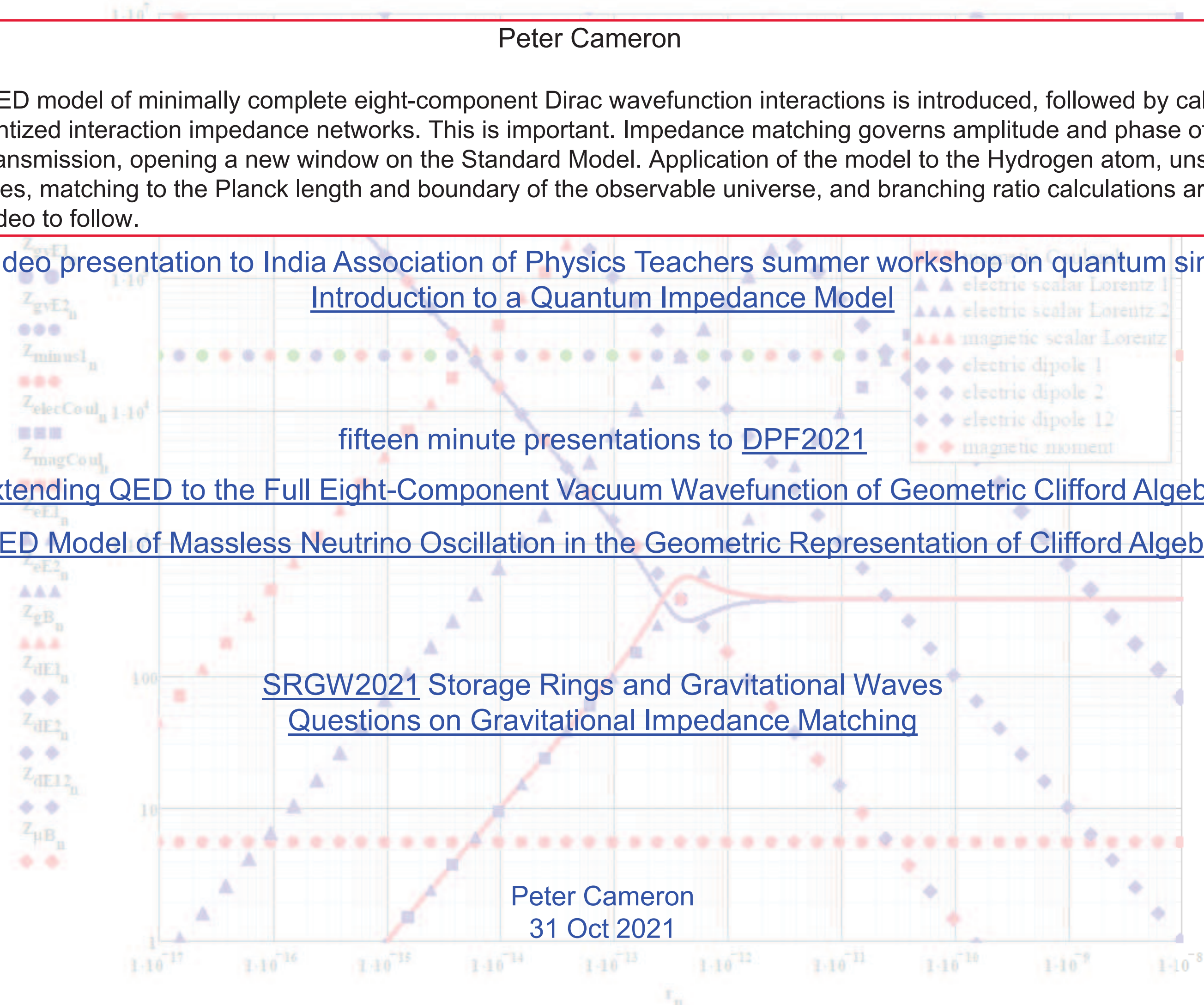
Calculating Quantum Impedance Networks of Octonion String Wavefunction Interactions

Peter Cameron

Abstract: A QED model of minimally complete eight-component Dirac wavefunction interactions is introduced, followed by calculation details of quantized interaction impedance networks. This is important. Impedance matching governs amplitude and phase of energy/information transmission, opening a new window on the Standard Model. Application of the model to the Hydrogen atom, unstable particle lifetimes, matching to the Planck length and boundary of the observable universe, and branching ratio calculations are presented. Video to follow.



hour+ video presentation to India Association of Physics Teachers summer workshop on quantum simulation

Introduction to a Quantum Impedance Model

fifteen minute presentations to DPF2021

Extending QED to the Full Eight-Component Vacuum Wavefunction of Geometric Clifford Algebra

QED Model of Massless Neutrino Oscillation in the Geometric Representation of Clifford Algebra

