Introduction to a Quantum Impedance Model

Peter Cameron

Abstract

Two fundamental conceptual structures have been lost in quantum mechanics - geometric representation of Clifford algebra and quantization of wavefunction interaction impedances. This presentation outlines their histories and how their synthesis opens a new window on the standard model.

Department of Physics and Astronomical Sciences

Central University of Himachal Pradesh (CUHP)

and

Indian Association of Physics Teachers–Regional Council (IAPT-RC3)

Jointly Organise an

Online Faculty Development Programme (FDP) from 1st to 7th August, 2021

on the topic

Quantum Physics Simulations Using Gnumeric Worksheets

Introduction to a Quantum Impedance Model

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Brookhaven National Laboratory (retired)

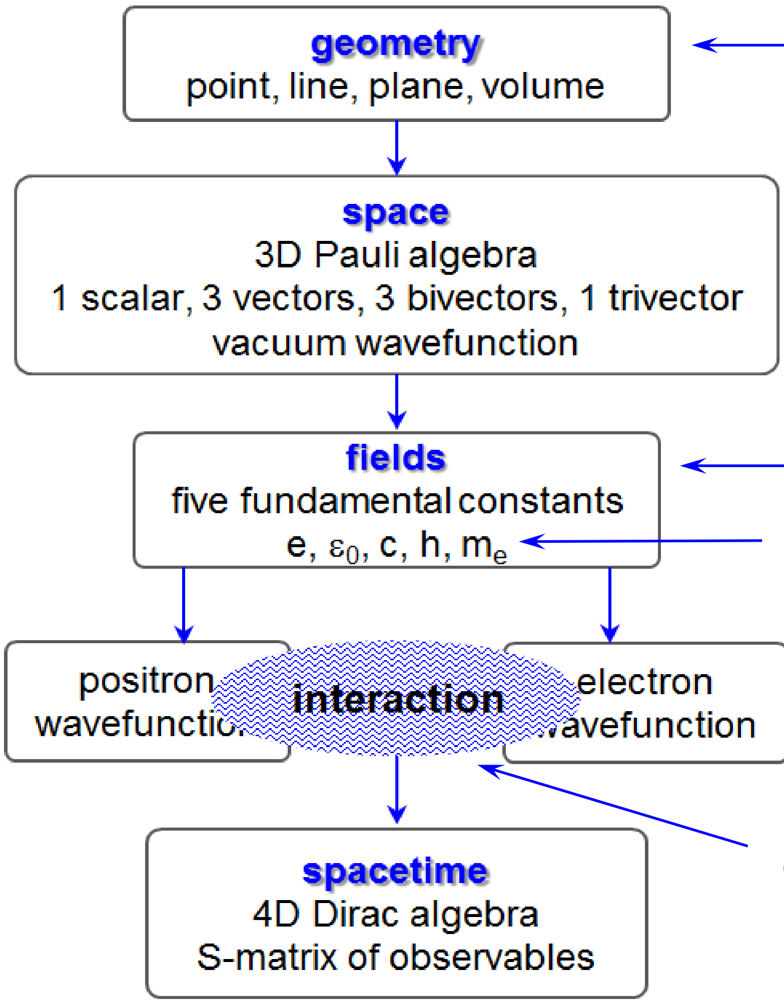
The content shall be uploaded on the following website: https://fdpqmsim.saivyasa.in/

Dr. Pawan Kumar Sharma
(Organising Secretary)
Executive Council Member(IAPT-RC3)

Prof. O.S.K.S.Sastri
(Convenor)
Vice-President(IAPT-RC3)

The Theoretical Minimum

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



6D phase space

geometric quantization

Pauli σ matrices are basis vectors of 3D space,
Dirac γ matrices those of 4D spacetime

https://www.youtube.com/watch?v=60z_hpEAtD8

Clifford algebra in geometric representation
the same at all scales

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

no free parameters
- emergence

Outline

- → defining impedance - *a brief history*
- → impedance matching – *like energy, what matters is relative*
- photon impedance match to a single free electron – *H atom*
- mechanical impedance – *topological inversion in SI units*
- unstable particle spectrum – *nodes of the quantized impedance network*
- geometric and topological impedances – *scale dependent and invariant*
- parametric impedances – *noiseless nonlinearity essential in QM*
- geometric representation of Clifford algebra – *vacuum wavefunction (1,3,3,1)*
- wavefunction interactions – *the 'geometric S-matrix'*
- physical manifestation – *the 'electromagnetic S-matrix', origin of inertial mass,…*
- examples – *particle physics, gravitational mass, cosmology,…*
- condensed matter – *the next frontier, lattice impedances, quantum computing,…*

A History of ^ Impedance Measurements

classical

by Henry P. Hall

https://www.ietlabs.com/genrad_history/history_of_impedance_measurements

Defining Impedance

All rest mass particles have mechanical impedance.
Mass is quantized.
EM to mass conversion
$[coul/m]^2$
line charge density squared

- impedance *matching* governs amplitude and phase of energy/information transmission,…
- examples
  - trumpet (mechanical)
  - loudspeaker (electromechanical)
  - cellphone (electromagnetic)
- impedance matching, like energy, is relative
  - what matters are differences

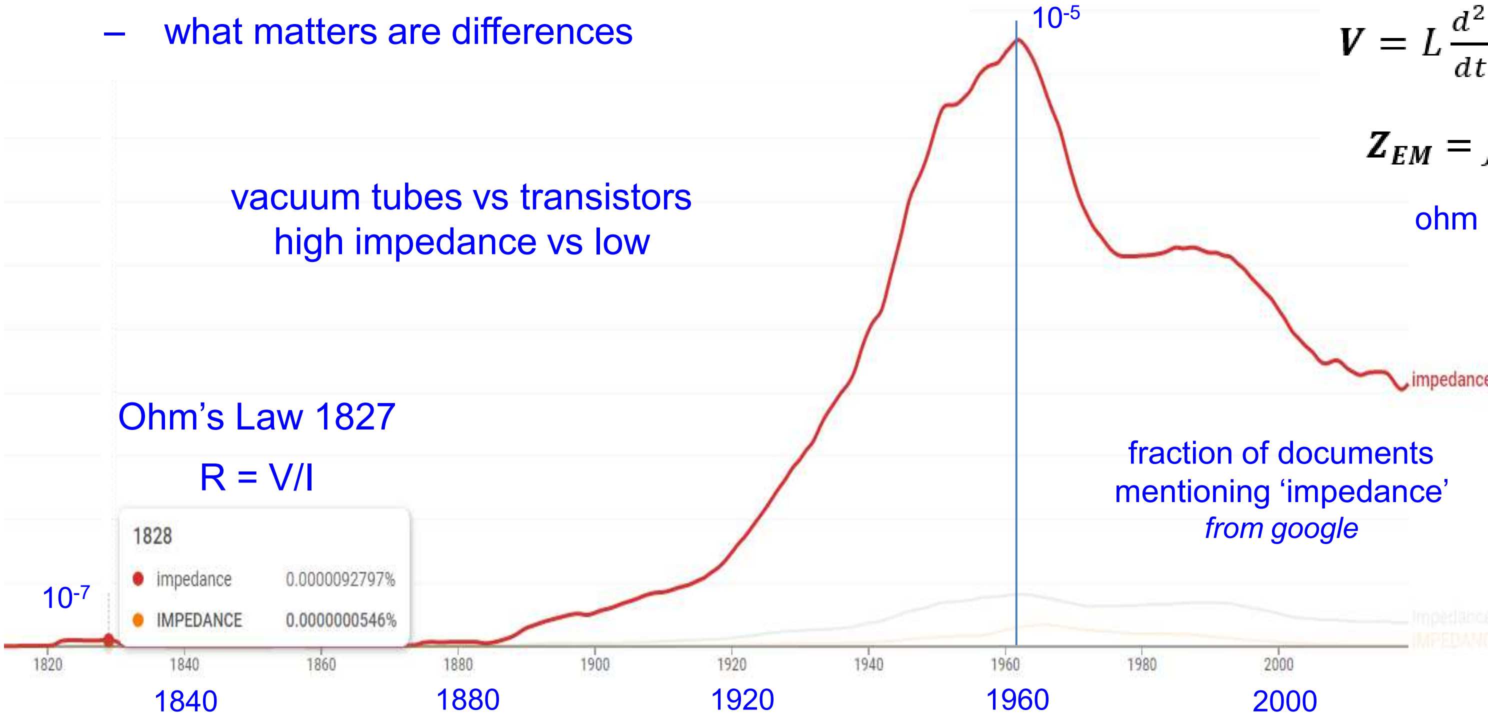
$$F = m\frac{d^2x}{dt^2} + R\frac{dx}{dt} + kx$$

