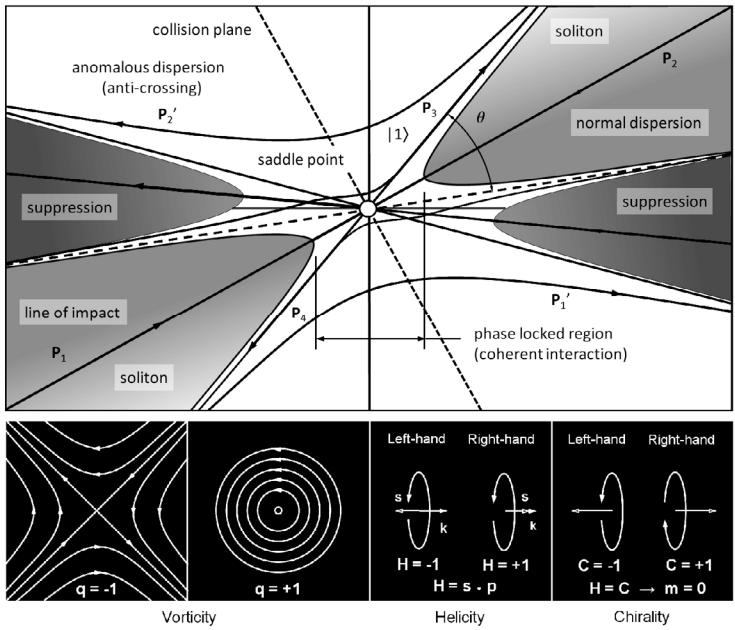


Fig. 44-4. Illustration of soliton-soliton interaction with time reversal invariance. The saddle point represents the linear combination of a 3-edge vertex pair in a spin network. Varying energy states such as $e^- - e^-$ repulsion or bond angle obey a non-crossing rule. Converging states do not cross if of the same symmetry. Avoided crossings such as adiabatic transitions represent level repulsion as a consequence of nonpenetrability of differing energy levels. Wavefront tangent vectors correspond to different symmetry states. If counter-propagating waves are close in frequency, the waves couple to generate a single frequency in the phase-locked region. Mandelstam variables relating energy and momentum for elastic scattering of identical particles in s-, t-, and u-channels: $s = (p_1 + p_2)^2$, $t = (p_1 - p_3)^2$, $u = (p_1 - p_4)^2$. The particle trajectories resemble shear flow stream functions contours in three dimensional fluid flow such as generated by two co-rotating rollers. For n = 2, an example saddle function is $f(x,y) = x^2 - y^2$ which exhibits one saddle point. $v = (d\phi/dy, -d\phi/dx)$. The particle trajectories correspond to asymptotic lines of a hyperbola in a stereographic projection on a Riemann sphere onto a tangent plane.

Primary causes are unknown to us; but are subject to simple and constant laws, which may be discovered by observation, the study of them being the object of natural philosophy. – Joseph Fourier

We're unaware of the causes of most of the events we witness. – Ron Reed

Poincaré observed this phenomenon mathematically among colliding particles, which impart some of resonances to each other leading to a degree of synchronized resonance. – R. Marion and J. Bacon

45. Graviton Model

And so you will excuse me, Monsieur [Le Sage], if I still feel a very great repugnance for your ultramundane corpuscles; and I would rather admit my ignorance of the cause of gravity than to have recourse to hypotheses so strange. – Leonard Euler

They never called Einstein crazy. Well, they would have if he carried on like this. – Dr. Noah (Casino Royale)