SRGW2021 Storage Rings and Gravitational Waves

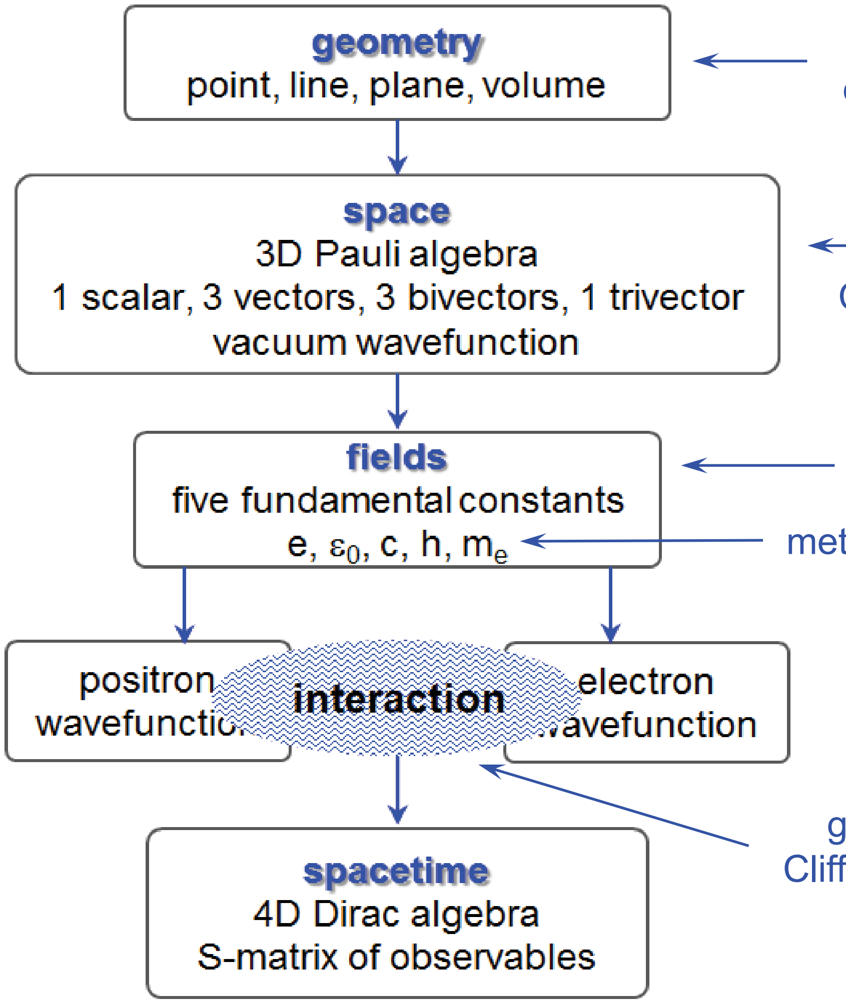
Questions on Gravitational Impedance Matching

Peter Cameron

31 Oct 2021

The Theoretical Minimum

Three assumptions – geometry, fields, and 'mass gap'



geometric quantization

https://www.youtube.com/watch?v=60z_hpEAtD8
Clifford algebra in geometric representation

electromagnetic quantization

metric = mass gap = m_e

$$\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} \approx 0.0073$$

$$1/\alpha \approx 137$$

geometric Clifford product

6D phase space

no free parameters - emergence

how to: Calculating Quantum Impedance Networks of QED String Wavefunction Interactions

Model presented here emerges from three assumptions. First, vacuum wavefunction in the intuitive geometric representation of Clifford algebra (math language of quantum mechanics), as opposed to the less easily visualized matrix representations of Pauli and Dirac. Second, introduction of the electromagnetic coupling constant a ~ 1/137 to permit physical manifestation of the geometry, to assign electromagnetic field quanta to the eight vacuum wavefunction components. And third, mass of the lightest charged particle, the 'mass gap', to define the electron Compton wavelength, setting the scale of space.

1. Vacuum wavefunction is comprised of eight fundamental geometric objects - one scalar point, three vector line elements (orientational degrees of freedom), three bivector area elements, and one trivector volume. These define a minimally complete basis of space, a 3D Pauli algebra, the same at all scales. Wavefunction interactions are modeled by the geometric Clifford product, generating a 6D phase space - three space and three relative phases of the three orthogonal field orientations. Time is the integral of phase, the same for all three, reducing dimensionality to 4D Dirac algebra of flat Minkowski spacetime. Geometric products lower and raise dimensionality, such that time emerges from interactions. Pauli matrices are basis vectors of space in geometric representation, Dirac matrices those of spacetime

$$\alpha := \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{\text{hbar}\cdot c}$$

2. Combinations of the four fundamental constants that define α (electric charge quantum, electric permittivity of space, angular momentum quantum, and speed of light) permit assigning geometrically and topologically appropriate electric and magnetic field quanta to the eight vacuum wavefunction components - one electric charge (scalar), three 1D dipole moments (vector), three 2D axial vectors (bivector pseudovector), and one 3D magnetic charge (trivector/pseudoscalar). Appearance of different physics at different confinement scales arises from scale-dependent energies of the field quanta. Smaller means more energy.

3. QED requires a 'mass gap', a lightest rest mass charged particle to couple to the photon, setting the scale of space.
Natural choice is Compton wavelength of the electron rest mass. $\lambda = h/mc$

Given these three assumptions, one can calculate quantized impedance networks of wavefunction interactions.

This is important. Impedance matching governs amplitude and phase of energy flow, of information transmission. Understanding structure and meaning of wavefunction interaction impedance networks opens a new window on quantum dynamics at all scales.
In what follows we show the method to calculate mechanical and electromagnetic impedances of scale-dependent geometric and scale-invariant topological wavefunction component interactions (the S-matrix).

Outline

I. Fundamental Constants

particleDataBase2020

The four fundamental physical constants that define α permit assigning geometrically and topologically appropriate E and B flux quanta to the eight fundamental geometric objects that comprise vacuum wavefunctions, as shown in the following section.

electric charge quantum $e := 1.602176634 \times 10^{-19}\ \text{coul}$

angular momentum quantum $\text{hbar} := 1.054571817 \times 10^{-34}\ \frac{\text{kg}\cdot\text{m}^2}{\text{sec}}$

$h := 2\pi\cdot\text{hbar}$

magnetic permeability $\mu_0 := 4\cdot\pi\cdot 10^{-7}\cdot\frac{N}{A^2}$

speed of light $c := 2.99792458 \times 10^8\ \frac{m}{s}$

electromagnetic coupling constant $\alpha := \frac{\mu_0}{2}\cdot\frac{e^2\cdot c}{h}$ $\frac{1}{\alpha} = 1.37 \times 10^2$

defining $\varepsilon_0 := \frac{1}{\mu_0\cdot c^2}$ $\alpha := \frac{1}{2\varepsilon_0}\cdot\frac{e^2}{h\cdot c}$ $\alpha = 7.297 \times 10^{-3}$

A fifth constant is required, a lightest electrically charged particle, the 'mass gap', to set the scale of space at the electron Compton wavelength.

$m_e := 9.109383702 \times 10^{-31}\ \text{kg}$

$\lambda\text{bar}_e := \frac{\text{hbar}}{m_e\cdot c}$ $\lambda\text{bar}_e = 3.862 \times 10^{-13}\,\text{m}$

$\lambda_e := \frac{h}{m_e\cdot c}$ $\lambda_e = 2.426 \times 10^{-12}\,\text{m}$

II. Assigning quantized fields to wavefunction components

Of the **eight field quanta** needed to physically manifest the eight vacuum wavefunction components, **Scalar electric charge** is one of the four fundamental constants that define α.

