Not Your Father's Physics

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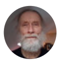

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Not Your Father's Physics

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Abstract

Two essential conceptual structures - impedance quantization and geometric representation of Clifford algebra - were lost in physics. Background independent analysis of Mach's principle makes possible calculation of quantum impedance networks of wavefunction interactions in the background independent geometric representation. Their synthesis fills gaps in the history of physics.

"To understand the electron would be enough"

Einstein

Written for the 2024 APS History of Physics Essay Competition

Not Your Father's Physics

The art of fiction rests upon suspension of disbelief. We each watch our own movies. Mainstream content of a history of physics is predictable, challenging attempts to offer anything new and novel. This is no problem for outliers[1]. Here the challenge is to suspend disbelief, to make safe space for curious minds.

Theoretical minimum of quantum electrodynamics requires acceptance of three assumptions - vacuum wavefunction, flux quantization, and a mass gap.

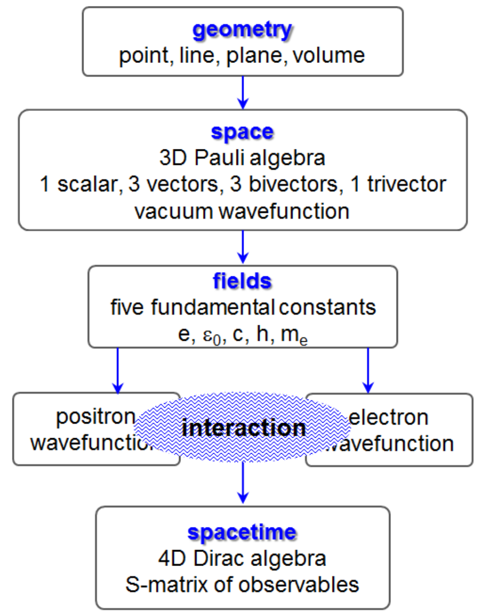

FIG. 1. Theoretical Minimum

Vacuum wavefunction is written in 3D Clifford algebra, here not in unintuitive matrix representations of Pauli and Dirac, but rather in easily visualized geometric representation of Clifford and Hestenes[2–4]. Vacuum wavefunction is comprised of one scalar, three vectors (orientations), three bivector area elements, and one trivector volume (1,3,3,1).

Topology requires inversion. There are only four normed division algebras, all Clifford - real, complex, quaternion, and octonion. Pauli's SU(2) is the double cover of SO(3), our vacuum wavefunction in geometric representation of mathematicians' octonion[5,6]. It is minimally and maximally complete, bounded by least required components and largest possible algebra[7]. Nature makes use of every possible degree of freedom in the math foundation of quantum mechanics. Vacuum wavefunction is the *same at all scales*.

Flux quanta enter via the four fundamental constants that define the coupling constant $\alpha = e^2/4\pi\epsilon_0\hbar c$. Their various combinations permit assigning geometrically and topologically appropriate electric and magnetic flux quanta to the eight wavefunction components, and calculating impedance networks of wavefunction interactions[8,9]. This is important. Impedance matching governs amplitude and phase of energy flow, of information transmission.

Different physics at different scales arises from scale to which flux quanta are confined by reflections from impedance mismatches as energy seeks to flow away from given Compton wavelengths, from network nodes where impedances are matched, asymptotically free[10,11].

Mass gap[12] sets the scale of space with the lightest charged particle at $\lambda_e = h/m_e c$, the electron Compton wavelength[13] of archetypal photon-electron interactions of QED.

Geometric Algebra

Wavefunction interactions are modeled by geometric Clifford products, mixing bosons and fermions, dynamic SUSY. Product of two vector bosons $ab = a \cdot b + a \wedge b$ yields scalar boson and bivector fermion, $WZ = Higgs + top$. These comprise a minimally complete 2D algebra - scalar, two vectors, and bivector (1,2,1). WZ sum mode is *top* mass, difference mode ∼10 GeV bottomonium family of figure 8. *Higgs* mass is absent.