The hypothetical graviton is described as a spin 2 boson posited as the carrier of the gravitational force. Photons are spin 1 bosons that are the carrier of the electromagnetic force. While photons are readily detectable, the elusive gravitons have not been detected in particle physics experiments and have remained mysterious. However, in terms of the geometrical model of the photon previously defined, the geometry, mechanism for creation, and inability for detection of the graviton may be understood. In the model described here, the graviton $\gamma\gamma^*$ is averred to be a resonance interaction of a photon γ and its phase conjugate γ^*. The phase conjugate photon γ^* is generated upon reflection from an EM wave interference pattern with nodal spacing comparable to the incident photon γ. A gravitating mass consists of a collection of EM oscillators (e.g., electrons, atoms, molecules, etc) with a frequency range over the entire EM spectrum up to the Planck frequency. The incident photon has phase and group velocities parallel and in the direction of propagation. As previously described, a phase conjugate wave has phase and group velocities anti-parallel with the phase velocity opposite to the direction of propagation. The phase conjugate is not an anti-particle as the spins are in the same direction. As a result, upon reflection, the phase conjugate photon spin adds to that of the incident photon (1s + 1s = 2s). The phase conjugate photon has an identical frequency and wavelength of the incident photon. The graviton wave train length at any given instant is the momentary length of the overlap region. The graviton resonance interaction is not directly observable, however, the gravitational effects may be observable. The effect of the resonance interaction is to locally increase the energy density of the Planck vacuum increasing the refractive index K_{PV} and gravitational gamma Γ.

Graviton formation from a counter-propagating photon and phase-conjugate photons is illustrated in Fig. 45-1 in terms of Whittaker[120,121] scalar potentials. The wave equation describes the evolution of the wave function with time. In addition, the wave function also describes the evolution of the complex conjugate wave function in time. The complex conjugate wave is a time-reversed replica of the wave equivalent to wave propagating backward in time. Unlike the Wheeler – Feynman absorber theory of radiation proposed in 1945, there no advanced wave propagating backward in time to interact with the retarded wave propagating forward in time.

Schematic diagrams of resonance interaction of a pair of phase-conjugate photons is shown in Figs. 45-2 and 45-3 illustrating graviton formation. As shown, a phase-conjugate pair of counter-propagating spin 1 photons (RH helix, LH helix) interfere to give rise to a spin 2 graviton (helicoid). The graviton has two helicity states with a spin projection on the propagation direction equal to ±2, hence, the gravitational field has two degrees of freedom. Unlike electromagnetic charge, vortices of opposite spin repel resulting in deflection of the photon wave vectors. Fields carried by exchange particles with odd integer spins with aligned spin vectors are repulsive whereas those with opposed spins are attractive. Even spins lead to attractive forces proportional energy content and varies as $1/r^2$. For a spin-2 graviton, the polarization rotational phase change corresponds to $e^{2i\theta}$ and $e^{-2i\theta}$.

45. Graviton Model

In the graviton model illustrated, the linear momentum is zero. Hence, a freely-propagating graviton as such is not predicted to exist. In addition, the theoretic Ivanenko process $(2\gamma \rightarrow e^- + e^+)$ in which two gravitons collide head-on to create matter, an electron and positron, does not occur as the relative velocity is zero. The effect of gravity is not due to the momentum exchange of gravitons in billiard ball fashion, but rather is a harmonic resonance phenomena of quantum oscillators mediated by photons. The photon and graviton flux alters the local vacuum energy density of aggregated concentrations of matter. As in quantum field theory, the massless spin-2 graviton model illustrated has just two helicity states. In string theory, bosons, including gravitons, form closed loops. Similar to string theory, the periphery of the graviton represented here forms a closed loop. As the graviton ($h_{\mu\nu}$) carries energy, it contributes to the gravitational field energy density and the energy-momentum tensor. A gravity wave as a function of time may be represented as $h_{\mu\nu} = A_{\mu\nu}\sin(t - \chi/c)$. Gravitational waves $g_{\mu\nu}(x)$ as a coherent states of many gravitons may be considered as excitation of the background metric where the metric is not the Minkowski spacetime $\eta_{\alpha\beta}$, but the electromagnetic field interference pattern metric $\eta_{\mu\nu}$: $g_{\mu\nu}(x) = \eta_{\mu\nu} + h_{\mu\nu}$. The gravitational wave amplitude is the sum of two polarizations: $g_{\mu\nu} = h_{+}e_{\mu\nu}^{+} + h_{x}e_{\mu\nu}^{x}$ where " + " and "x" denote polarization directions.