$$Z_m = \frac{F}{\Delta v} \quad \text{[kg/s]}$$

$$V = L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C}$$

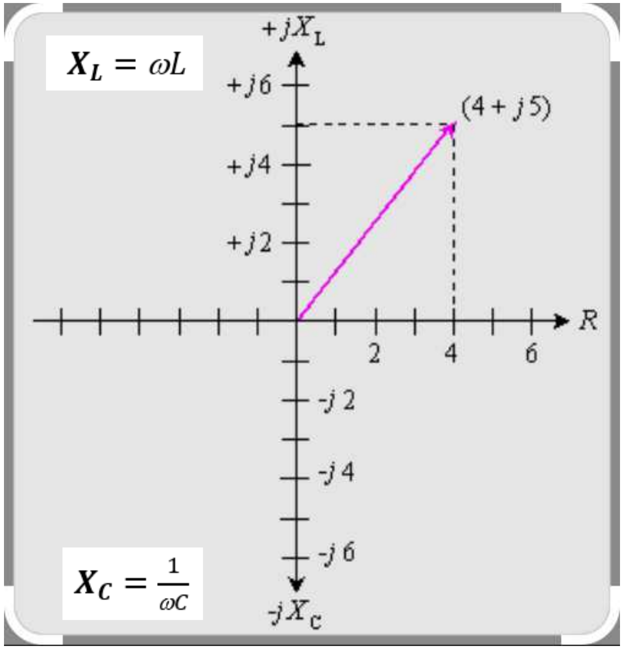
$$Z_{EM} = j\omega L + R - \frac{j}{\omega C}$$

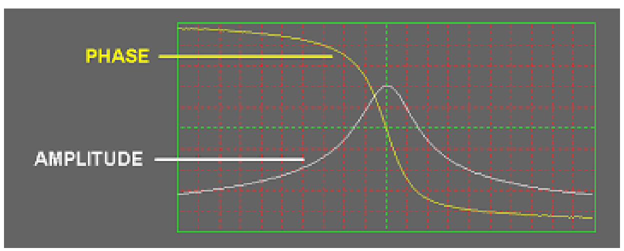
ohm $[kg \cdot m^2/coul^2 \cdot s]$



phase space conservation - Liuoville
Conjugate variables – x and p, E and t,…

Impedance History





Heaviside introduced the following terms of art:

Sep 1885 conductance *real part of admittance, reciprocal of R*

Sep 1885 permeability μ *a measure of magnetization*

Feb 1886 inductance ***L***

July 1886 impedance ***Z***

Nov 1886 elastance *reciprocal of capacitance*

Jun 1887 permittance ***C*** *now capacitance*

Jun 1887 permittivity ε

Dec 1887 admittance *reciprocal of impedance*

May 1888 reluctance *reciprocal of susceptance*

electret - electric analogue of a permanent magnet, in other words, substance exhibiting quasi-permanent electric polarization (e.g. ferroelectric);

Heaviside is sometimes also credited with introducing *susceptance* (the imaginary part of admittance, reciprocal of reactance), but this is actually due to Charles Proteus Steinmetz

As important as Heaviside was in early history of electromagnetics, his influence (and Gibbs) there is far overshadowed by his role in the math war between Clifford algebra (valid in all dimensions) and his invention of vector algebra (valid in 3D only). Clifford algebra is math of physics, vector algebra that of the engineer.

The physicists (and mathematicians!) lost.

Impedance Matching

https://studylib.net/doc/8358945/impedance-matching *Iulian Rosu, YO3DAC / VA3IUL, http://www.qsl.net/va3iul/*

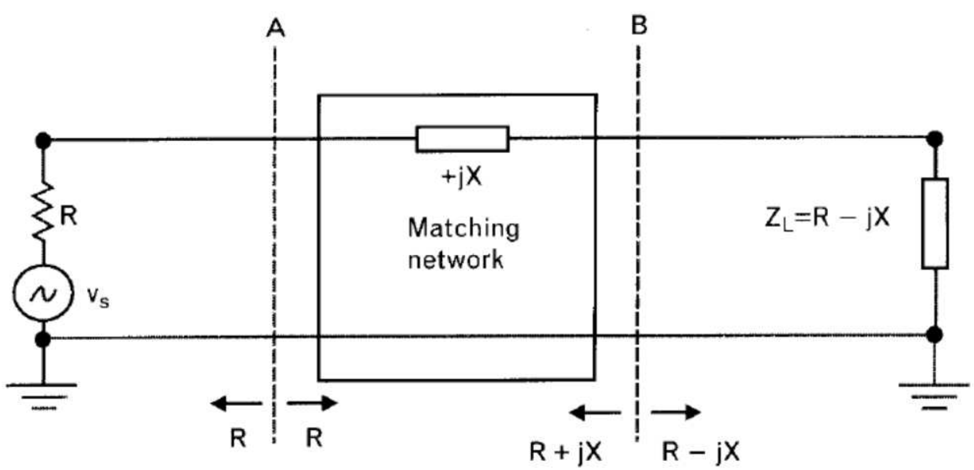
The term ***Impedance*** is a general term which can be applied to any electrical ethnicity which *impedes* (obstruct) the flow of the current. *Oliver Heaviside* (1850-1925) coined ***Impedance*** definition, as well as many other terms of art in electromagnetic theory: *Inductance, Admittance, Conductance, Permeability, Permittance (Susceptance), Reluctance, Electret.*

Oliver Heaviside also reformulated Maxwell's field equations in terms of electric and magnetic forces and energy flux, and independently co-formulated ***Vector Analysis,*** which is needed to express the ***impedance*** in coordinates. not true? dimensionality, background independence,…

Impedance Matching was originally developed for electrical power, but can be applied to any other field where a form of energy (not necessarily electrical) is transferred between a *source* and a *load*.

- The first *Impedance Matching* concept in RF domain was related to ***Antenna Matching***. Designing an antenna can be seen as matching the free space to a transmitter or a receiver.

***Impedance Matching* is always performed between two specified terminations**



Conjugate match of resistive source and complex load
for maximum power transfer

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- examples – *particle physics, gravitational mass, cosmology,…*
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http://redshift.vif.com/JournalFiles/V17NO3PDF/V17N3CA1.pdf

Photon Impedance Match to a Single Free Electron

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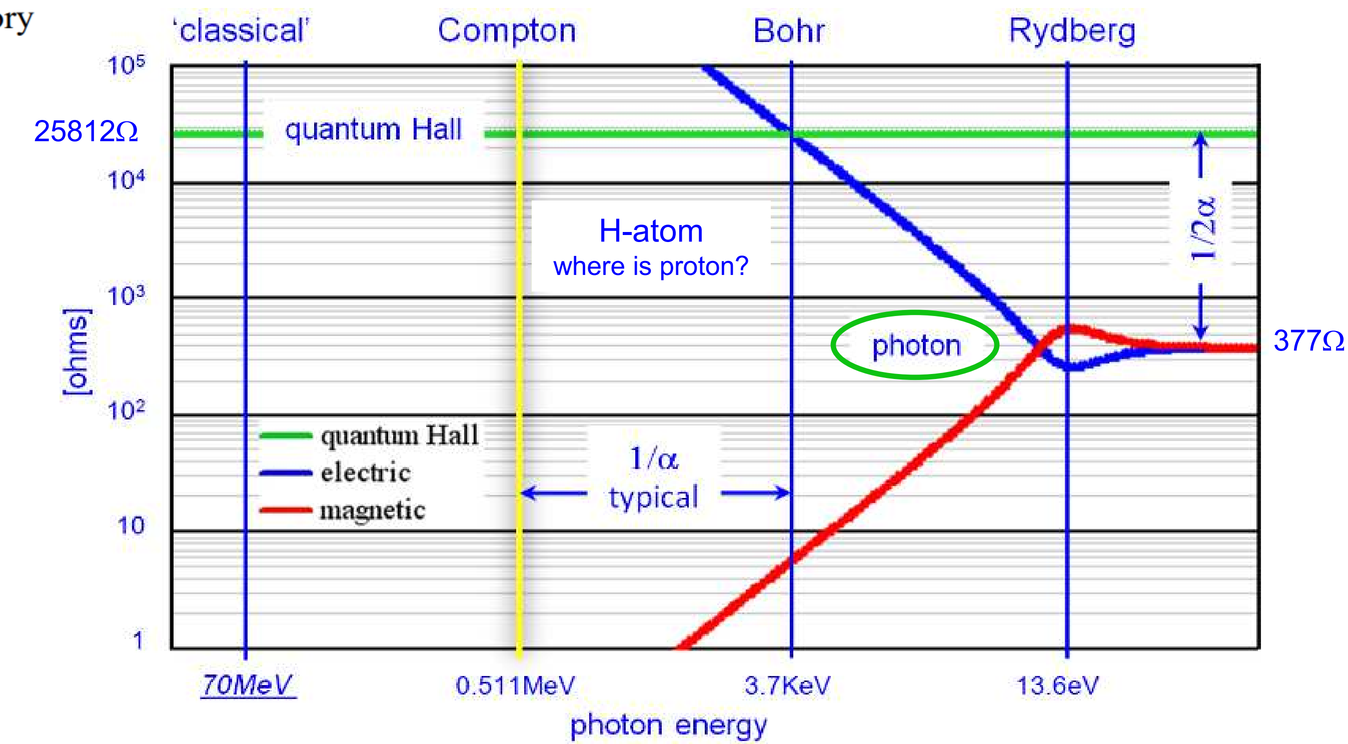
Electromagnetic Impedance

Near-field photon impedance of the basic photon-electron interaction of QED is not to be found in the curriculum, textbooks, or journals of the physicist.