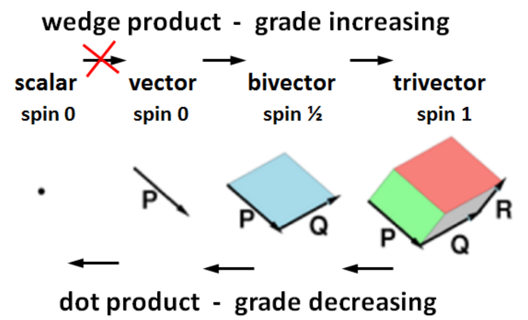

FIG. 2. Pauli algebra of 3D space

Product of two eight-component wavefunctions is S-matrix of observables in 6D phase space, three each space and phase. Time emerges naturally[14–17], integral of phase, same for all three (modulo 2 for bosons and fermions), collapses 6D to flat 4D Minkowski spacetime.

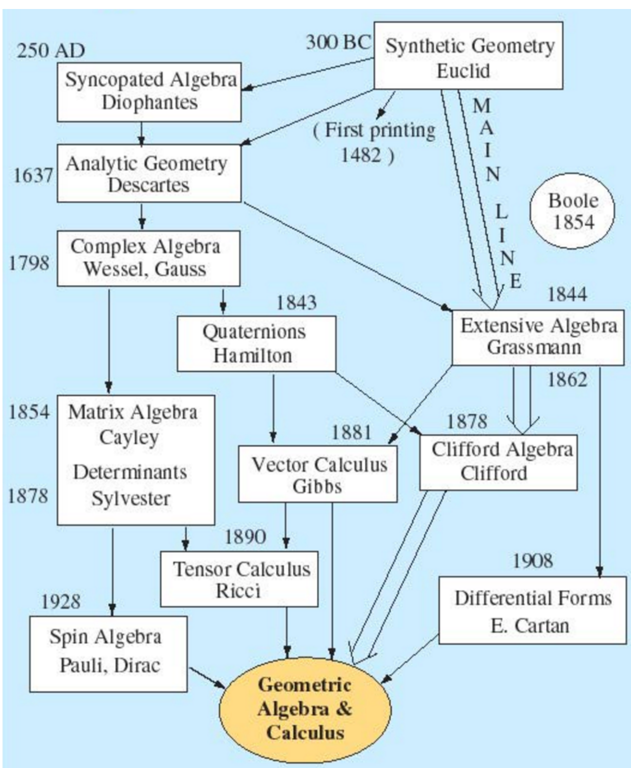

FIG. 3. Geometric Algebra Lineage

Lineage of Geometric Algebra is compelling by breadth, unreasonable effectiveness in bringing together diversity, and where it sits in the foundation of quantum mechanics, in wavefunction interactions.

Original intent of Grassman and Clifford was a *geometric* algebra, an algebra of geometric objects. This was lost in the late 19th century math wars. With the early death of Clifford, there was no strong proponent to oppose the more simple vector algebra of Heaviside and Gibbs[18,19].

Had geometric representation not been lost, Einstein might well have found simplicity of flat space Geometric Algebra to be the natural language for his general relativity[20,21]. In private conversation he disowned Riemannian curvature as nothing more than a calculational tool[22]. Similarly, had geometric representation not been lost, the founders of QED might have taken it to be the natural language of quantum mechanics[23].

Quantum Impedance Networks

The history outlined herein began with Mach's principle[24,25] and vibratory piledrivers. Synchronous counter-rotating eccentrics add vertically and cancel horizontally, transforming 2D rotations to 1D translation, a Clifford product analog of Dirac electron and positron spinors counter-rotating in phase space. Via Mach's principle, they provide shortcuts to calculating impedance networks[8,24]. Impedance matching governs transmission of energy, the flow of information.