First of the three 1D vector dipoles is the topological magnetic flux quantum, whose trivector magnetic charge 'pseudopoles' are at 'infinity'.

$\Phi_B := \frac{h}{2e}$ $\Phi_B = 2.068 \times 10^{-15}\,\text{tesla}\cdot\text{m}^2$

Topological inversion has gone unnoticed in particle physics, yet when examined becomes obvious.
Units of mechanical impedance, of that which governs flow of energy of all rest mass particle interactions, are [kg/s]. One might reasonably expect that more [kg/s] would mean more flow, and consequently less impedance. However in the physical world more [kg/s] means less flow. This implies that the origin of mass is, at least in part, topological. Among others, this stymied both Bjorken and Feynman, and is discussed in greater detail elsewhere. naturalness ***link here***

Second of the **vector dipoles** is comprised of two magnetic charges (topological dual of electric charge), separated by the reduced Compton wavelength. Magnetic charge is defined by the Dirac quantization condition eg=h/2.

defining $g := \frac{h}{2e}$ $\qquad g = 2.068 \times 10^{-15}\,\text{tesla}\cdot\text{m}^2$

yields $d_{E1} := \frac{\varepsilon_0}{4\pi}\cdot\frac{h^2}{e\cdot m_e}$ $\qquad d_{E1} = 2.12 \times 10^{-30}\,\text{m coul}$

ε

Interaction of electric and magnetic charge is the 'dyon', generates angular momentum of rotation gauge fields, which are topological. One topological consequence is symbolic and numerical identity of geometrically different 1D vector magnetic flux quantum and **3D trivector magnetic charge**.

Last of the **three 1D vector dipoles** is comprised of two electric charges, again separated by the reduced Compton wavelength

$d_{E2} := \frac{1}{2\pi}\cdot\frac{e\cdot h}{m_e\cdot c}$ $\qquad d_{E2} = 6.187 \times 10^{-32}\,\text{m coul}$

The two electric dipoles are related by 4α $\qquad \frac{4\alpha\cdot d_{E1}}{d_{E2}} = 1 \times 10^0$

The effect of topological inversion of magnetic charge is evident here. Magnetic flux quantum is vector rather than bivector, as required by the observed axial bivector property of the Bohr magneton.

2D Bivector magnetic moment is the Bohr magneton, an axial pseudovector rather that a true dipole moment. If dipole moment is defined as the product of charges and their separation, then one would expect the Bohr magneton (a fundamental constant) to be the product of magnetic charge and some fundamental length, likely the Compton wavelength. However the Bohr magneton is defined in terms of electric charge:

$\mu_B := \frac{1}{4\pi}\cdot\frac{e\cdot h}{m_e}$ $\qquad \mu_B = 9.274 \times 10^{-24}\,\frac{\text{joule}}{\text{tesla}}$

Like the two electric vector dipoles, **two electric bivectors** can be defined:

$\Phi_{E1} := \frac{h\cdot c}{2e}$ $\qquad \Phi_{E1} = 6.199 \times 10^{-1}\,\text{mvolt}\cdot\text{mm}$

$\Phi_{E2} := \frac{e}{\varepsilon_0}$ $\qquad \Phi_{E2} = 1.81 \times 10^{-2}\,\text{mvolt}\cdot\text{mm}$

Like the two electric vector dipoles, the two electric bivectors are related by 4α. $\qquad \frac{4\alpha\cdot\Phi_{E1}}{\Phi_{E2}} = 1 \times 10^0$

Summarizing, the eight field quanta assigned to the vacuum wavefunction are shown in terms of various combinations of the five fundamental constants of the model at the electron Compton wavelength:

1 scalar

electric charge $e = 1.602 \times 10^{-19}\,\mathrm{coul}$

3 vectors

electric dipole 1 $d_{E1} := \frac{\varepsilon_0}{4\pi} \cdot \frac{h^2}{e \cdot m_e}$ $d_{E1} = 2.12 \times 10^{-30}\,\mathrm{m \cdot coul}$

electric dipole 2 $d_{E2} := \frac{1}{2\pi} \cdot \frac{e \cdot h}{m_e \cdot c}$ $d_{E2} = 6.187 \times 10^{-32}\,\mathrm{m\ coul}$

magnetic flux quantum $\Phi_B := \frac{h}{2e}$ $\Phi_B = 2.068 \times 10^{-15}\,\mathrm{tesla \cdot m^2}$

3 bivectors

electric flux quantum 1 $\Phi_{E1} := \frac{h \cdot c}{2e}$ $\Phi_{E1} = 6.199 \times 10^{-1}\,\mathrm{mvolt \cdot mm}$

electric flux quantum 2 $\Phi_{E2} := \frac{e}{\varepsilon_0}$ $\Phi_{E2} = 1.81 \times 10^{-2}\,\mathrm{mvolt \cdot mm}$

magnetic moment $\mu_B := \frac{1}{4\pi} \cdot \frac{e \cdot h}{m_e}$ $\mu_B = 9.274 \times 10^{-24}\,\frac{\mathrm{joule}}{\mathrm{tesla}}$

