Quantum Impedance Matching of Rabi Oscillations

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Abstract: We present a model of Geometric Wavefunction Interactions, the GWI model, that offers an alternative (perhaps equivalent) representation of QED, and use it to explore the quantized impedance structure governing energy flow in Rabi oscillations.

OCIS codes: 020.5580, 270.0270, 270.5585

1. Geometric Wavefunctions

The naive realist [1] wants a vacuum wavefunction that can be visualized in physical three-dimensional space. The reductionist begins by modeling wavefunctions with fundamental geometric objects of Euclid - point, line, plane, and volume elements. These comprise a minimally complete eight component Pauli algebra of space - one scalar, three vectors (three orientational degrees of freedom), three bivector area elements, and one trivector volume element - the string theory octonion wavefunction [2]. Interactions permit emergence, are modeled by the geometric product of Clifford algebra, generate the particle physicist's S-matrix [3–5].

The geometric product changes dimensionality of geometric objects, as shown in figure 1. This mixing makes Geometric Algebra unique in the ability to handle geometric and topological dynamics [6].

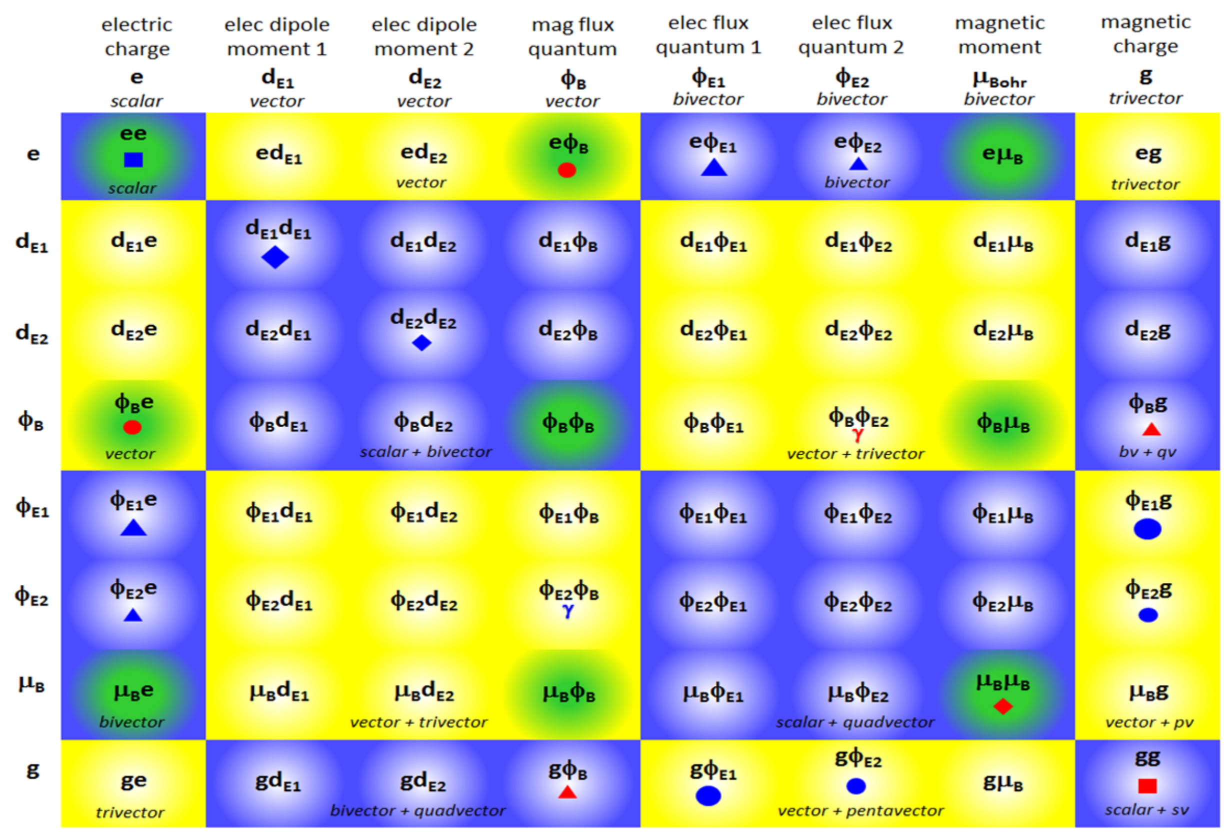

Fig. 1. S-matrix: Octonion wavefunctions at top and left correspond to Dirac electron and positron. Mode interaction impedances indicated by symbols (triangle, square,...) are plotted in figure 3 [7].