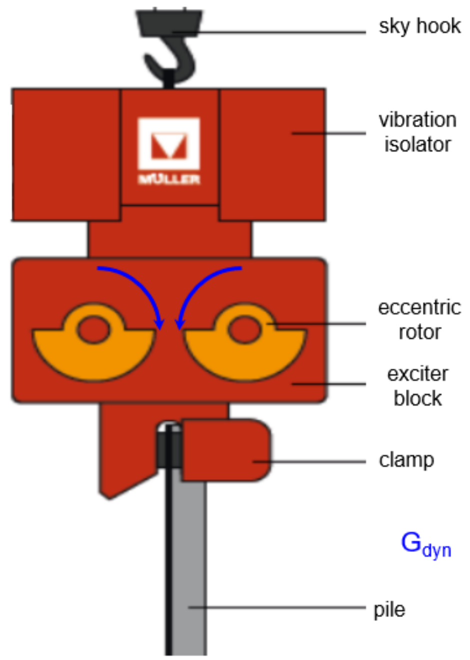

FIG. 4. Vibratory Piledriver

Paradoxically, to calculate with Mach's principle one must write background independent equations of motion[26]. There are no distant stars, no observers, no independent reference frames, only two interacting bodies. As in the 1960s S-matrix bootstrap[27] (progenitor of string theory), no Lagrangian[28]. Equations of motion calculate impedance networks. What governs the flow of energy was lost in both general relativity and quantum mechanics, a consequence of three historical oversights.

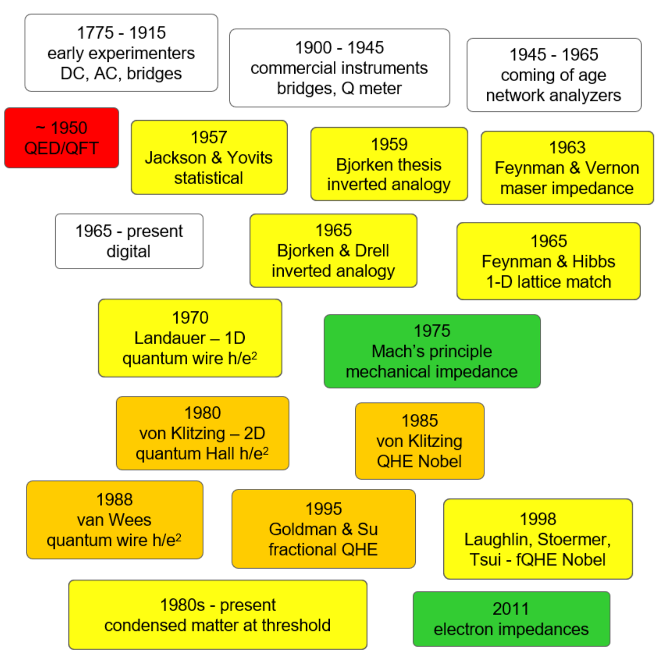

FIG. 5. Impedance matching timeline

The **first** arose from order in which experiment revealed relevant phenomena. QED was set long before the 1980 Nobel prize discovery of scale-invariant quantum Hall impedance[29]. *Exact* impedance quantization concept did not exist, and scale-invariant impedance is far easier to measure than scale-dependent.

Second cause was theorists' habit of setting fundamental constants to dimensionless unity, including the 377 ohm free space impedance excited by the photon. Dimensionless unity made impedance quantization far too easily overlooked.

The **third oversight** was summarized[30,31] as "...an analogy between Feynman diagrams and electrical circuits, with Feynman parameters playing the role of resistance, external momenta as current sources, and coordinate differences as voltage drops. Some of that found its way into section 18.4 of..." the canonical text[32]. As presented there, units of Feynman parameters are [sec/kg], units not of resistance, but *conductance*. One would think more [kg/sec] means more mass flow. However, reality is more [kg/sec] means more impedance, *less* flow. This topological inversion sits in our systems of units, ironically developed with intent to "...facilitate relating standard units of mechanics to electromagnetism." With this oversight Bjorken's anticipated intuitive advantage was lost.

Two points to consider when working with impedance networks:

First, what matters are not absolute impedances, but relative values, the matching. In this they are like the energy whose transmission they govern.

The second point distinguishes scale-dependent and scale-invariant impedances.

Scale-dependent impedances are geometric, include Coulomb, scalar Lorentz, and dipole-dipole, with $1/r$ and $1/r^3$ potentials. They are causal and local, communicate both amplitude and phase, can do work. Resulting motion is parallel to applied force. Scale dependence renders them parametric[33], nonlinear, permitting essential noiseless frequency domain transformation of energy during wavefunction collapse. They are translation gauge fields of Gauge Theory Gravity[20,21].