1 trivector

magnetic charge $g := \frac{h}{2e}$ $g = 2.068 \times 10^{-15}\,\mathrm{tesla \cdot m^2}$

	electric charge e *scalar*	elec dipole moment 1 d_{E1} *vector*	elec dipole moment 2 d_{E2} *vector*	mag flux quantum ϕ_B *vector*	elec flux quantum 1 ϕ_{E1} *bivector*	elec flux quantum 2 ϕ_{E2} *bivector*	magnetic moment μ_{Bohr} *bivector*	magnetic charge g *trivector*
e	ee *scalar*	ed_{E1}	ed_{E2} *vector*	$e\phi_B$	$e\phi_{E1}$	$e\phi_{E2}$ *bivector*	$e\mu_B$	eg *trivector*
d_{E1}	$d_{E1}e$	$d_{E1}d_{E1}$	$d_{E1}d_{E2}$	$d_{E1}\phi_B$	$d_{E1}\phi_{E1}$	$d_{E1}\phi_{E2}$	$d_{E1}\mu_B$	$d_{E1}g$
d_{E2}	$d_{E2}e$	$d_{E2}d_{E1}$	$d_{E2}d_{E2}$	$d_{E2}\phi_B$	$d_{E2}\phi_{E1}$	$d_{E2}\phi_{E2}$	$d_{E2}\mu_B$	$d_{E2}g$
ϕ_B	$\phi_B e$ *vector*	$\phi_B d_{E1}$	$\phi_B d_{E2}$ *scalar + bivector*	$\phi_B\phi_B$	$\phi_B\phi_{E1}$ γ	$\phi_B\phi_{E2}$ *vector + trivector*	$\phi_B\mu_B$	$\phi_B g$ *bv + qv*
ϕ_{E1}	$\phi_{E1}e$	$\phi_{E1}d_{E1}$	$\phi_{E1}d_{E2}$	$\phi_{E1}\phi_B$ γ	$\phi_{E1}\phi_{E1}$	$\phi_{E1}\phi_{E2}$	$\phi_{E1}\mu_B$	$\phi_{E1}g$
ϕ_{E2}	$\phi_{E2}e$	$\phi_{E2}d_{E1}$	$\phi_{E2}d_{E2}$	$\phi_{E2}\phi_B$	$\phi_{E2}\phi_{E1}$	$\phi_{E2}\phi_{E2}$	$\phi_{E2}\mu_B$	$\phi_{E2}g$
μ_B	$\mu_B e$ *bivector*	$\mu_B d_{E1}$	$\mu_B d_{E2}$ *vector + trivector*	$\mu_B\phi_B$	$\mu_B\phi_{E1}$	$\mu_B\phi_{E2}$ *scalar + quadvector*	$\mu_B\mu_B$	$\mu_B g$ *vector + pv*
g	ge *trivector*	gd_{E1}	gd_{E2} *bivector + quadvector*	$g\phi_B$	$g\phi_{E1}$	$g\phi_{E2}$ *vector + pentavector*	$g\mu_B$	gg *scalar + sv*

S-matrix of Dirac's QED, extended to the full eight-component vacuum wavefunction in the geometric representation of Clifford algebra. Symbols (triangle, diamond,…) correspond to following slides.

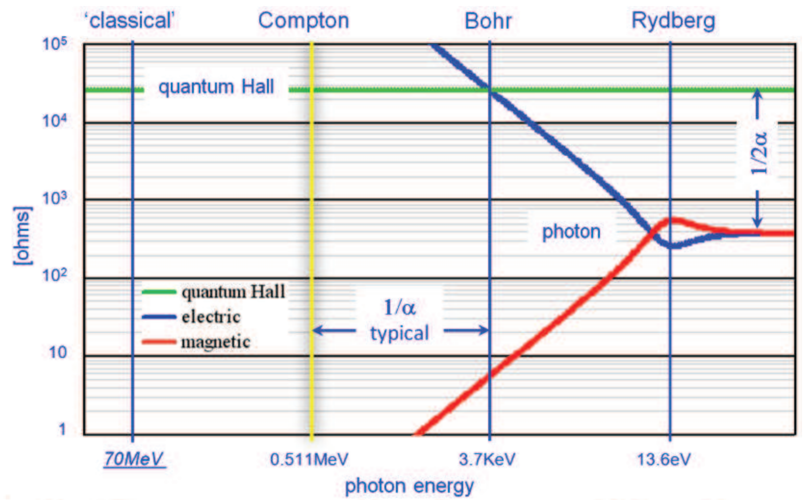
IV. Quantized impedances of S-matrix modes as a function of scale

a. The photon - unique in that it has both scale dependent far-field and invariant near-field impedances

$n := 1..2000 \qquad r_n := 10^{-0.01n} \cdot m \qquad j := \sqrt{-1} \qquad Z_0 := \sqrt{\frac{\mu_0}{\varepsilon_0}} \qquad Z_0 = 3.767 \times 10^2 \, ohm$

$$Z_{E_n} := \frac{Z_0 \cdot \left| 1 + \frac{\lambda bar_e}{j \cdot r_n} + \frac{\lambda bar_e^{\,2}}{(j \cdot r_n)^2} \right|}{\left| 1 + \frac{\lambda bar_e}{j \cdot r_n} \right|}$$

$$Z_{B_n} := \frac{Z_0 \cdot \left| 1 + \frac{\lambda bar_e}{j \cdot r_n} \right|}{\left| 1 + \frac{\lambda bar_e}{j \cdot r_n} + \frac{\lambda bar_e^{\,2}}{(j \cdot r_n)^2} \right|}$$



b. Inverse square potentials - centrifugal and three vector Lorentz impedances are scale-invariant, topological. Three of the four are equal to quantum Hall, with the fourth a factor of 1/2a=68.5 times larger.

$Z_{centri} := \frac{h}{e^2} \qquad Z_{centri} = 2.581 \times 10^4 \, ohm \qquad Z_{centri_n} := \frac{h}{e^2}$

$Z_{qvB} := \frac{h}{e^2} \qquad Z_{qvB} = 2.581 \times 10^4 \, ohm \qquad Z_{qvB_n} := \frac{h}{e^2}$

$Z_{gvE1} := \frac{1}{\mu_0} \cdot \frac{h^2}{e^4 \cdot c} \qquad 2\alpha Z_{gvE1} = 2.581 \times 10^4 \, ohm \qquad Z_{gvE1_n} := \frac{1}{\mu_0} \cdot \frac{h^2}{e^4 \cdot c}$

$Z_{gvE2} := \frac{h}{e^2} \qquad Z_{gvE2} = 2.581 \times 10^4 \, ohm \qquad Z_{gvE2_n} := \frac{h}{e^2}$

In addition, we admit the possibility of low values of invariant impedances, the first at ~5.5 ohms, middle of optimal voice coil 4-8 ohm impedance range for loudspeaker electromechanical impedance coupling.

