Validating a Maximally Natural Electromagnetic Model of the Four Forces

Peter Cameron and Michaele Suisse

Abstract

We offer a model based upon three `assumptions': The first is geometric, that the vacuum wavefunction is comprised of Euclid's fundamental geometric objects - point, line, plane, and volume elements, the geometric representation of Clifford algebra. The second is electromagnetic, that physical manifestation follows from introducing the dimensionless electromagnetic coupling constant alpha. The third takes the electron Compton wavelength to set the scale of space. The model is arguably maximally natural. Wavefunction interactions are modeled by geometric products of Clifford algebra. What emerges is naturally gauge invariant, finite, confined, asymptotically free, and background independent, and contains the four forces, dark matter, and dark energy. Complementing the Standard Model, it focuses not on Lagrangian flow of energy between kinetic and potential, but rather on what governs amplitude and phase of that flow - quantized impedance networks of geometric wavefunction interactions. Claims presented here are extraordinary}. The model requires validation. While in concordance with the Standard Model, it offers new perspectives. Many connections to SM have been established, however they're but a small fraction of what remains to be done. In particular, it's far from clear how the many broken symmetries in the two models are related.

Snowmass2021 - Letter of Interest

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Thematic Areas: (check all that apply □/■)

■ (TF1) String theory, quantum gravity, black holes
■ (TF2) Effective field theory techniques
■ (TF3) CFT and formal QFT
■ (TF4) Scattering Amplitudes
■ (TF5) Lattice Gauge Theory
■ (TF6) Theory techniques for precision physics
■ (TF7) Collider
■ (TF8) **BSM model building - primary channel**
■ (TF9) Astro-particle physics and cosmology
■ (TF10) Quantum Information Science
■ (TF11) Theory of neutrino physics - secondary channel
■ (Other) Foundation of the model is a phenomenological wavefunction, philosophically driven by the data. If validated, it is likely to be relevant to all channels, to all things quantum.

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Authors: (those interested in the model and its possible validation can join the Loi after the references)

Abstract: (maximum 200 words)

We offer a model based upon three 'assumptions':

The first is geometric, that the vacuum wavefunction is comprised of Euclid's fundamental geometric objects - point, line, plane, and volume elements, the geometric representation of Clifford algebra.

The second is electromagnetic, that physical manifestation follows from introducing the dimensionless coupling constant $\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} \approx 0.0073 \quad 1/\alpha \approx 137.$

The third takes the electron Compton wavelength to set the scale of space. $\lambda_e = \frac{h}{m_e c} \approx 2.42 \cdot 10^{-12}$ meters

The model is arguably maximally natural. Wavefunction interactions are modeled by geometric products of Clifford algebra. What emerges is naturally gauge invariant, finite, confined, asymptotically free, and background independent, and contains the four forces, dark matter, and dark energy. Complementing the Standard Model, it focuses not on Lagrangian flow of energy between kinetic and potential, but rather on what governs amplitude and phase of that flow - quantized impedance networks of geometric wavefunction interactions.

Claims presented here are extraordinary. The model requires validation. While in concordance with the Standard Model, it offers new perspectives. Many connections to SM have been established, however they're but a small fraction of what remains to be done. In particular, it's far from clear how the many broken symmetries in the two models are related.

Introduction

"...naturalness seems to be one of the best-kept secrets of physicists from the general public, a secret weapon for evaluating and motivating theories of the world on its deepest levels"[1–3].

Physics has its roots in natural philosophy. It was only in the 1800s, when the pace of scientific knowledge exceeded the capacity of any one individual, that the separate disciplines of physics, chemistry, and biology emerged. With that emergence and the technology it spawned, naturalness became less direct, more instrumental, not so easily intuited and defined, and even now still lingers unsettled in foundations of the standard models of physics and cosmology[4–10].

To address this requires that which has been lost in physics. The culmination of a series of historical accidents[11, 12], two fundamental conceptual structures - geometric representation of Clifford algebra[13–18] and generalized impedance quantization[19–21] - are absent from the Standard Model.

Geometric Wavefunction Interactions and Quantized Interaction Impedances

The GWI model has three assumptions - vacuum wavefunction, EM coupling constant, and electron mass.