Scale-invariant impedances are topological, include vector Lorentz of quantum Hall and Aharonov-Bohm effects, centrifugal, chiral, Coriolis, and three-body. Associated potentials are inverse square, the $1/r^2$ of anomalies[34]. Resulting motion is perpendicular to applied force. They cannot do work, communicate only relative phase. They cannot be shielded, are acausal channels of non-local entanglement, rotation gauge fields of GTG.

Hydrogen atom ionization

In far-to-near field transition the atom's inductive impedance advances the photon's electric flux quantum, while capacitive impedance retards the magnetic. The phase shifts decouple Maxwell's equations, decouple the two flux quanta. Scale-dependent inductive impedance transforms electric flux quantum from 377 ohm at inverse Rydberg to 25812 ohm centrifugal impedance at Bohr radius. Here mainstream physics is lost. Neither photon nor electron near-field impedances can be found in physicists' texts or journals.

Photon appears unique in having both scale-dependent near-field geometric and invariant far-field topological impedances. The two photon polarizations sit on the skew diagonal of figure 7, adjacent main diagonal.

S-matrix of observables

QED S-matrix is shown in figure 7. We ‘see’ scalar electric charge, vector magnetic flux quantum, and bivector magnetic moment. We don’t see vector electric dipole moments, bivector electric flux quanta, and trivector magnetic charge. They are ‘dark’, a consequence of topological inversion of magnetic charge. Modes comprised of one each visible and dark are the unstable particle spectrum of figure 8. Blue backgrounds indicate fermionic eigenmodes, yellow bosonic transition modes, flavor and color.