1 $Z_{minus1} := 4 \cdot \alpha^2 \cdot \frac{h}{e^2} \qquad Z_{minus1} = 5.498 \times 10^0 \, ohm \qquad Z_{minus1_n} := 4 \cdot \alpha^2 \cdot \frac{h}{e^2}$

c. 1/r potentials - scale-dependent capacitive geometric impedances, evaluated at the electron Compton wavelength.

Two Coulomb impedances, one each electric and magnetic

$$Z_{elecCoul} := \frac{m_e}{\varepsilon_0 \cdot h} \cdot \lambda_e \qquad \frac{1}{2\alpha} Z_{elecCoul} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{elecCoul_n} := \frac{m_e}{\varepsilon_0 \cdot h} \cdot (2\pi r)_n$$

$$Z_{magCoul} := \frac{h \cdot m_e}{\mu_0 \cdot e^4} \cdot \lambda_e \qquad 2\alpha Z_{magCoul} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{magCoul_n} := \frac{h \cdot m_e}{\mu_0 \cdot e^4} \cdot (2\pi r)_n$$

Three scalar Lorentz impedances, one magnetic and two electric

$$Z_{eE1} := \frac{m_e \cdot c}{e^2} \cdot \lambda_e \qquad Z_{eE1} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{eE1_n} := \frac{m_e \cdot c}{e^2} \cdot (2\pi r)_n$$

$$Z_{eE2} := \frac{m_e}{\varepsilon_0 \cdot h} \cdot \lambda_e \qquad \frac{1}{2\alpha} Z_{eE2} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{eE2_n} := \frac{m_e}{\varepsilon_0 \cdot h} \cdot (2\pi r)_n$$

$$Z_{gB} := \frac{h \cdot m_e}{\mu_0 \cdot e^4} \cdot \lambda_e \qquad 2\alpha Z_{gB} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{gB_n} := \frac{h \cdot m_e}{\mu_0 \cdot e^4} \cdot (2\pi r)_n$$

d. 1/r^3 potentials - scale-dependent inductive geometric impedances, evaluated at the electron Compton wavelength.

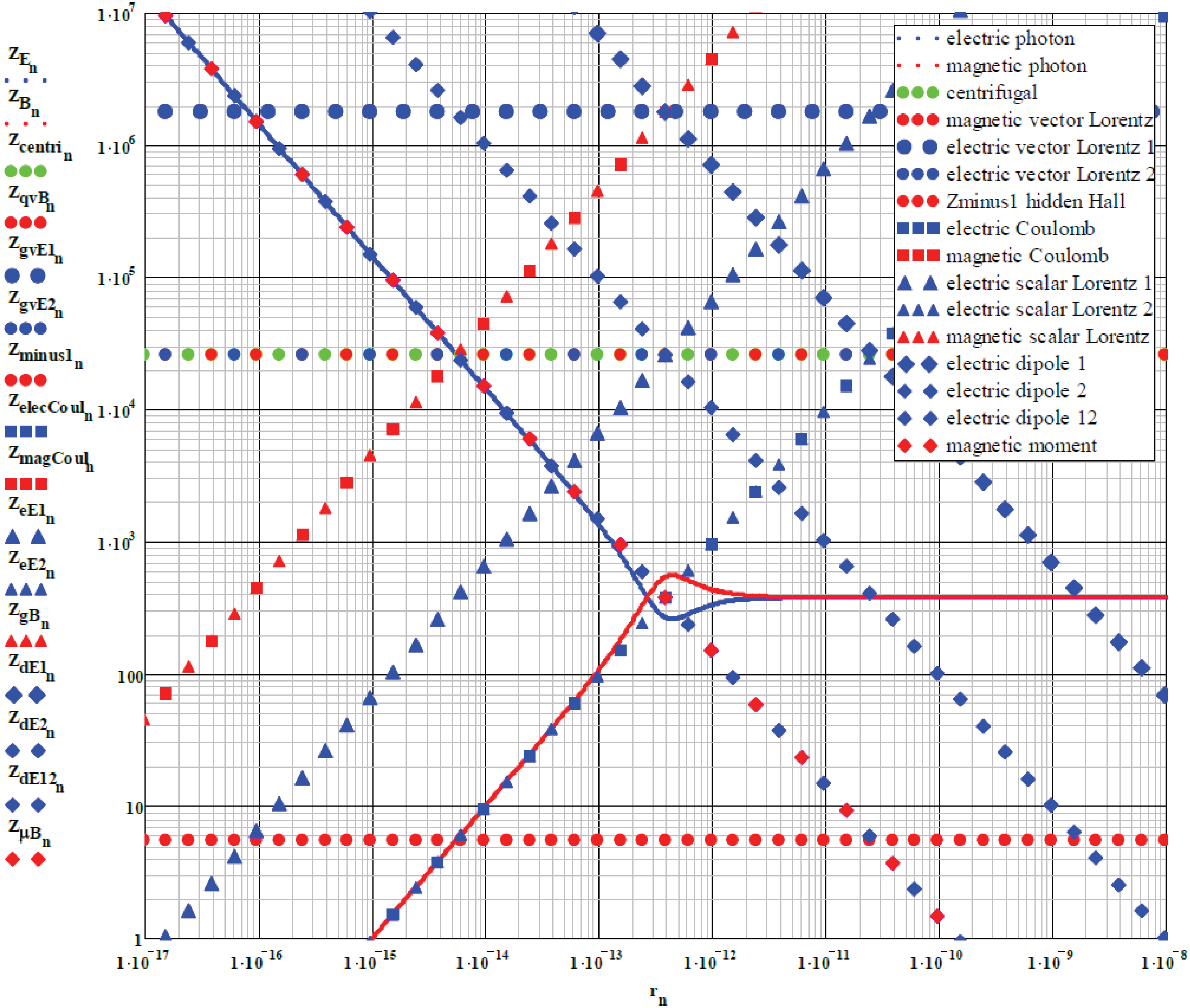
$$Z_{dE1} := \frac{\varepsilon_0 \cdot h^3}{e^4 \cdot m_e} \cdot \frac{1}{\lambda_e} \qquad 2\alpha Z_{dE1} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{dE1_n} := \frac{\varepsilon_0 h^3}{e^4 \cdot m_e} \cdot \frac{1}{(2\pi r)_n}$$

$$Z_{dE2} := \frac{h}{\varepsilon_0 \cdot m_e \cdot c^2} \cdot \frac{1}{\lambda_e} \qquad \frac{1}{2\alpha} Z_{dE2} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{dE2_n} := \frac{h}{\varepsilon_0 \cdot m_e \cdot c^2} \cdot \frac{1}{(2\pi r)_n}$$