- vacuum wavefunction - while the Dirac matrix formalism in flat Minkowski spacetime is the foundation of particle physicists' representations of Clifford algebra, geometric representation is more useful for present purposes - less abstract, more intuitive, more natural. Geometric Algebra takes Pauli matrices to be the basis vectors of real physical space, Dirac matrices those of real physical spacetime.

  In GA the vacuum wavefunction is comprised of one scalar point, three vector line elements (three orientational degrees-of-freedom), three bivector area elements, and one trivector volume element. This eight-component Pauli wavefunction in physical 3D space can be identified with the string theory octonion[22–24].

  Wavefunction interactions are modeled by the geometric product. As in the two-component positron and electron spinors of the Dirac wavefunction, the product of two octonion wavefunctions yields observables - the particle physicist's S-matrix[25–28]. This requires that fields be associated with the geometry.

- coupling constant - four fundamental constants define the dimensionless electromagnetic coupling constant α. These four permit assignment of topologically appropriate quantized electric and magnetic fields to the eight-component vacuum wavefunction, and calculation of quantized impedance networks of wavefunction interactions in powers of α (figure 1). Given that wavefunction fields are quantized in quantum field theory, it is unavoidable that impedances of wavefunction interactions will likewise be quantized.

  this is important: Impedance matching governs amplitude and phase of energy transmission, governs the flow of information in quantum mechanics.

- electron mass - quantum excitation requires a 'mass gap', a particle with both rest mass and electromagnetic fields to couple to the photon of QED[29]. The lightest rest mass particle (neutrino is without rest mass yet oscillates in the GWI model[30]) sets the scale of space via the electron Compton wavelength.

Quantized Impedance Networks and the Unstable Particle Spectrum

The causal role of GWI in coherence and decoherence of the unstable particle spectrum is illustrated in the figure[31]. A subset of S-matrix mode interaction impedances are plotted in the network at lower left. Phase correlation of unstable particle lifetimes/causal light cone coherence lengths [32–34] with nodes of the network follows from the fact that impedances must be matched for the energy transmission essential in decay. The network shown there can be extended in both UV and IR, beyond both Planck length and boundary of the observable universe[35]. Vacuum wavefunction is the same at all scales. Field quantization yields scale-dependent physics.

All rest mass particles have easily calculated mechanical impedances[19–21]. Transformation to electromagnetic impedances is straightforward via the electromechanical oscillator[36]. A tremendous simplification, bypassing the much more difficult task of calculating scale-dependent quantized EM impedances via Maxwell's equations (if such a thing can even be done - a computational challenge of immediate interest).