What governs amplitude and phase of the flow of energy in QED got lost in physics.



topological inversion!

(and the big bang bounce)

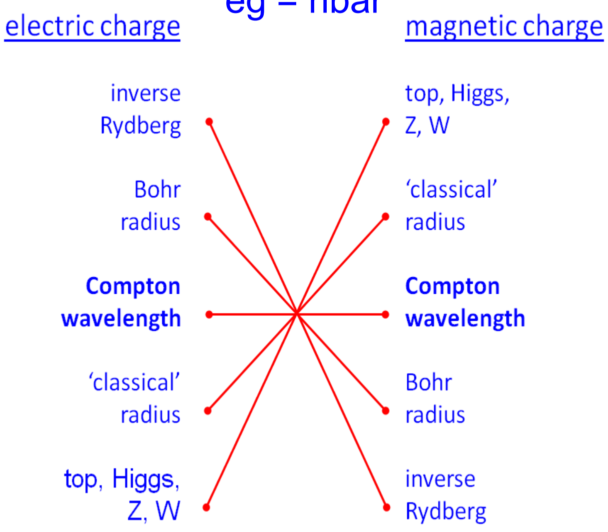
what defines the mass scale?

In addition to near-field impedance of the photon, one's model must include the corresponding quantized near-field impedance of the electron. A second piece of the puzzle that got lost in physics.

How Impedance matching was lost in QM

1. Topological inversion – units of mechanical impedance are [kg/s]. Intuitively one might expect that more [kg/s] would mean more mass flow. However more impedance means less flow. Thwarted Bjorken, Feynman,…
2. concept of ***exact*** impedance quantization did not exist until vonKlitzing et.al discovered QHE in 1980.
3. QHE was easy – scale invariant!
4. habit of setting fundamental constants to dimensionless unity h = c = G = Z = … = 1 let Z slip over the horizon.

Dirac relation
eg = hbar



Mismatches are Feynman's regularization parameters of QED.
Inclusion renders QED finite. This is what Bjorken discovered back in 1959, anticipated it would be a powerful tool, was led astray by the inversion of SI units.
Feynman had an EE student do a thesis on impedance matching to the maser.

Bjorken was perhaps not familiar with their work when writing his 1959 thesis[46]. In that thesis is an approach summarized[47] 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[48]. As presented there, the units of the Feynman parameter are [sec/kg], the units of mechanical *conductance*[5].

One of the black hole event horizon impedances is the 25812 ohm quantum Hall. scale invariant, topological, communicates phase only, can do no work.

J. Bjorken, "Experimental tests of Quantum electrodynamics and spectral representations of Green's functions in perturbation theory", Thesis, Stanford (1959) http://searchworks.stanford.edu/view/2001021

J. Bjorken, private communication (2014)

J. Bjorken, and S. Drell, *Relativistic Quantum Fields*, McGraw-Hill, section 18.4 (1965)

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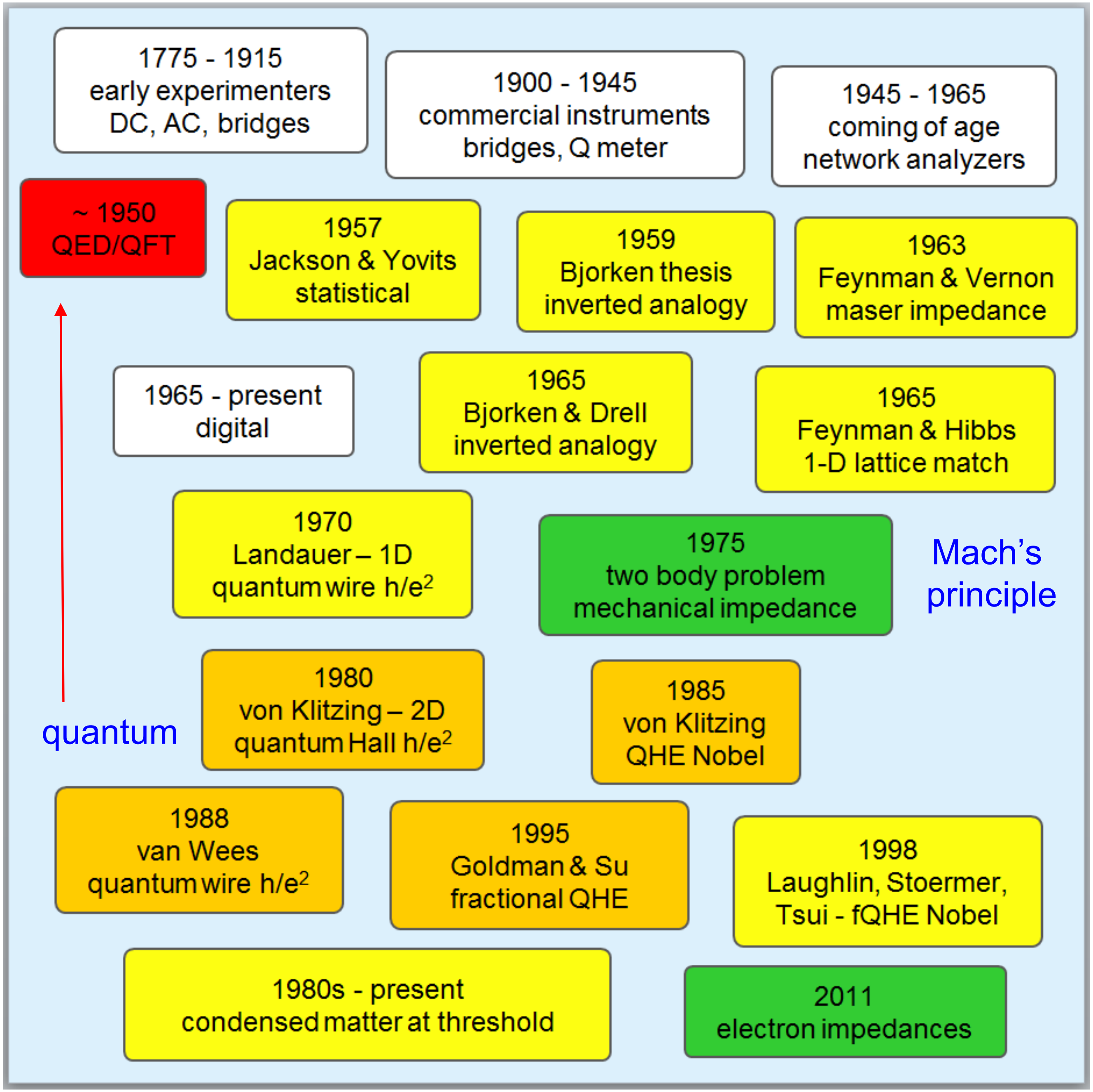
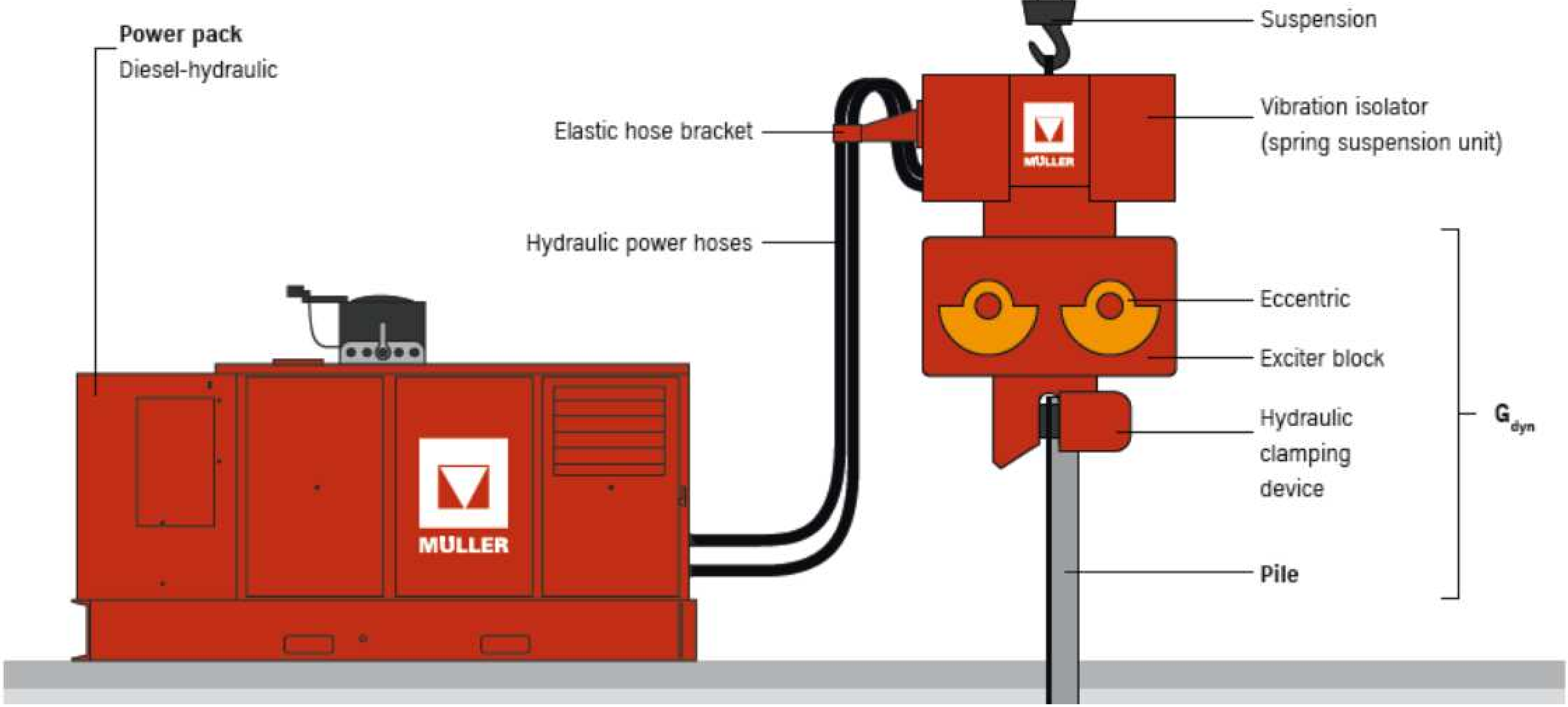
Impedance History