Counter-propagating traveling harmonic waves $\phi(x,t)$ @ fixed instant t

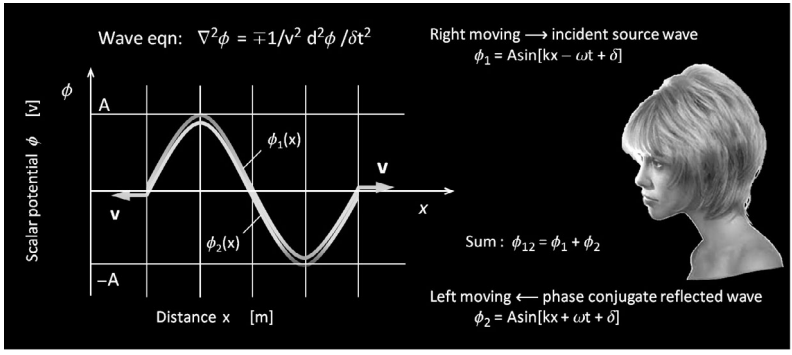


Fig. 45-1. Illustration of resonance interaction of counter-propagating phase-conjugate photons represented as counter-propagating scalar potential waves. Continuous mono-chromatic waves are spatially and temporally coherent with infinite coherence length $l_c = \lambda^2/2\Delta\lambda$ as the waves remain in phase for an infinite distance. Pulsed wave coherence duration is equal to the wave train duration. Linear momentum **p** (= $\hbar$**k**) cancels to zero.

It is by logic we prove, but it is by intuition we discover. To know how to criticize is good, to know how to create is better. – Henry Poincaré

We all try. You succeed. – Humpfrey Bogart (Casablanca)

There are very few things which we know, which are not capable of being reduced to a Mathematical Reasoning; and when they cannot it's a sign our knowledge of them is very small or confus'd. – Kurt Gödel

Gravitons are the avatars of general covariance. – Frank Wilczek

A graviton corresponds to transient standing wave produced as incident and phase conjugate reflected travelling photon waves cross during an overlap period upon reflection. The bi-directional traveling harmonic wave pattern is similar to the diatonic interference pattern energy flow model in music theory correlated to the exchange and energy flow in a standing wave for example, such as represented as $y = \sin(2x)$ and $y = -\sin(2x)$. Harmonic interference theory suggests geometric patterns of a graviton field arise as a result of interference of reflected harmonic waves with resonance and amplification at harmonic frequency multiples.

The propagation velocity and frequency of photon wave quanta are dependent on the gravitation potential which is influenced by the action of graviton flux. Gravitons are associated with gravitational waves generated from mass oscillations such as binary stars, exploding or collapsing stars, etc. Gravity is far weaker than other forces; coupling of gravitational waves/gravitons to matter fields is weak. Macken has shown for a pair of electrons in terms of Planck units, the electromagnetic force $F_{e/p} = (\omega_c)^2/N^2$ while the gravitational force $F_{g/P} = (\omega_C)^4/N^2$ where ω_c is the Compton frequency and N is a dimensionless ratio of separation distance r divided by the Compton length R_C. That $F_{g/P} = F_{e/P}^2$ is a consequence that EM forces are proportional to e^2 mediated by exchange of a pair of virtual photons ($\omega_{c1}\omega_{c2}$) whereas gravitational forces are proportional to m^2 mediated by exchange of a pair of virtual photons and a pair of phase conjugate photons $(\omega_{c1}\omega_{c2})^2$.