2. Quantum Impedance Matching

Given that wavefunction fields are quantized in quantum field theory, it is unavoidable that impedances of wavefunction interactions will likewise be quantized. Physical manifestation of the vacuum wavefunction follows from introducing the dimensionless electromagnetic coupling constant $\alpha = \frac{e^2}{2\varepsilon_0 hc}$. The four fundamental constants that define α permit assignment of topologically appropriate quantized E and B fields to the eight vacuum wavefunction components, and to calculate quantized impedance networks of wavefunction interactions [8, 9].

This is important: Matching governs amplitude and phase of energy flow, of information transmission.

Figure 2 shows photon near-field dipole impedance match from inverse Rydberg to Bohr radius. Here the mainstream community is lost, at the outset of exploring the Rosetta stone of atomic physics. Photon near-field impedance [10] is not to be found in textbooks, curricula, or journals of physics, is absent from education and practice. That which governs amplitude and phase of information transmission in photon-electron interactions is absent from QED.

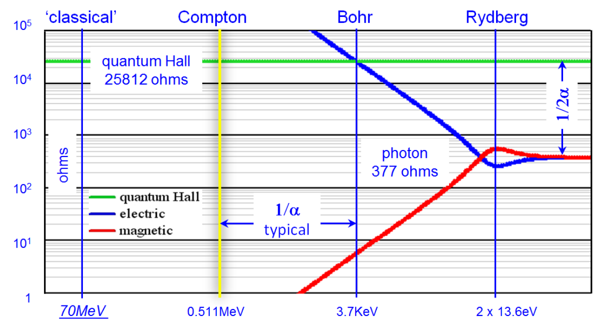

Fig. 2. 13.6eV photon coupling to Bohr radius [11]

3. Rabi Oscillations

Rydberg core electrons shield the outer electron from the nuclear electric field such that the electric potential looks like that of a hydrogen atom, suggesting that the impedance network of figure 3 may be helpful in understanding Rabi oscillations.