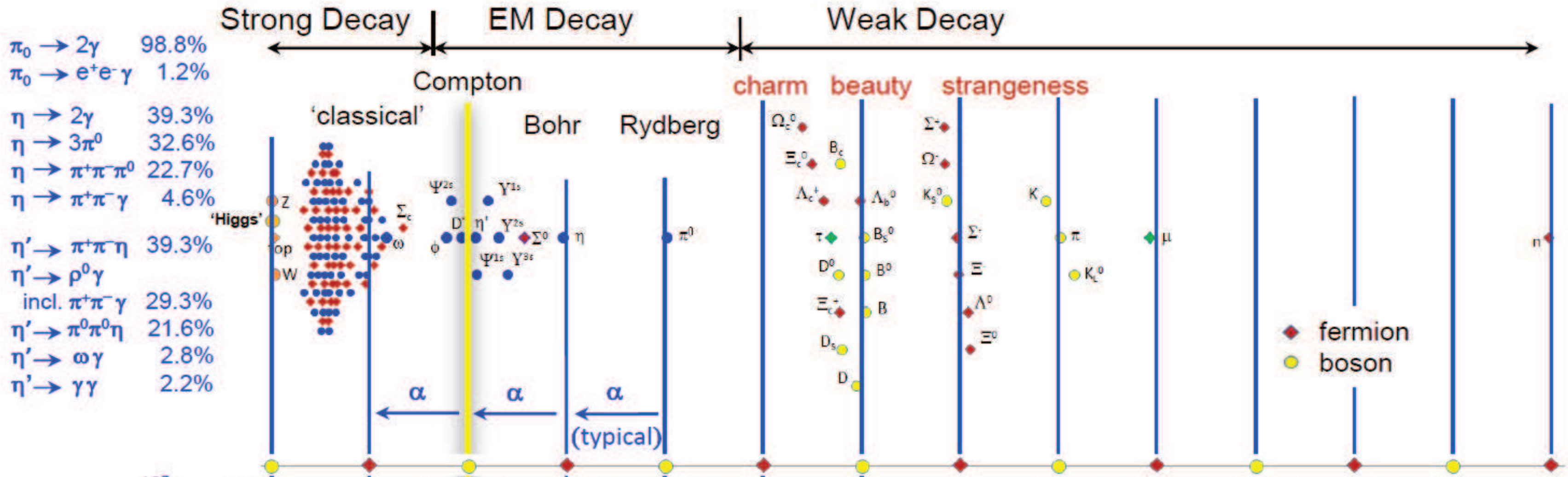
$$Z_{dE12} := \frac{h^2}{e^2 \cdot m_e \cdot c} \cdot \frac{1}{\lambda_e} \qquad Z_{dE12} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{dE12_n} := \frac{h^2}{e^2 \cdot m_e \cdot c} \cdot \frac{1}{(2\pi r)_n}$$

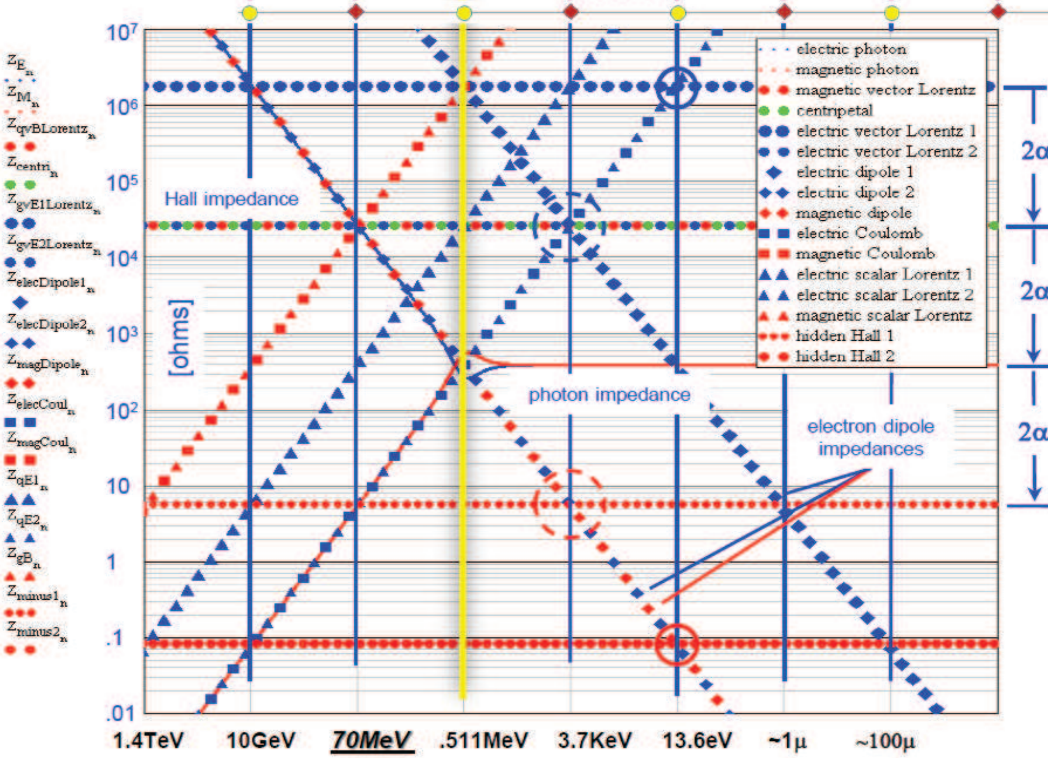
$$Z_{\mu B} := \frac{\mu_0 \cdot h}{m_e} \cdot \frac{1}{\lambda_e} \qquad \frac{1}{2\alpha} Z_{\mu B} = 2.581 \times 10^4 \, \text{ohm} \qquad Z_{\mu B_n} := \frac{\mu_0 \cdot h}{m_e} \cdot \frac{1}{(2\pi r)_n}$$