color code

white – classical
yellow – quantum theory
gold – experiment
green - BSM

Mechanical analog of the Dirac equation



Synchronous counter-rotating eccentrics transform 2D rotation to 1D translations, are an analog to electron and positron spinors of Dirac equation counter-rotating in phase space.

A typical vibratory piledriver generates a sinusoidal inertial force of many tens or hundreds of tons, might be thought of as an `inertia wave generator'. Given equivalence of gravitational and inertial mass, it might also be called a gravitational wave generator.

The extent to which such a toy model might ultimately prove useful remains to be seen. For now it seems clear that it provides a simple shortcut to calculating quantized electromagnetic impedances

this is important – impedance matching governs amplitude and phase of energy transmission

July 24, 1975

THE TWO BODY PROBLEM AND MACH'S PRINCIPLE

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background independence!

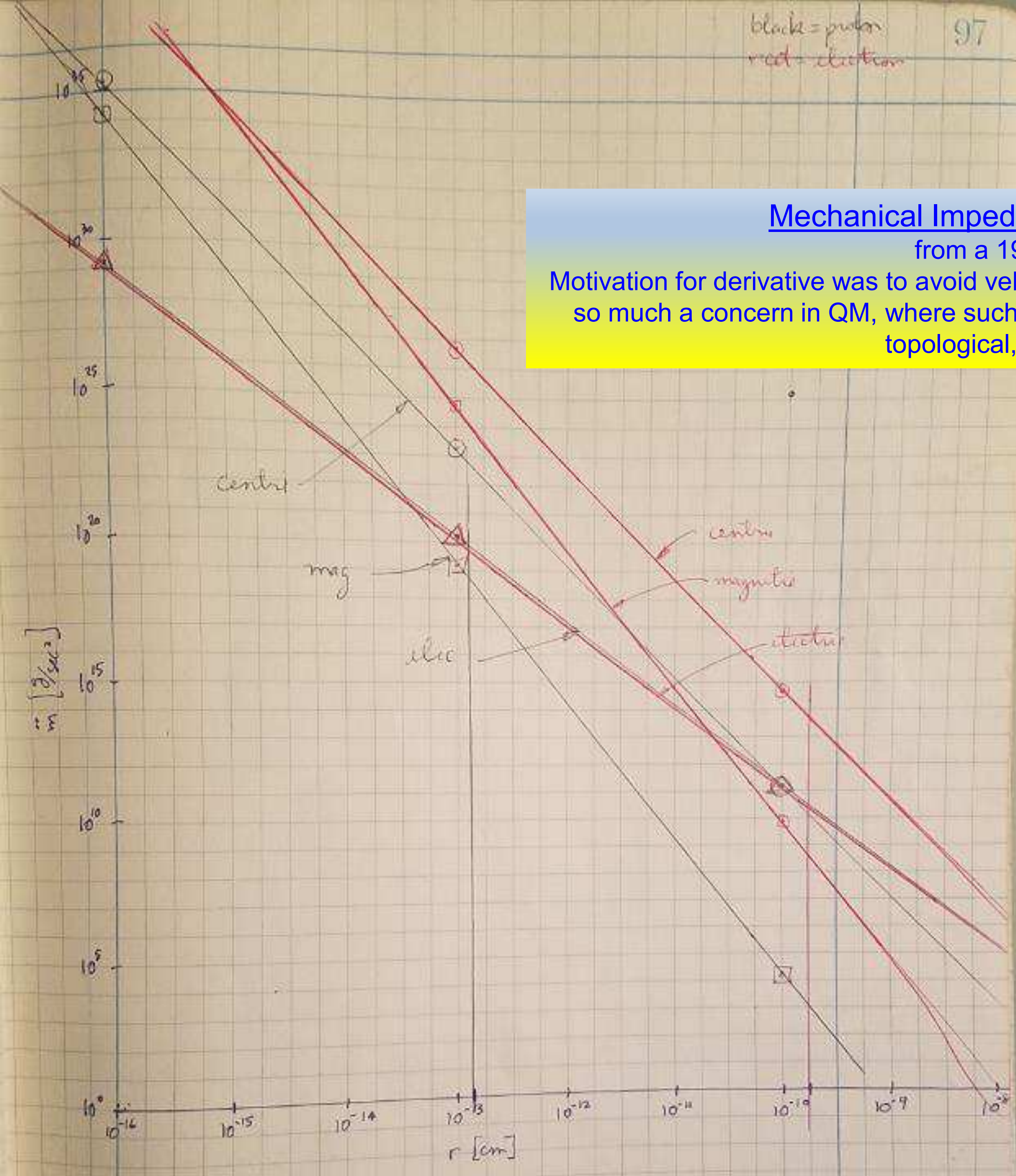
submitted to Am.J.Phys 1975
referees: 'No new physics here'
Published 2011 as an appendix to the Electron Impedances paper.
http://redshift.vif.com/JournalFiles/V18NO2PDF/V18N2CAM.pdf

The classical analysis of the two-body problem is frequently complicated by the introduction of a system of co-ordinates which is independent of either of the bodies. The validity of such an analysis rests upon the premise that the co-ordinate frame does not interact with the physical system via any known physical laws, and that one is therefore free to choose whatever reference frame seems most useful.