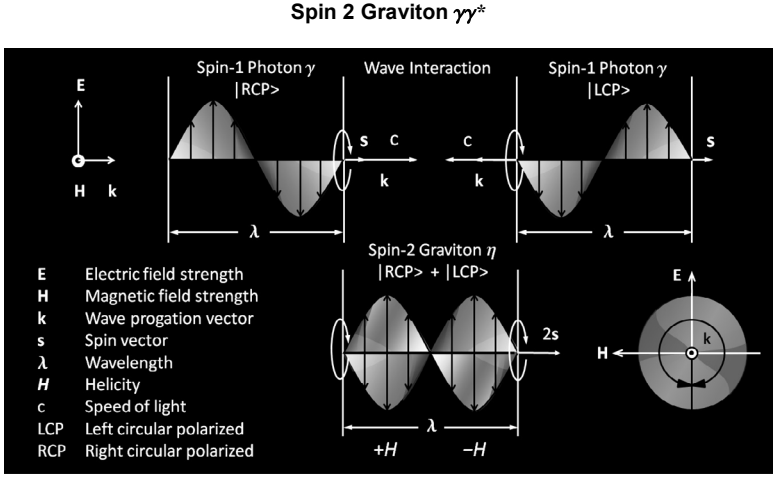


Fig. 45-2. Diagram of graviton formation from coupling of a pair of counter-propagating phase-conjugate photons. The phase conjugate photon γ^* is a time-reversed replica of the incident photon γ. The graviton has spirality with spin projection $\boldsymbol{s}$ on the propagation direction $\boldsymbol{k}$ equal to ±2. Spin angular momentum is additive ($s = 2\hbar$). Helicity H cancels..

The energy of gravitons is proportional to frequency ($E = 2h\nu$). Emitted gravitational waves are of low energy and notoriously difficult to detect. Similar to Delbrück scattering of photons by photons, gravitons should likewise undergo scattering interactions. The strength of graviton scattering interactions vary with frequency, the probability of interactions described by the vertex in terms of the fine structure constant. The higher the frequency of gravitons, the greater the strength of interaction.

45. Graviton Model

Frolov[118] has proposed a gravitation concept as a paired process of radiation and gravitation. In terms of duality of action: Radiation is emission of photons from a mass object; gravitation is the absorption of photons by a mass object. Material mass, in other words, represents the absorption and transformation of electromagnetic waves. Radiation emission is associated with a contraction of mass and absorption with an increase in mass. The instability of the interaction of phase-conjugate photons arises as the result of the phase-conjugate wave has negative action ($A = -h$) producing a negative energy state ($E = -h\nu$) in which the group velocity is opposite to the spin vector. This false vacuum instability ($E = h\nu - h\nu = 0$) results in spontaneous symmetry breaking as represented by the Higgs potential and resultant photon scattering. Storti and Diemer[33] maintain that dark energy is in the form of conjugate photons (i.e., gravitons) which would account for the observational difficulty for direct detection. Conjugate photons are a feature of the Electro-Gravi-Magnetic (EGM) quantized theory of gravity.

A vector diagram of graviton formation from phase conjugate beams is depicted in Fig. 45-3. The graviton arises from a photon gauge field and its phase conjugate emergent from an interference network lattice containing quantum spins. The graviton has only two polarizations: parallel or anti-parallel to the wave vector $\boldsymbol{k}$. The rotational phase change varies as $e^{2i\theta}$ and $e^{-2i\theta}$. A spin 1 photon γ and its counter-propagating phase conjugate γ^* are both described as a helix. The spin 2 graviton $\gamma\gamma^*$ conforms to a helicoid geometry. Each represent minimal ruled surfaces. The curvature and torsion characteristics of each are illustrated in Fig. 45-4. Coupling of counter-propagating photon (right hand helicity) and phase-conjugate photon (left hand helicity) results in creation of false vacuum instability and photon scattering. Gravitation phenomena appears associated with photon wave-function pairing in a phase conjugate mixing interaction in which energy density is momentarily reduced to a false vacuum state as a result of vector addition of conjugate phase amplitudes. The massless spin 2 graviton $\gamma\gamma^*$ has just two helicity states. Spins are additive as chirality equals helicity resulting in a spin (torsion) field with no net longitudinal momentum transfer ($\langle \mathbf{S} \rangle = 0$). Hence, gravitons have negligible interaction cross-section with matter.