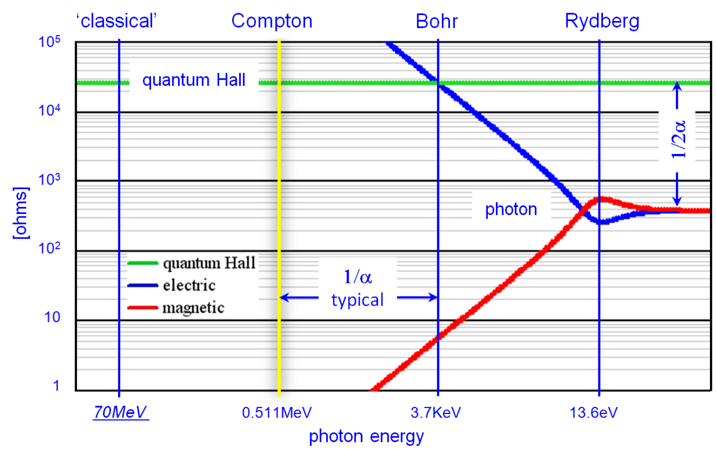

FIG. 6. Hydrogen atom ionization

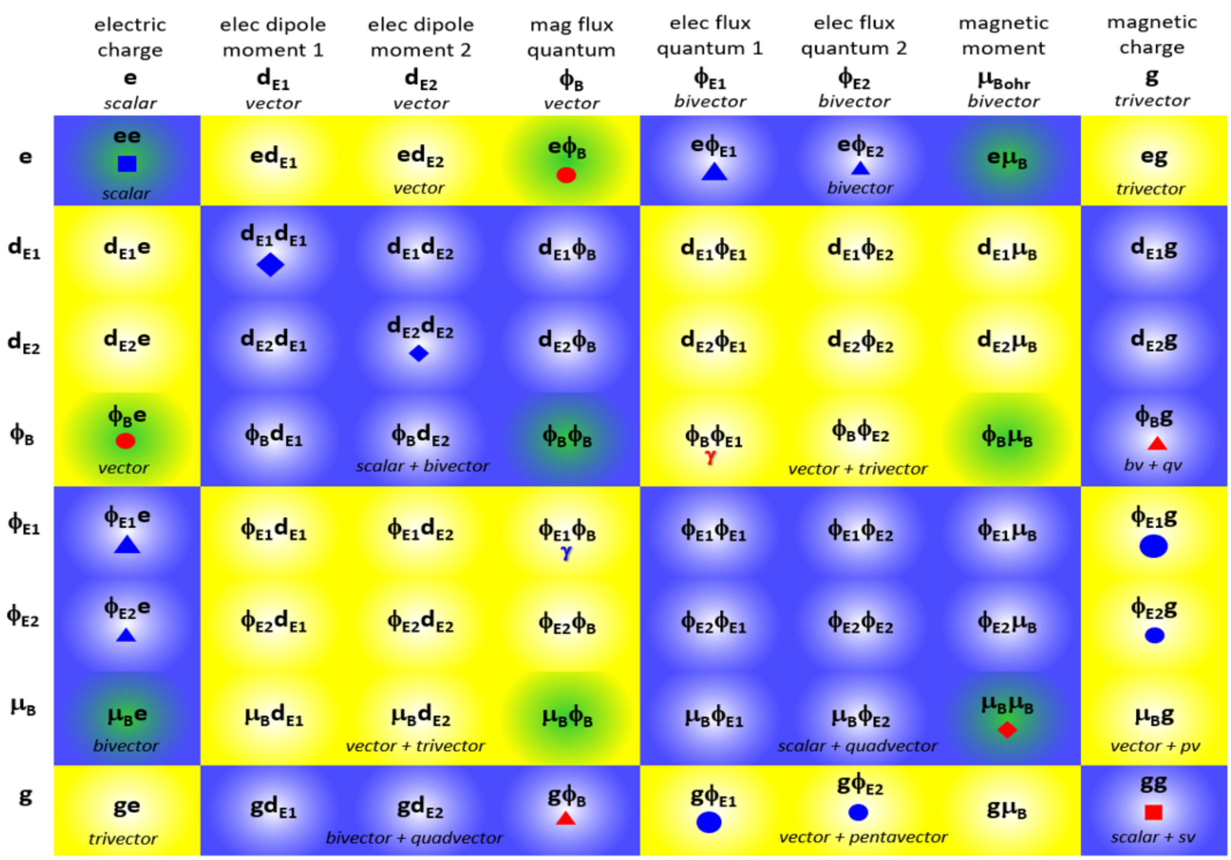

FIG. 7. S-matrix of observables generated by Clifford product of minimally complete wavefunctions

Unstable particle lifetimes

Impedance network of figure 7 is centered upon the QED mass gap at the electron Compton wavelengh. A subset of figure 7 S-matrix mode impedances indicated by symbols (triangles, diamonds,...) are plotted in the network of figure 8, revealing their causal role in coherence and decoherence[35,36]. Unstable particle lifetime correlation (the light cone coherence lengths) with α-spaced network nodes, where capacitive and inductive impedances are matched, is required for reflectionless flow of energy during particle decoherence.