A strong epistemological argument might be advanced against this reasoning. If sufficently rigorous constraints are placed upon the spatial properties of the interacting bodies, the introduction of an independent observer will have a radical effect upon the form of the equations which describe the interaction, to the extent that strongly differing concepts might be developed regarding such fundamental things as space, time, and matter. Newton

Mass is quantized. All rest mass particles have quantized mechanical impedances.
EM conversion factor is squared inverse of line charge density [m/coul]^2
Resulting model has correct amplitudes and some phase information, but
mass is single field,
EM is two fields –
orientational information needed to apply Maxwell's eqns is lacking.

pizza sauce

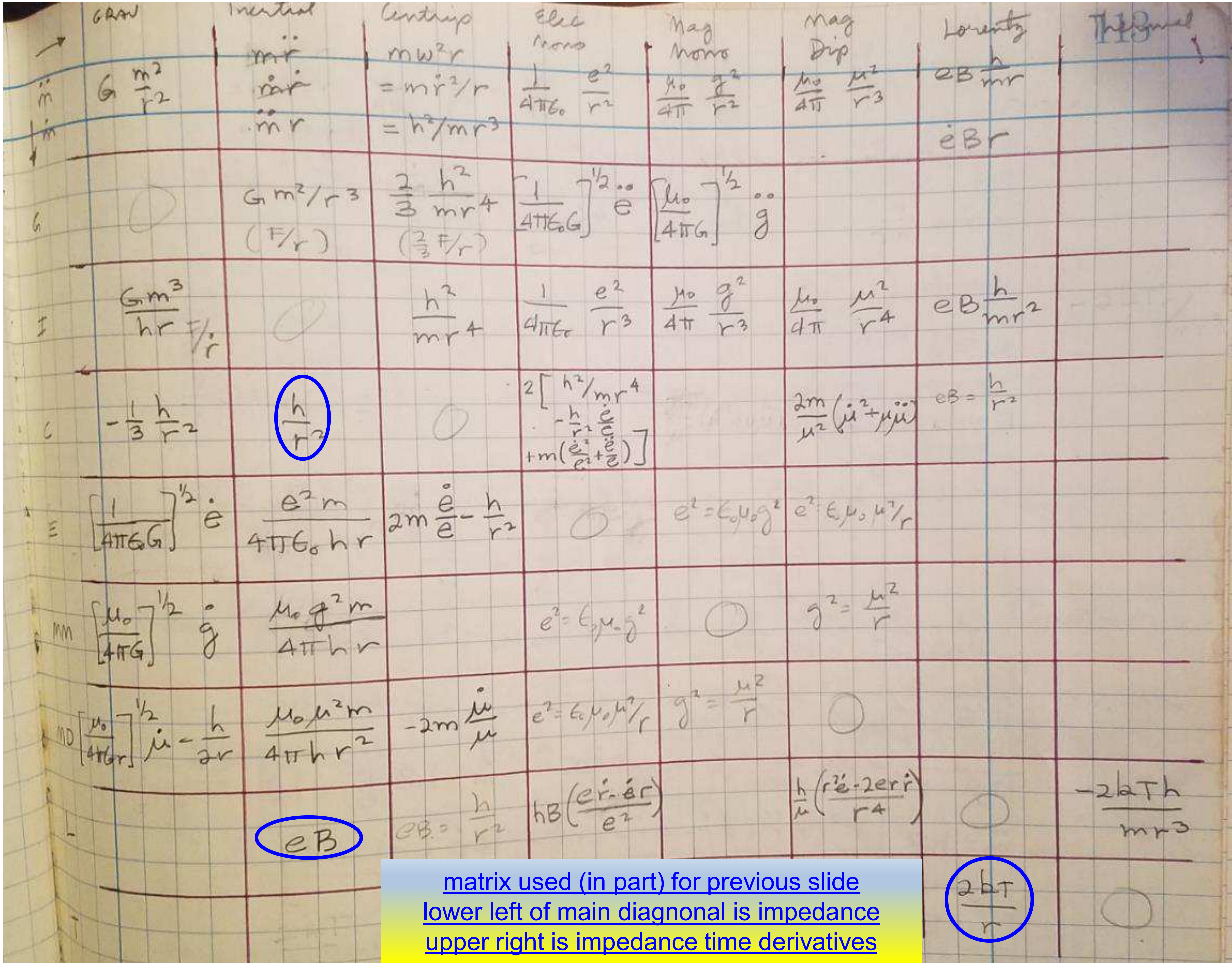


Mechanical Impedance Time Derivatives

from a 1982 notebook

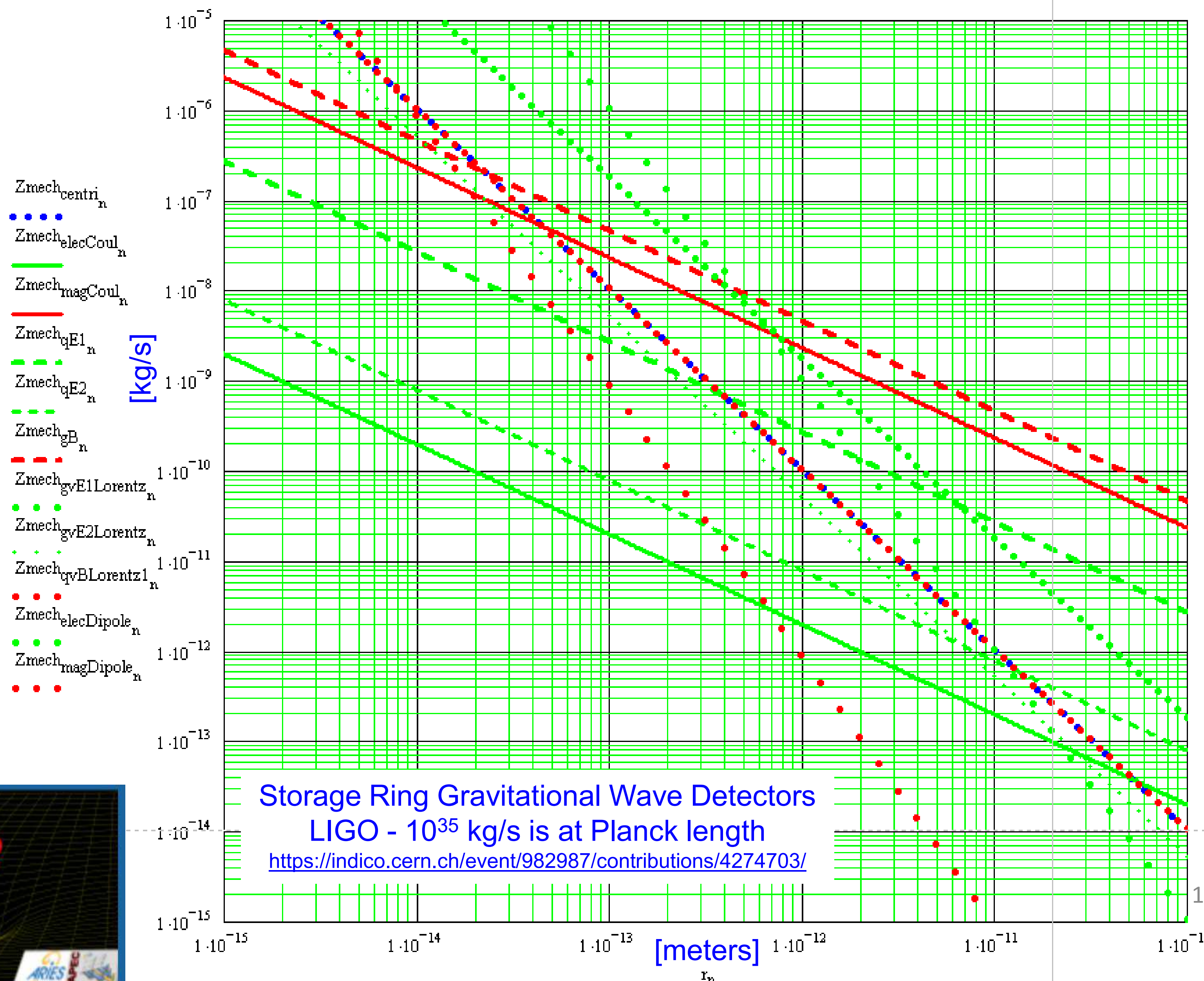
Motivation for derivative was to avoid velocity-dependent dissipative impedances. Not so much a concern in QM, where such impedances are not dissipative, but rather topological, scale invariant.

three potentials – $1/r$, $1/r^2$, and $1/r^3$ - are shown here for proton and electron