Some years ago, Pauli and Fierz considered the question, what relativistic wave equations would be appropriate for particles of zero rest mass and spin two. Now in a relativistic theory for spin S, 2(2S + 1) components are needed, so a second-rank tensor is required… Since the only available direction is the direction of motion, it follows that the spin angular momentum must be oriented in the direction of motion. Since the gravitational forces have infinite range, it follows that the rest mass of the graviton must be zero. – Joseph Weber

Provando e riprovando. (trying and trying again) – Academia del Cimento motto

Everthing flows and nothing persists, or nothing endures. – Heraclitis

In Terra inest virtus, quae Lunam dei. (There is a force in the earth which causes the moon to move) – Johannes Kepler

Real gravitons make up what classical physicists would call gravitational waves, which are very weak – and so difficult to detect that they have not yet been observed. – Stephen Hawking

The new mathematics, which is responsible for the merger of these two theories [Riemann geometry of Einstein's theory and Lie Groups coming from quantum theory] is topology, and it is responsible for accomplishing the seemingly impossible task of abolishing the infinities of a quantum theory of gravity. – Michio Kaku

Terrans are known for their stupidity. – Philip K. Dick

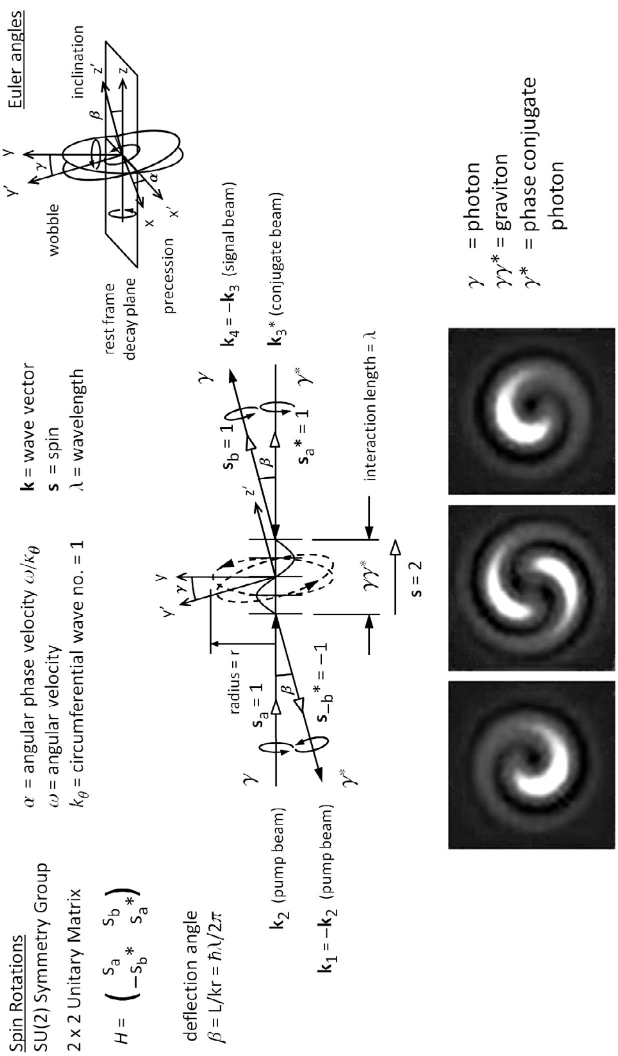


Fig. 45-3. Graviton formation by phase conjugate coupling of counter-propagating photons. Spins are additive (s = 1 + 1 = 2).