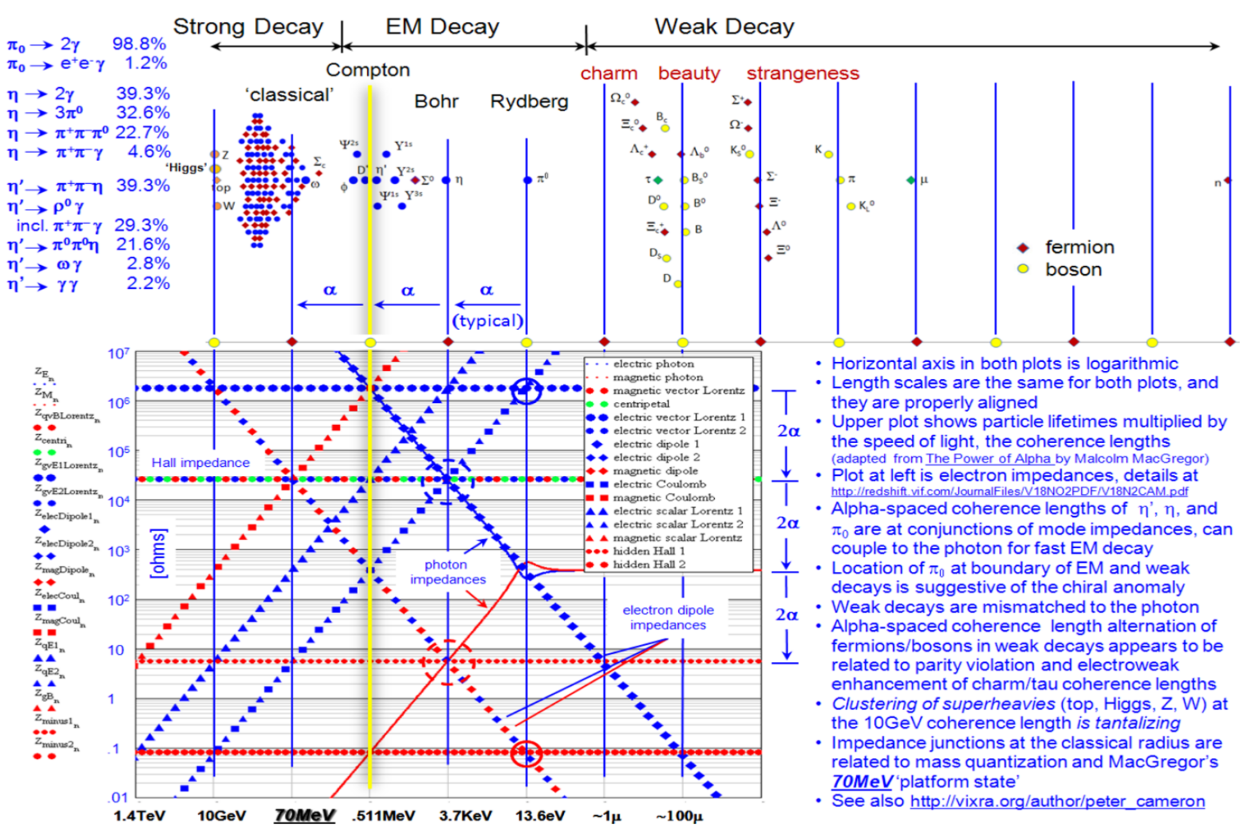

Fig. 3. Correlation of unstable particle lifetimes/coherence lengths [12, 13] with nodes of impedance network generated by electron mass gap excitation of vacuum wavefunctions [14]. Matched impedances at nodes permit energy transmission essential for particle decay. Nonlinearity of scale dependence renders quantum impedances parametric, noiseless [15].

In figure 3, photon absorption occurs when relative phase of the 13.6eV photon's electric and magnetic flux quanta is shifted by the Rydberg electron's dipole impedance (blue diamonds), matching the photon's energy to the node at the Bohr radius (where there is no direct match to the photon, perhaps accounting in part for stability of atoms).

There we find the capacitive scalar Lorentz impedance that drives the Rabi oscillation (small blue triangles), the Coulomb impedance of electron-positron interaction (blue squares), and a variety of scale invariant topological impedances (quantum Hall/Chern-Simons, chiral, centrifugal, Coriolis, three-body,... phase shifters, mode couplers).

For Rabi oscillations one might reasonably argue that the analogy is weak, that differences between physics at the .511MeV electron Compton wavelength and microvolt Rydberg scales may be both subtle and gross. However it has been shown that the octonion wavefuction at the Planck length offers a plausible model for quantum gravity [16–18]. The vacuum wavefunction is the same at all scales. The physics changes as the quantized fields are confined to differing lengths. This gives hope that the GWI model might offer new insight into dynamics of Rabi oscillations.

4. Conclusion

Best part of the GWI model is that it offers a visual real space intuitive model of wavefunctions and their interactions, permitting resolution of paradoxes of quantum interpretations [19, 20]. From this solid foundation in natural philosophy, what emerges is naturally [21] gauge invariant, finite, confined, and asymptotically free. It contains gravitation and the strong and weak nuclear forces. What it does not yet contain is AMO/condensed matter. That's the hard part.

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