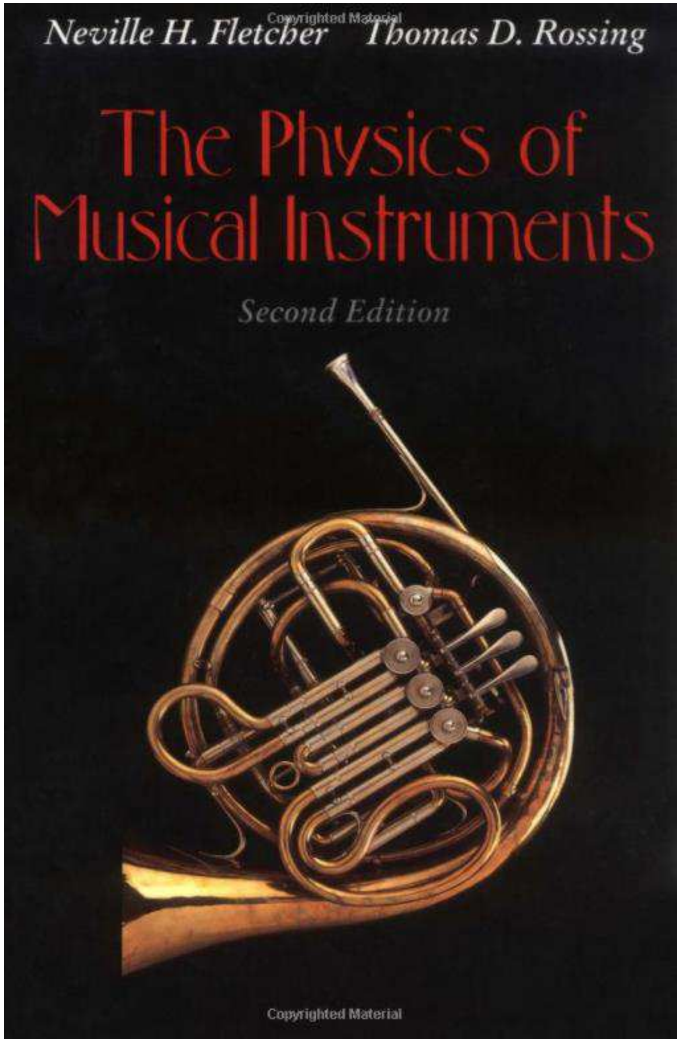


matrix used (in part) for previous slide
lower left of main diagnonal is impedance
upper right is impedance time derivatives

Mechanical Impedances - 2010



Storage Ring Gravitational Wave Detectors
LIGO - 10^{35} kg/s is at Planck length
https://indico.cern.ch/event/982987/contributions/4274703/



Apeiron, Vol. 18, No. 2, April 2011

impedance network of the 'mass gap'

Electron Impedances

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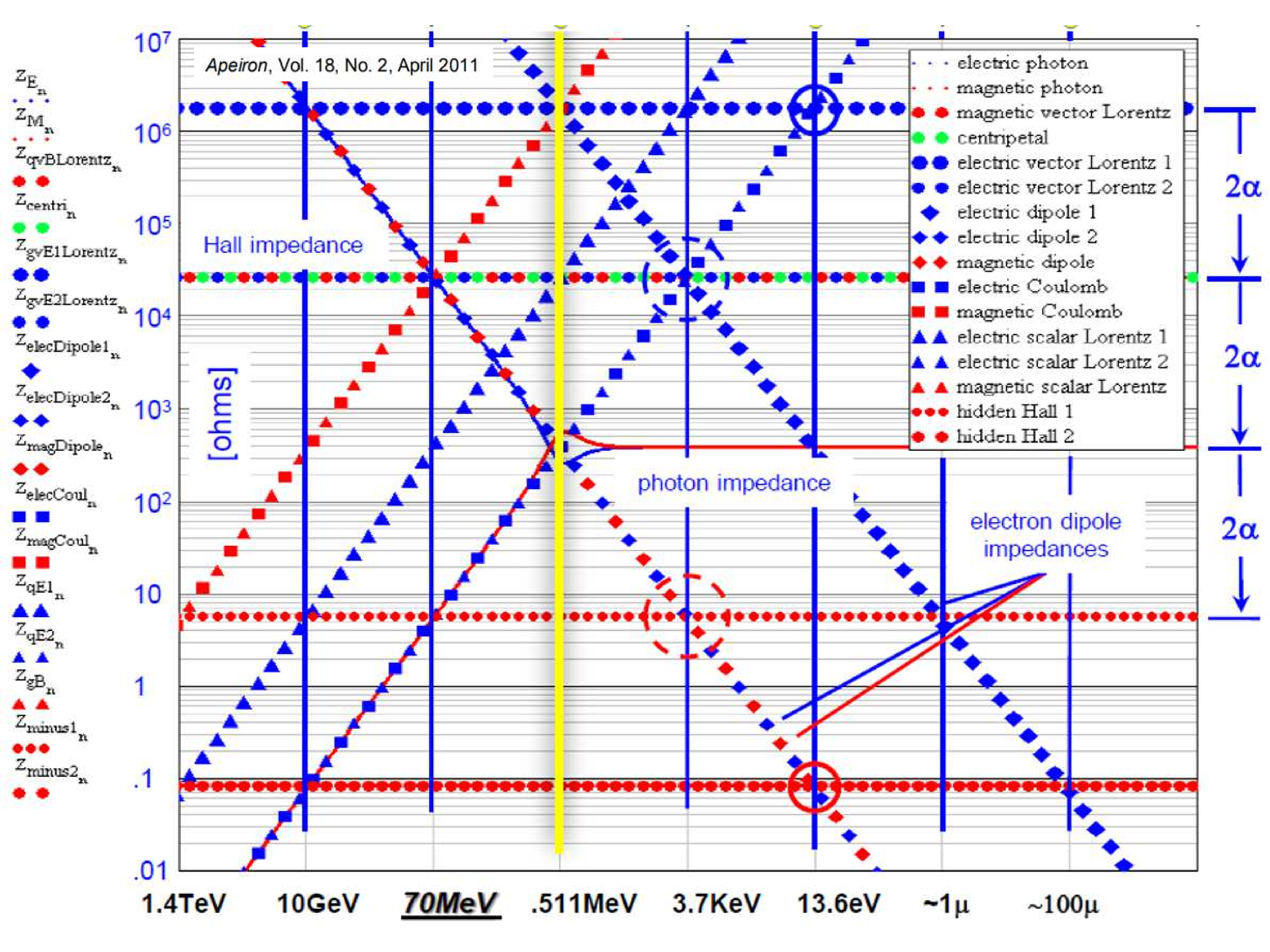
It is only recently, and particularly with the quantum Hall effect and the development of nanoelectronics, that impedances on the scale of molecules, atoms and single electrons have gained attention. In what follows the possibility that characteristic impedances might be defined for the photon and the single free electron is explored is some detail, the premise being that the concepts of electrical and mechanical impedances are relevant to the elementary particle. The scale invariant quantum Hall impedance is pivotal in this exploration, as is the two body problem and Mach's principle.

To understand the electron would be enough - Einstein



Apeiron, Vol. 18, No. 2, April 2011
electric photon
magnetic photon
magnetic vector Lorentz
centripetal
electric vector Lorentz 1
electric vector Lorentz 2
electric dipole 1
electric dipole 2
magnetic dipole
electric Coulomb
magnetic Coulomb
electric scalar Lorentz 1
electric scalar Lorentz 2
magnetic scalar Lorentz
hidden Hall 1
hidden Hall 2
Hall impedance
photon impedance
electron dipole impedances
[ohms]
2α
2α
2α
10^7
10^6
10^5
10^4
10^3
10^2
10
1
.1
.01
1.4TeV
10GeV
70MeV
.511MeV
3.7KeV
13.6eV
~1μ
~100μ
Z_{E_n}
Z_{M_n}
$Z_{qvBLorentz_n}$
Z_{centri_n}
$Z_{gvE1Lorentz_n}$
$Z_{gvE2Lorentz_n}$
$Z_{elecDipole1_n}$
$Z_{elecDipole2_n}$
$Z_{magDipole_n}$
$Z_{elecCoul_n}$
$Z_{magCoul_n}$
Z_{qE1_n}
Z_{qE2_n}
Z_{gB_n}
Z_{minus1_n}
Z_{minus2_n}

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Generalized Quantum Impedances: A Model for the Unstable Particles