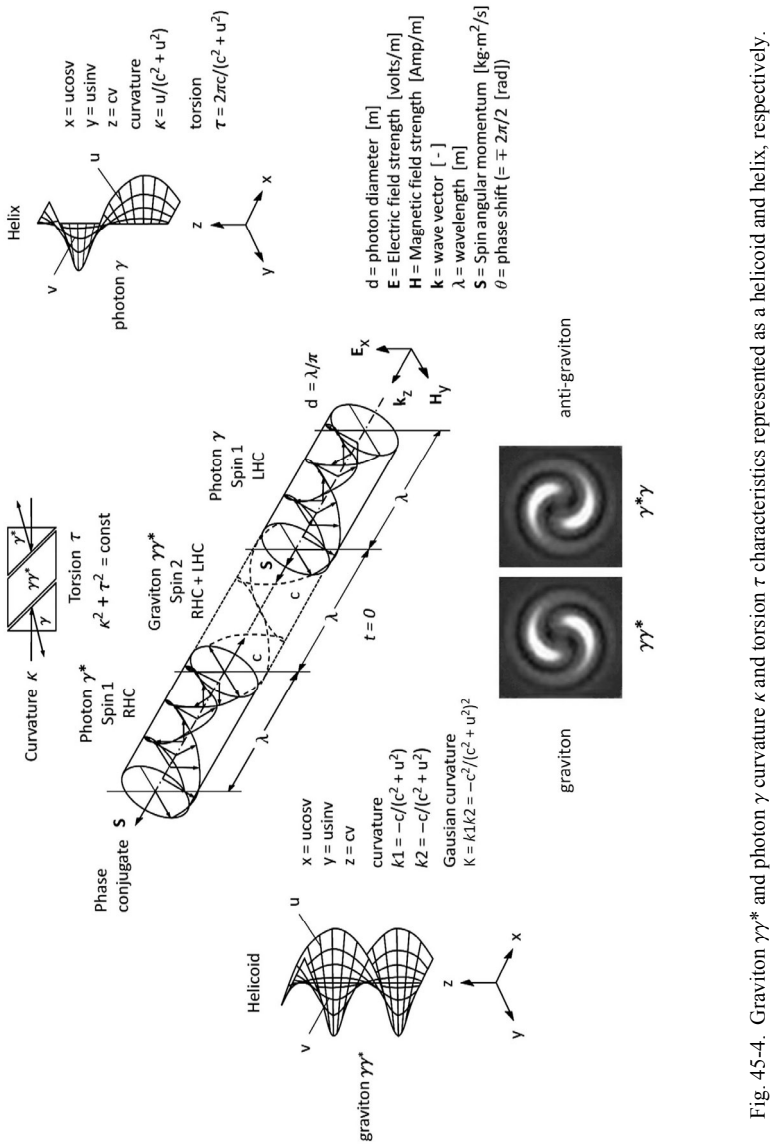


Fig. 45-4. Graviton $\gamma\gamma^*$ and photon γ curvature κ and torsion τ characteristics represented as a helicoid and helix, respectively.

46. Nonlinear Gravitational Field

Mass is associated with energy (i.e., wave function curvature) according to the Einstein mass-energy relation ($E = mc^2$) including gravitational energy. Consequently, both mass and gravitational energy are sources of gravitation. For mass concentrated at a point, the associated gravitational field has negative energy ($-mc^2$) equal to the positive mass-energy of matter ($+mc^2$). Rest mass produces a distortion field by transformation of energy. Condensation of matter produces an equal and opposite reaction: extraction of mass-energy from the vacuum: positive mass material and negative mass vacuum. Negative mass vacuum states may be described by contraction of dimensional spacetime coordinates. See Fig. 46-1. According to GR, gravitational energy becomes more negative as the mass density of an object increases as the volume contracts under the action of gravity. In the PV model, spacetime 4D mathematical construct remains Euclidean and the apparent contraction represents instead the contraction of electromagnetic wavelengths.