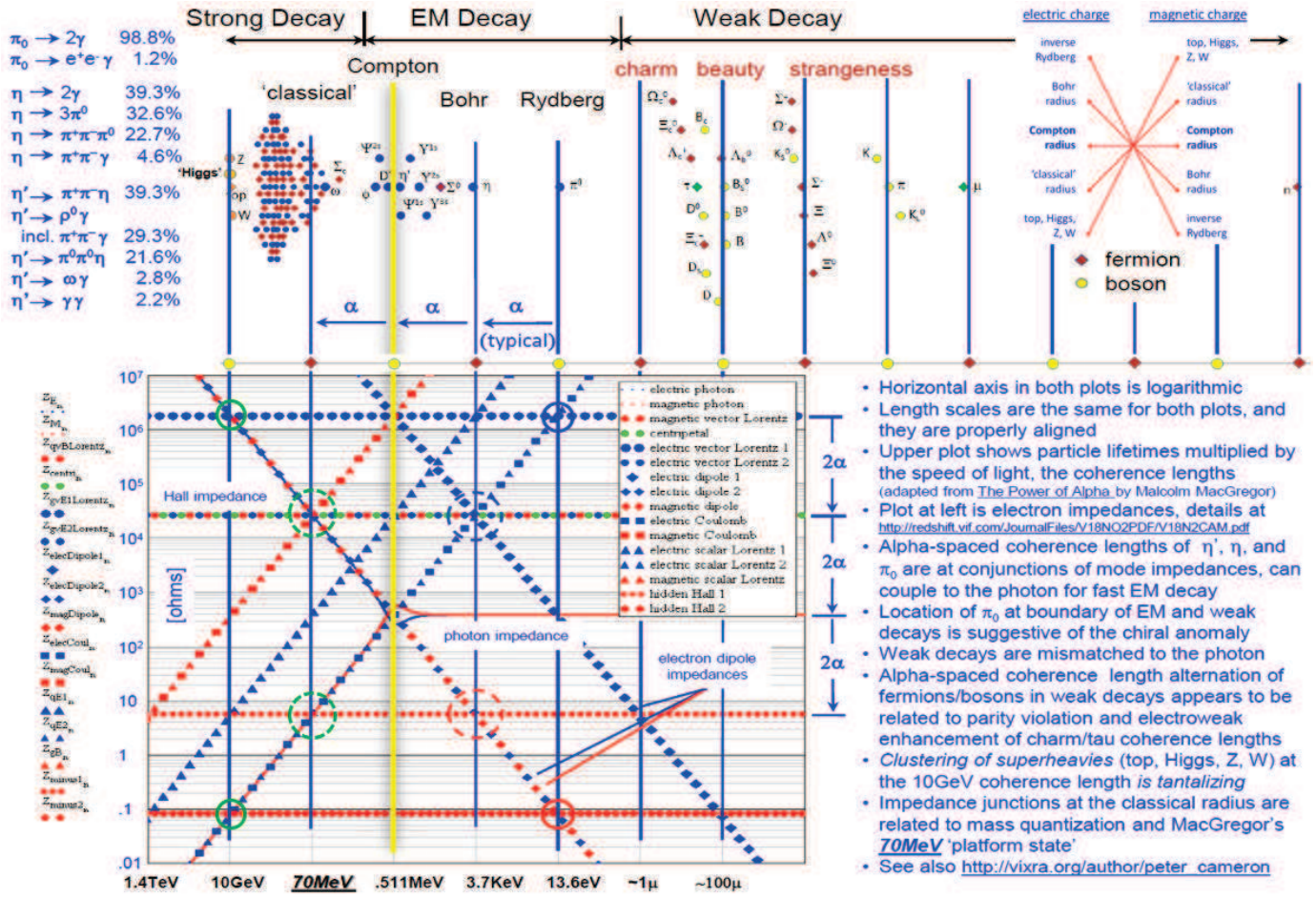

FIG. 1: BSM origin of unstable particle lifetimes in terms of quantized impedance networks of GWI. Dynamic SUSY of alternating fermion and boson lines in weak decays has its origin in topological symmetry breaking of the neutrino, as indicated by topological inversion of magnetic charge at upper right[37].

The abstract claims the model is "...naturally gauge invariant, finite, confined, asymptotically free, and background independent, and contains the four forces, dark matter, and dark energy." We offer the following rationales:

- **gauge invariance** - Impedances shift phases, provide a coherent alternative formulation of the effect of the covariant derivative.
- **finiteness** - Impedance mismatches provide natural QED cutoffs. Both singularity and the boundary at infinity are decoupled by the infinite quantum impedance mismatches. No renormalization[38].
- **confinement** - Confinement is the flip side of finiteness. Energy is reflected from mismatches, back to matched impedance nodes at the wavefunction wavelength, be it Planck, Compton, deBroglie,... GWI contains the strong and weak nuclear forces, is naturally confined.
- **asymptotic freedom** follows from exact matching at wavefunction impedance network nodes.
- **background independence** - In the two body problem motion is with respect to one of the two. There is no background. GWI is naturally background independent, a requirement for calculating mechanical impedances from Mach's principle[19].
- **gravitation** - Matching quantized impedances at the Planck scale reveals an exact identity between electromagnetism and gravity[24, 41–50], with an origin of mass arising from the mismatch to the event horizon. A second origin comes from shared wavefunction mode energies of quantized fields.

Author page[51] is perhaps best browse to start convincing one's self that the model should be validated. Or not. Calculate. Communicate. Confirm (and sign up for this Loi) or refute, please.

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