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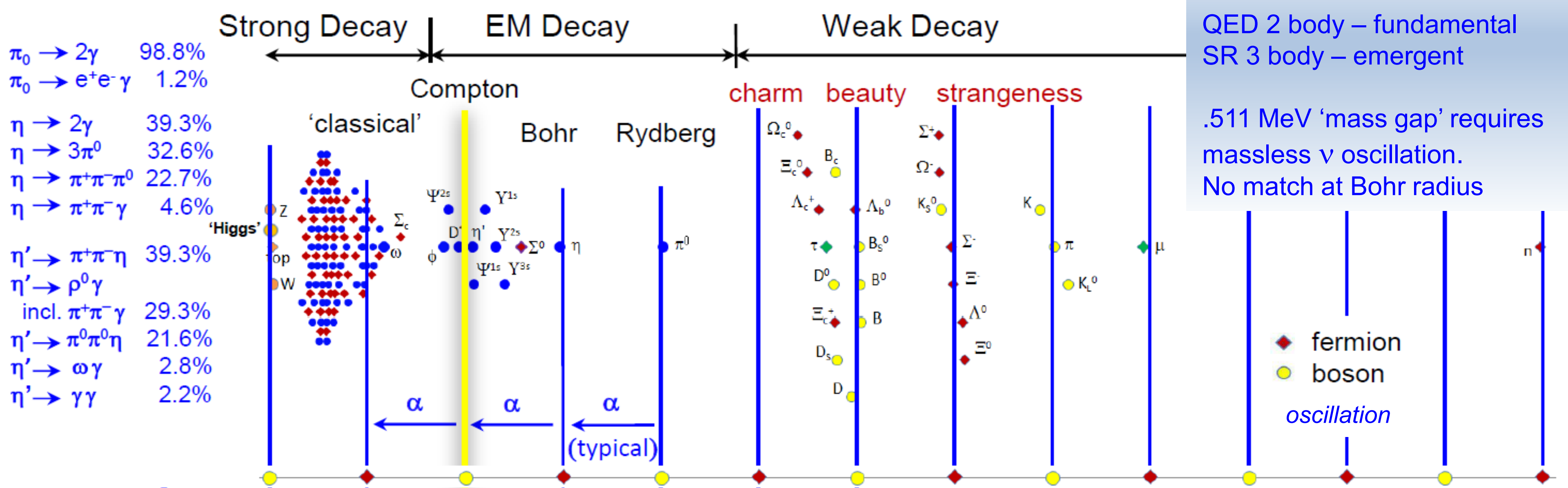
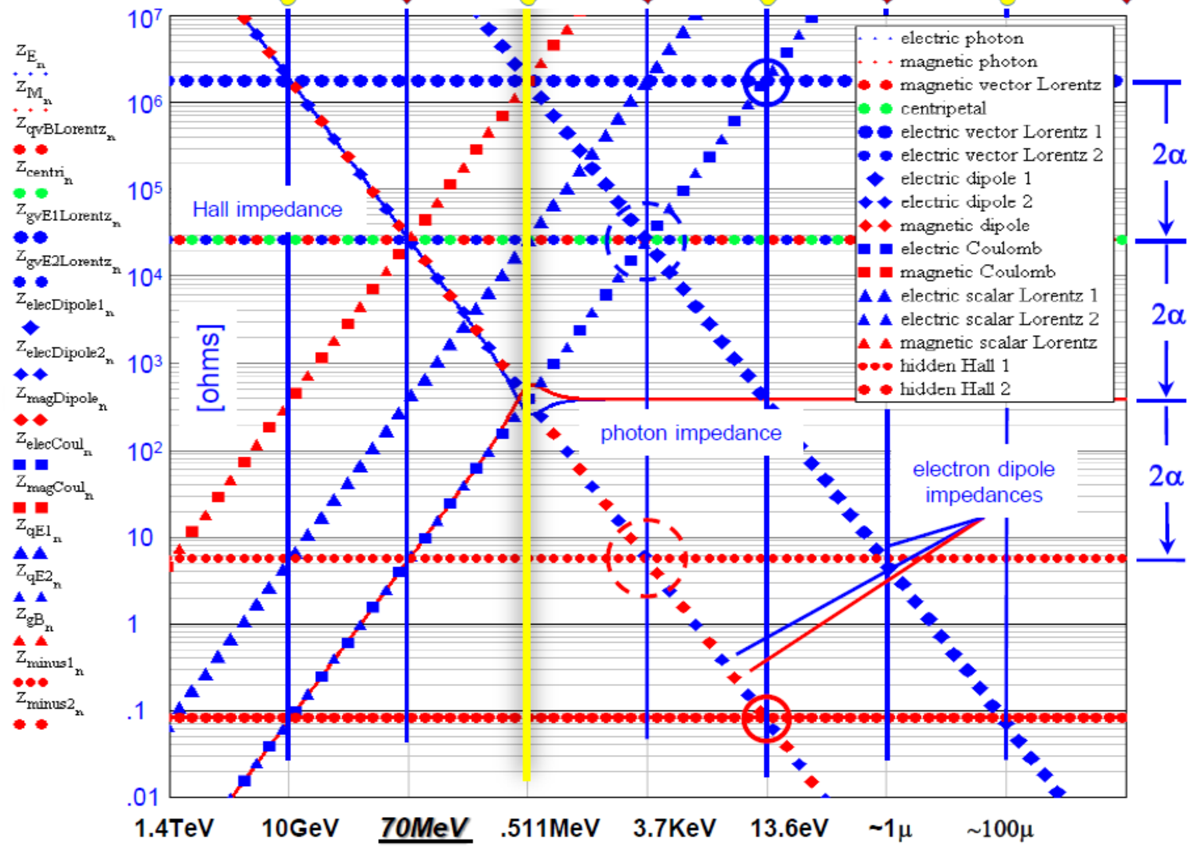
(Dated: June 20, 2012)

The discovery of exact impedance quantization in the quantum Hall effect was greatly facilitated by scale invariance. Both follow from the application of the Lorentz force to a two dimensional ballistic current carrier. This letter speculates upon the possibility that quantum impedances may be generalized, defined not just for the Lorentz force, but rather for all forces, resulting in a precisely structured network of scale dependent and scale invariant impedances. If the concept of generalized quantum impedances correctly describes the physical world, then in quantum physics such impedances govern how energy is transmitted and reflected, how the hydrogen atom is ionized by a 13.6eV photon, or why the π_0 branching ratio is what it is. An impedance model of the electron is presented, and explored as a model for the unstable particles as well.

QED 2 body – fundamental
SR 3 body – emergent

.511 MeV 'mass gap' requires massless ν oscillation.
No match at Bohr radius





- 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

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Geometric and Topological Impedances

- geometric impedances
  - gravitational/Coulomb, dipole, scalar Lorentz,…
  - $1/r$ and $1/r^3$ potentials
  - scale dependent
  - communicate both amplitude and phase
  - can do work – resultant motion is parallel to applied force
  - can be shielded
  - associated with translation gauge fields
- topological impedances
  - vector Lorentz (quantum Hall, Aharonov-Bohm), centrifugal, three-body,…
  - $1/r^2$ potentials
  - scale invariant
  - communicate phase only, not a single measurement observable
  - cannot do work – resultant motion is perpendicular to applied force
  - cannot be shielded
  - associated with rotation gauge fields and anomalies
  - the channel of non-local entanglement

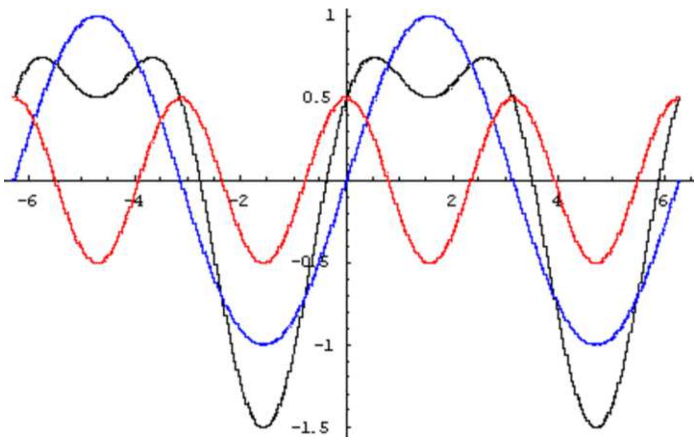
gauge = phase? phase coherence defines boundary of wavefunction
Impedances shift phases – alternative to covariant derivative

Parametric Impedances

- quantum mechanics requires a non-linear process for energy transformation in the frequency domain.