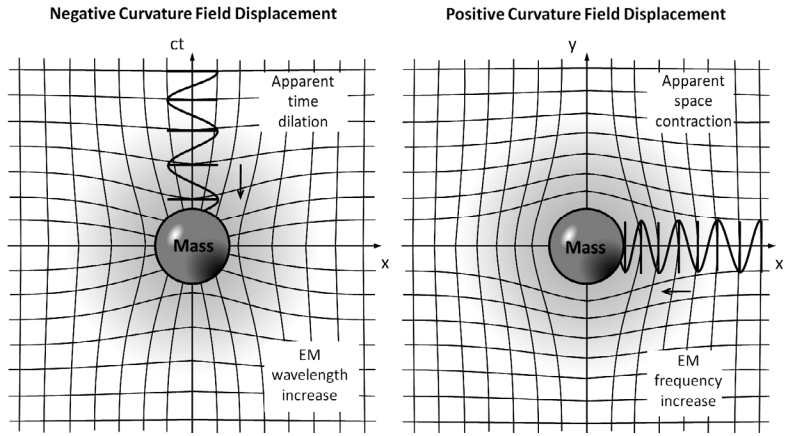


Fig. 46-1. EM wavelength increase corresponds to apparent time dilation and EM frequency increase corresponds with apparent space contraction of GR theory which posits curvature of spacetime. Change in wavelength $\Delta\lambda$ varies with change in light velocity c (= $\Delta c/\Delta\nu$). The orthogonal harmonic grid lattice of standing waves illustrated represents a metric connecting nodal points of EM waves. For a curved metric, the line element $ds^2 = g_{\mu\nu}dx^\mu dx^\nu$. Gravitational redshift frequency $\nu_\infty = \nu_{em}\sqrt{(1 - 2GM/c^2r)}$ where ν_∞ = frequency measured by a distant observer and ν_{em} = source emission frequency. Doppler frequency shift (decoherence) is given by $\nu_0 = \nu_{em}(1 - v/c) = \nu_{em}(1 - gh/c^2) = \nu_{em}(1 - 2\Delta\nu h/c)$ where ν_0 = measured velocity by an observer moving with relative velocity v, g = acceleration of gravity and h = height (vertical distance between source emitter and observer).

Winterberg[7] observes that negative gravitational field energy density implies negative mass which is one of the principal assumptions of the Planck aether hypothesis in which the physical vacuum is composed of an equal number of positive and negative Planck mass particles. See Fig. 46-2. The negative energy density of a gravitational field and positive energy density of mass may be understood as polarization effects of Planck dipoles in a

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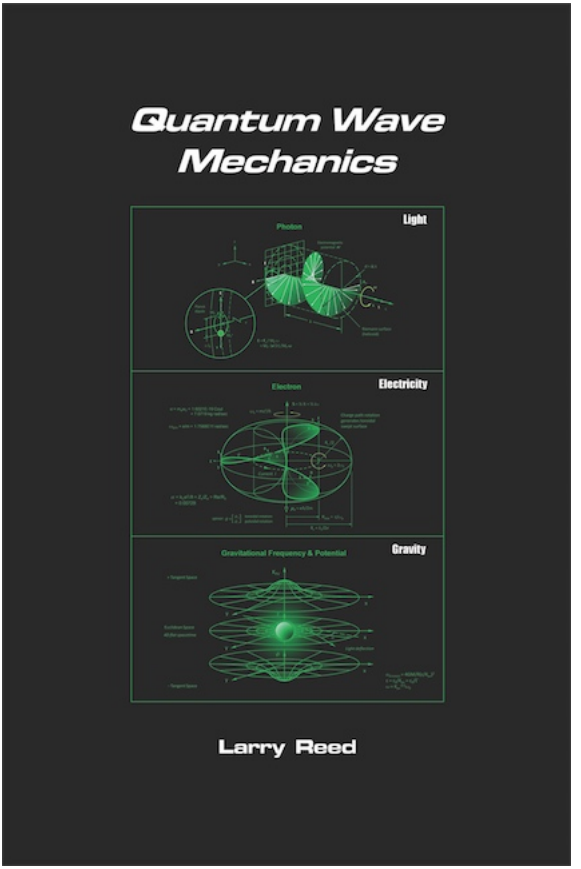

Geometrical description of photons, electrons and composite particles. Dimensional analysis of electrical charge. Quantum gravity, gravitational frequency spectrum, mass oscillator synchronization, spectral energy density modulation and phase conjugation. Origin of charge, fine structure constant and inertia. Prospects for wave-based EM propulsion.

Quantum Wave Mechanics

by Larry Reed