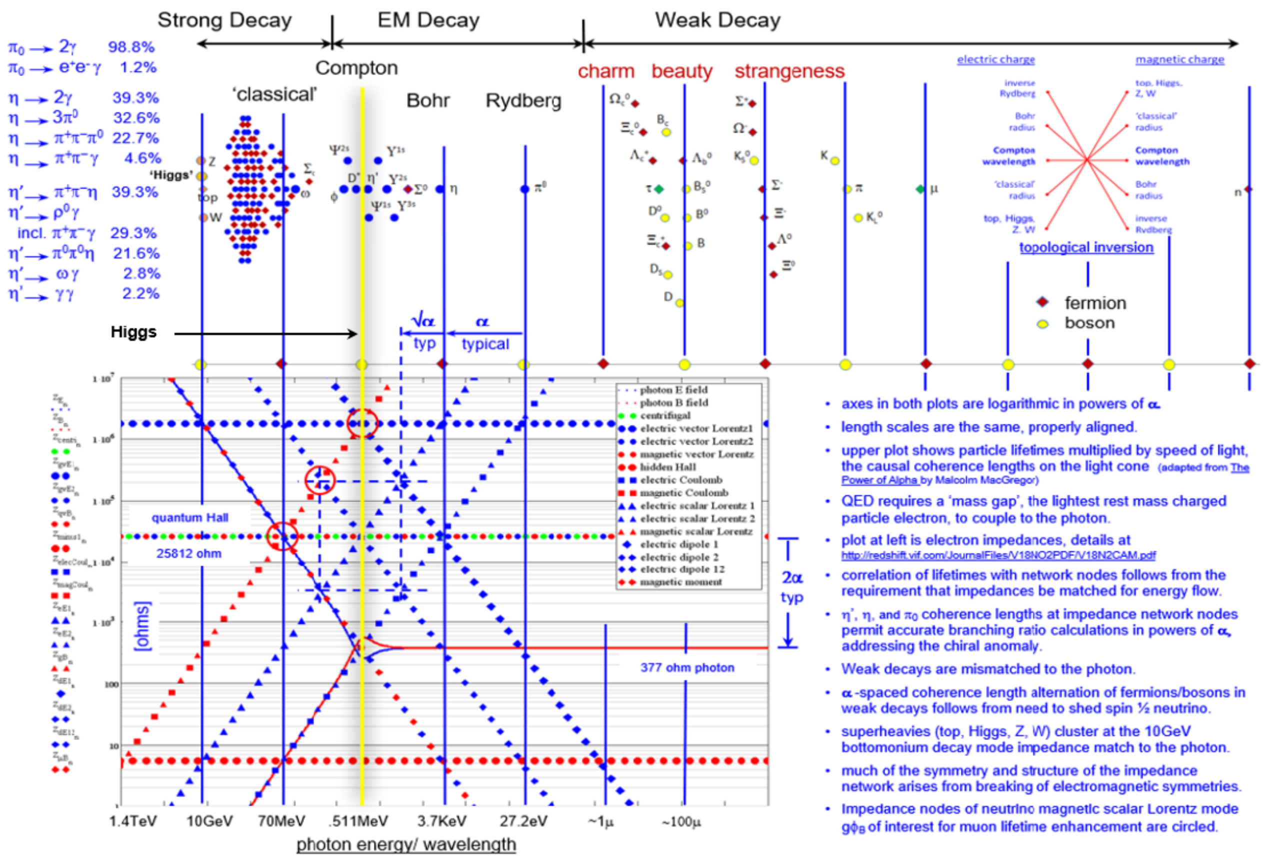

FIG. 8. Correlation of unstable particle spectrum lifetimes with α-spaced network nodes[37,38]

While the Higgs scalar completes the 2D algebra (1,2,1) of electroweak superheavies at the $\sim$10 GeV dominant bottomonium decay mode, only top mass emerges from the Clifford product of W and Z. Higgs measured lifetime extends to the .511 MeV mass gap, where its job of 'providing mass' to strong and electromagnetic particles is complete. There is no inductive impedance to form a node for the photon at the 10 GeV bottomonium scale, hence the small branching ratio.

In weak decays the alternating fermion-boson lifetime structure in powers of alpha is required by omnipresence of the three-component spin 1/2 neutrino[39,40].

Matching to the Planck length and the Universe

Impedance quantization offers immediate possibilities for quantizing gravity at the Planck length[41]. Gravitational force between Planck and Compton wavefunctions equals mismatch-attenuated electromagnetic force at the part-per-billion accuracy of our five fundamental constants input by hand, the origin of gravitational mass. Origin of inertial mass arises from field energy of flux quanta at a given confinement scale[44]. Flat spacetime electromagnetic phase shifts are the GTG equivalent of spatial curvature of GR. While strong classical arguments have been advanced against electromagnetic models of gravitation[45], such arguments fail point-by-point when full consequences of geometric wavefunction interaction impedances enter GTG[46].