V. Electromagnetic impedance network at the electron Compton wavelength (next page)


electric photon
magnetic photon
centrifugal
magnetic vector Lorentz
electric vector Lorentz 1
electric vector Lorentz 2
Zminus1 hidden Hall
electric Coulomb
magnetic Coulomb
electric scalar Lorentz 1
electric scalar Lorentz 2
magnetic scalar Lorentz
electric dipole 1
electric dipole 2
electric dipole 12
magnetic moment
ZE_n
ZB_n
Zcentri_n
ZqvB_n
ZqvE1_n
ZqvE2_n
Zminus1_n
ZelecCoul_n
ZmagCoul_n
ZeE1_n
ZeE2_n
ZqB_n
ZdE1_n
ZdE2_n
ZdE12_n
ZμB_n
1·10^7
1·10^6
1·10^5
1·10^4
1·10^3
100
10
1
1·10^-17
1·10^-16
1·10^-15
1·10^-14
1·10^-13
1·10^-12
1·10^-11
1·10^-10
1·10^-9
1·10^-8
r_n

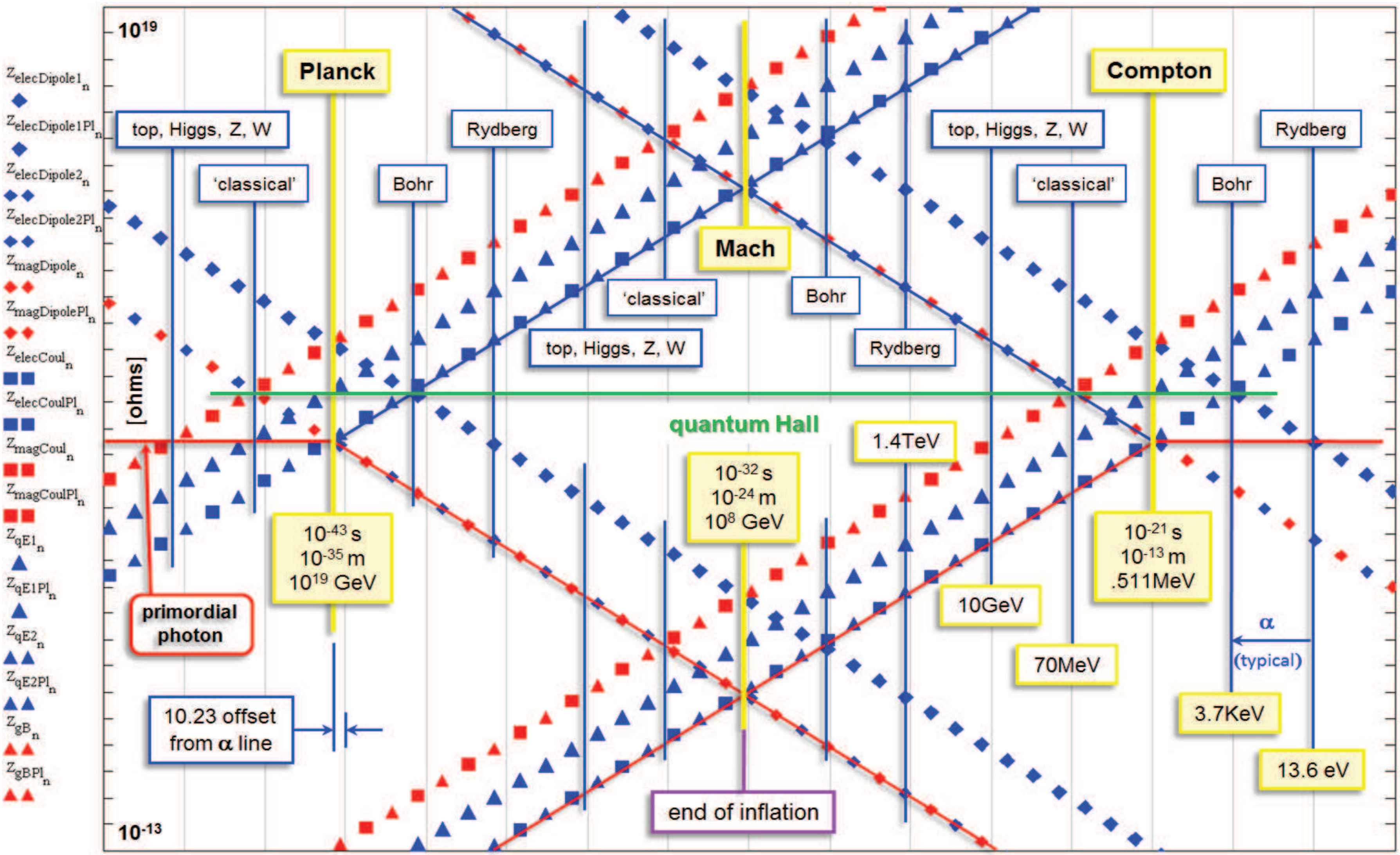
Beyond Standard Model correlation of network nodes with particle lifetimes/coherence lengths