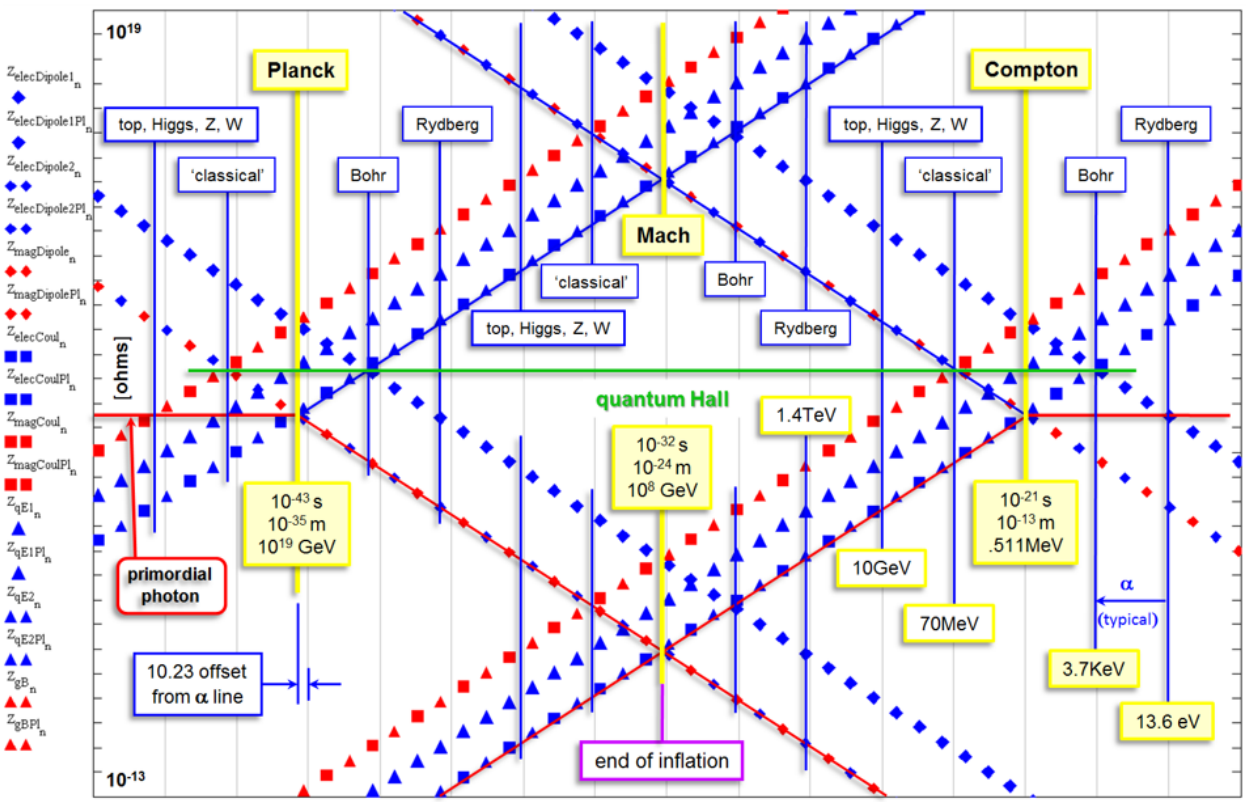

FIG. 9. Impedance network coupling Planck event horizon and electron Compton mass gap.

As shown in figure 10 and discussed in detail elsewhere[47], figure 9 can be extended to the observable universe boundary. Reflection from mismatches yields the continuously increasing Hawking photon wavelength of the full eight-component propagating wavefunction. The observable universe is within the extreme near-field first cycle of Hawking photons radiated from Planck lengths of every massive particle in the universe. The consequent phase shift is what we call gravity.

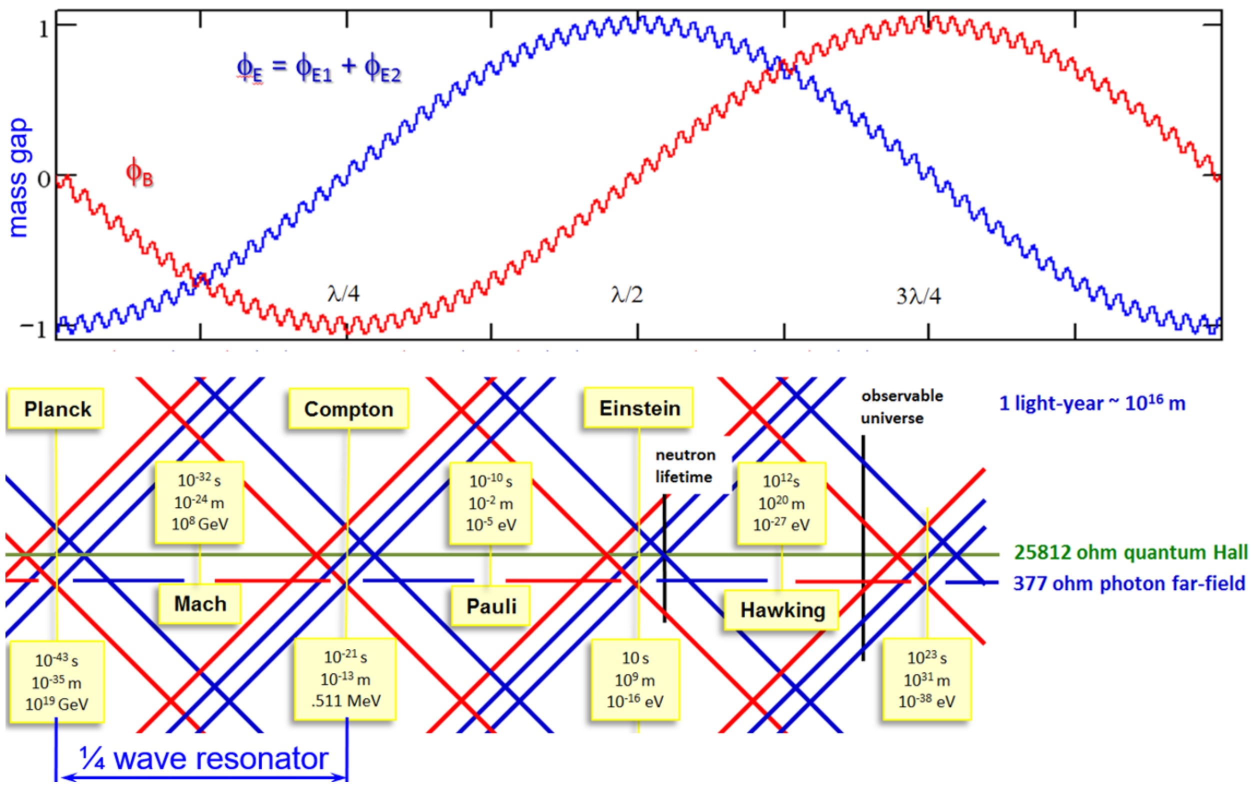

FIG. 10. Cosmological scale attenuation of the 'Hawking graviton' by impedance mismatches

Conclusion

The model presented here has its foundation in Mach's Principle. It is naturally background independent, gauge invariant, finite without renormalization, confined, asymptotically free, contains the four forces, dark matter, and dark energy. As shown in the figure, it establishes a commonality between the Standard Model and String Theory. Perhaps most noteworthy, it fully embodies naturalness[17].

A synthesis of two essential conceptual structures lost in physics, it opens a new window, offers new and novel penetrating insights into the history of physics.

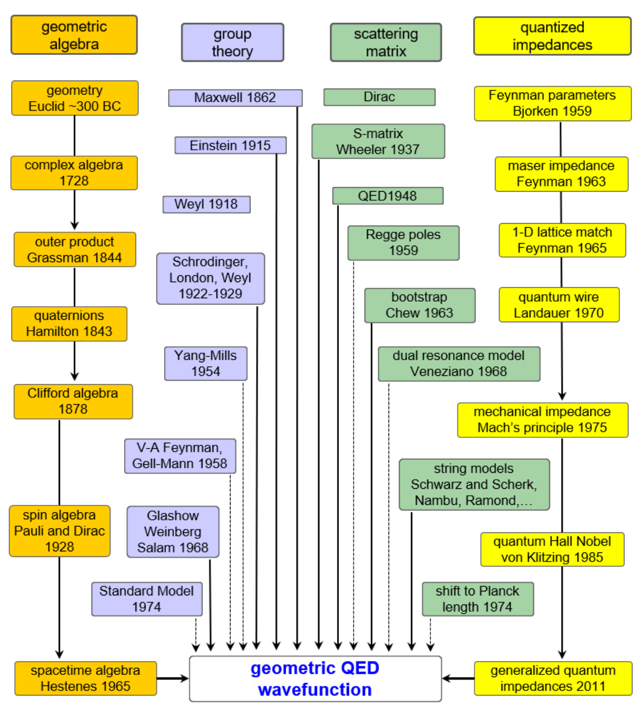

FIG. 11. Four timelines

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