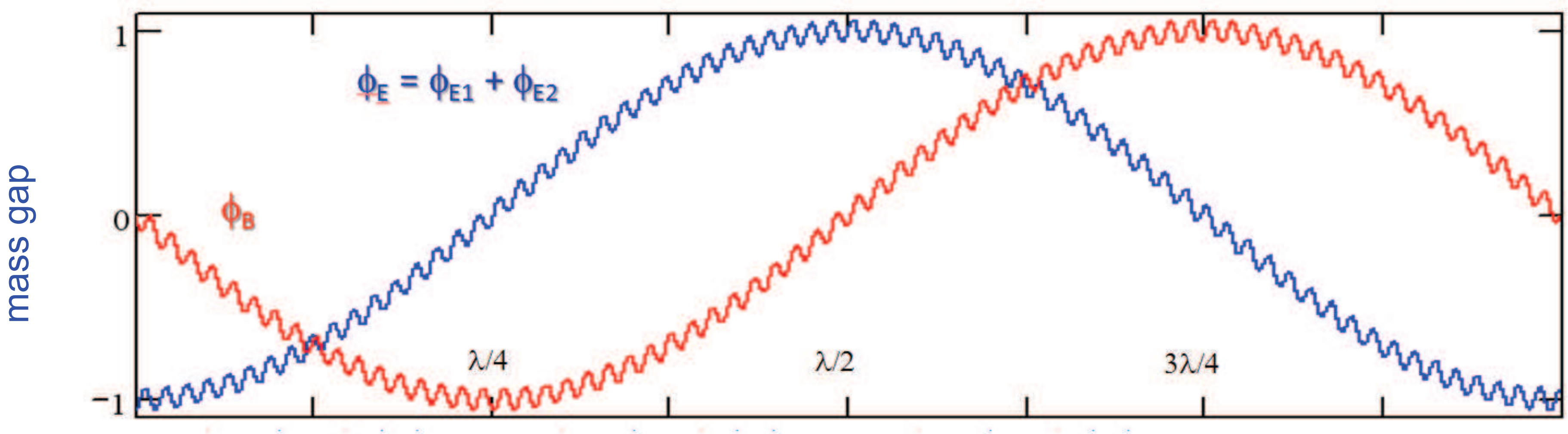
- Horizontal axis in both plots is logarithmic
- Length scales are the same for both plots, and they are properly aligned
- Upper plot shows particle lifetimes multiplied by the speed of light, the coherence lengths (adapted from The Power of Alpha by Malcolm MacGregor)
- Plot at left is electron impedances, details at http://redshift.vif.com/JournalFiles/V18NO2PDF/V18N2CAM.pdf
- Alpha-spaced coherence lengths of η', η, and π_0 are at conjunctions of mode impedances, can couple to the photon for fast EM decay
- Location of π_0 at boundary of EM and weak decays is suggestive of the chiral anomaly
- Weak decays are mismatched to the photon
- Alpha-spaced coherence length alternation of fermions/bosons in weak decays appears to be related to parity violation and electroweak enhancement of charm/tau coherence lengths
- *Clustering of superheavies* (top, Higgs, Z, W) at the 10GeV coherence length *is tantalizing*
- Impedance junctions at the classical radius are related to mass quantization and MacGregor's ***70MeV*** 'platform state'
- See also http://vixra.org/author/peter_cameron

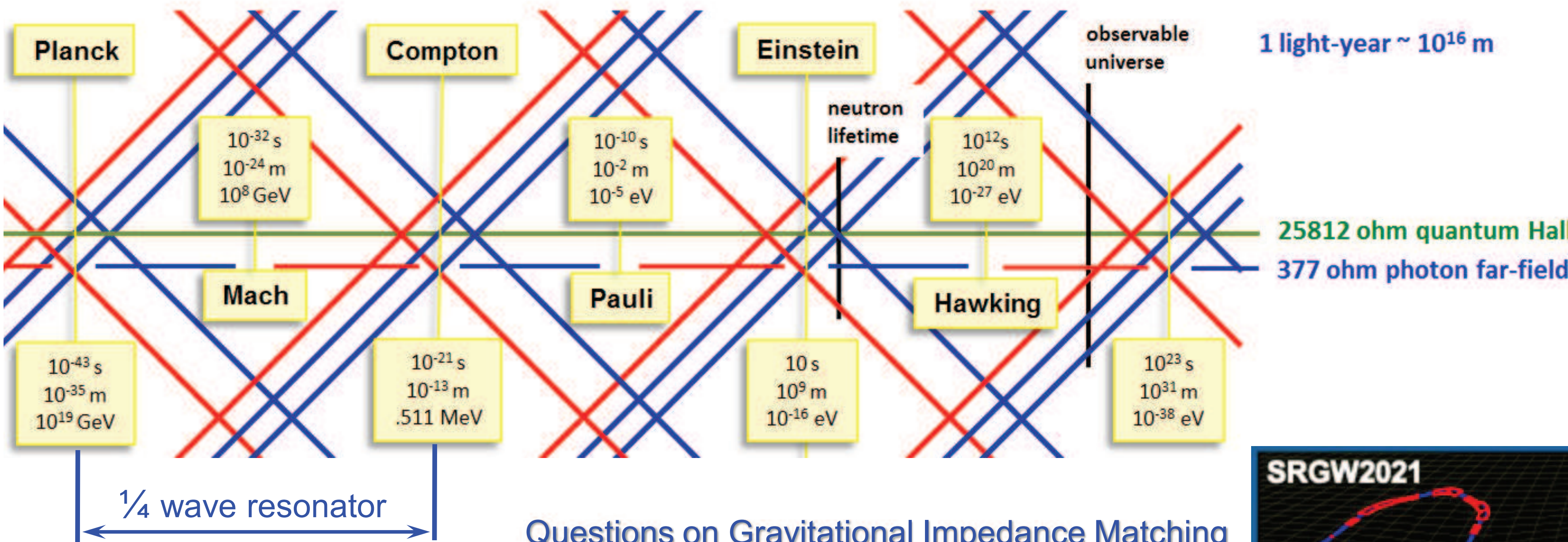
BSM 2 – origin of gravitational mass, inflation, chirality, baryon asymmetry,…



A Possible Resolution of the Black Hole Information Paradox
https://www.osapublishing.org/abstract.cfm?uri=QIM-2013-W6.01

BSM 3 mismatch-attenuated Hawking photon on the cosmological scale





Questions on Gravitational Impedance Matching

https://indico.cern.ch/event/982987/contributions/4274703/

BSM 4 – precise pizero, eta, and eta' branching ratios in powers of α

An Impedance Approach to the Chiral Anomaly