- Clifford algebra accomplishes this via multiplication, the geometric product.
- physics accomplishes this via the scale-dependent geometric impedances.
  - monopole, dipole, scalar Lorentz,…
  - $1/r$ and $1/r^3$ potentials
  - communicate both amplitude and phase
  - can do work – resultant motion is parallel to applied force
  - can be shielded
- child 'pumping' a swing at $2f_0$,
- variable capacitor/varactor,…

- topological impedances – cannot do work
  - phase shifters
  - mode couplers?
  - gravitation?



fermions, bosons, and the dimension changing geometric product

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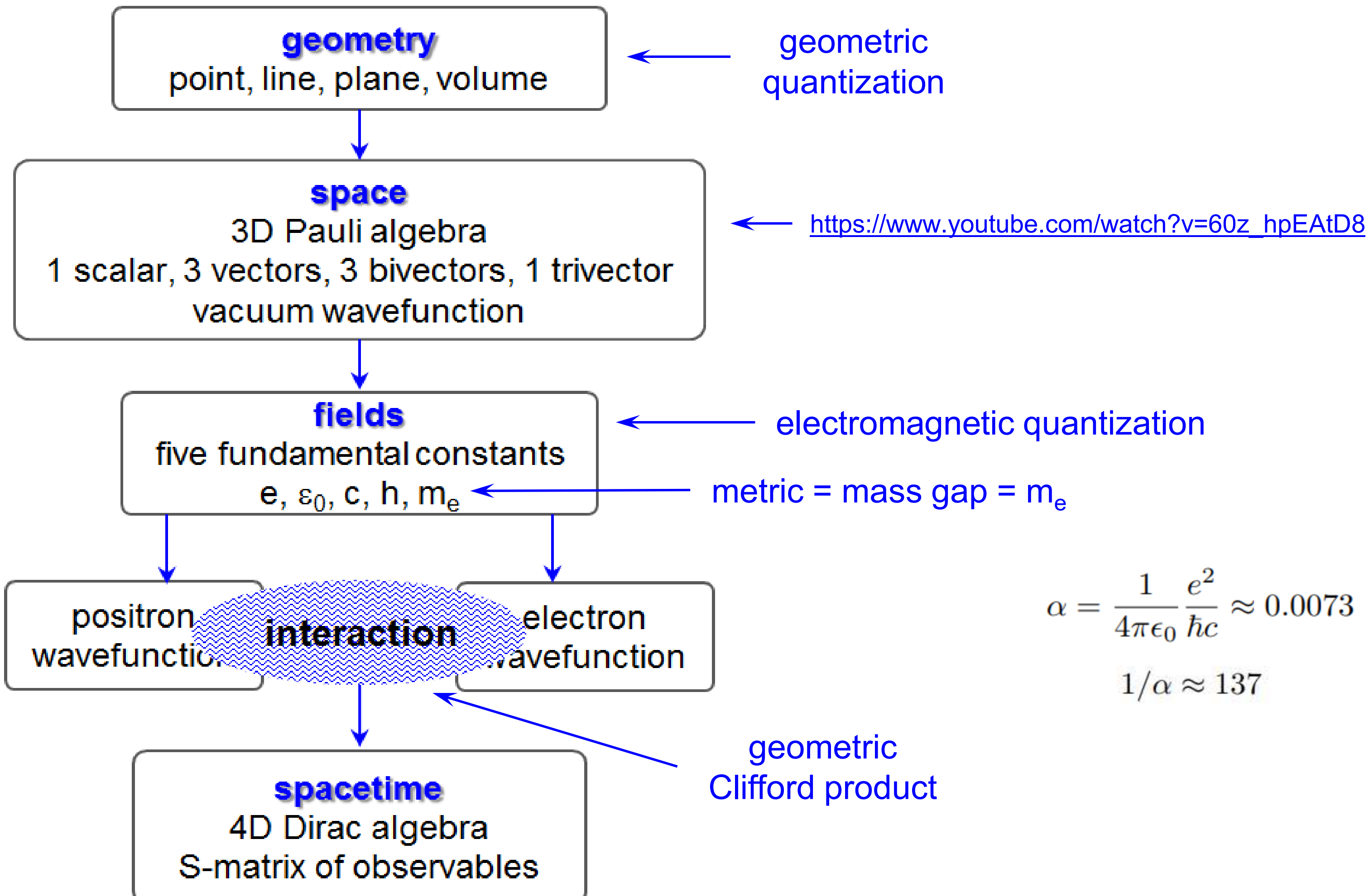
The Theoretical Minimum

Pauli σ matrices are basis vectors of 3D space, Dirac γ matrices those of 4D spacetime

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



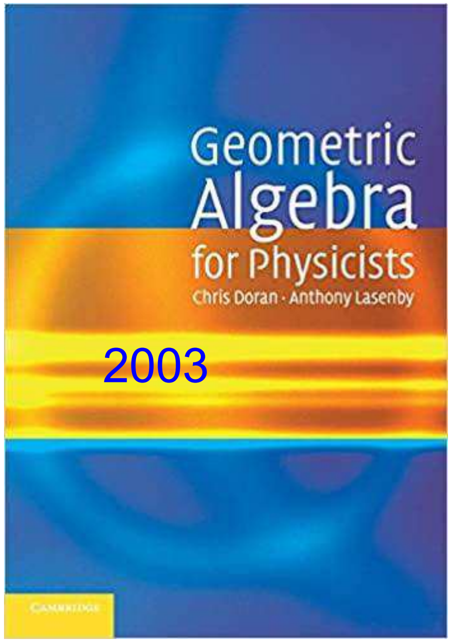
$$\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} \approx 0.0073$$

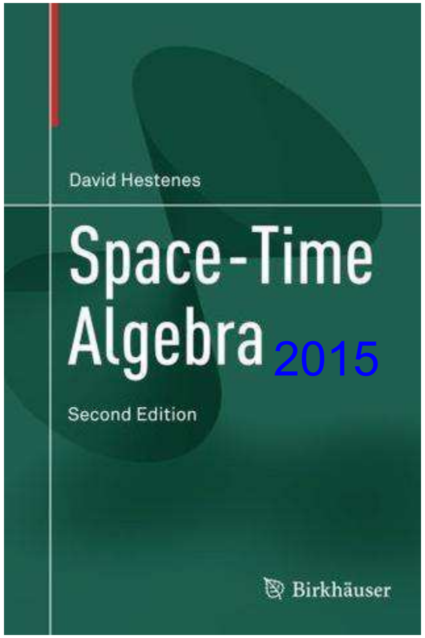
$$1/\alpha \approx 137$$

no free parameters
- emergence

Division Algebras - add, subtract, multiply, **divide**

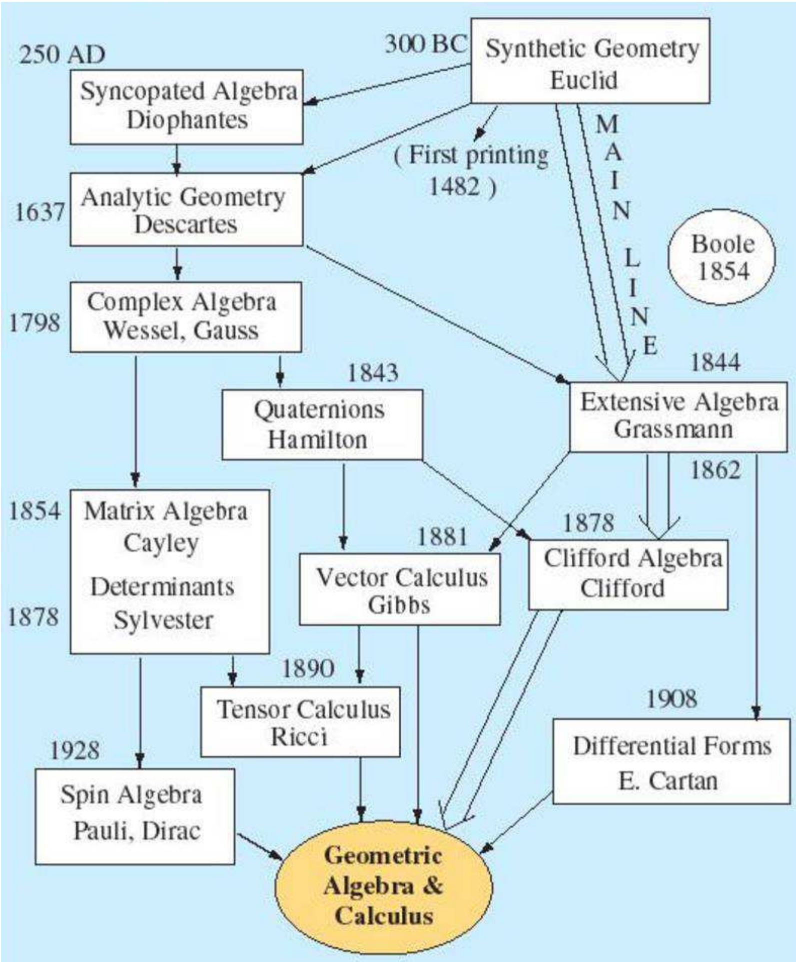
- division is essential for invertibility (… topology, singularities, dark matter, T-duality, …)
- there exist four normed division algebras – real, complex, quaternion, octonion ← Hurwitz theorem
- these are Clifford algebras, more familiar in Pauli and Dirac matrix representations
  - Pauli matrices are basis vectors of 3D space in GA
  - Dirac matrices " " " " 4D spacetime
- eight-component 3D Pauli algebra is minimally and maximally complete
- the 'natural' vacuum wavefunction of quantum mechanics – the same at all scales





http://geocalc.clas.asu.edu/pdf/SpacetimePhysics.pdf

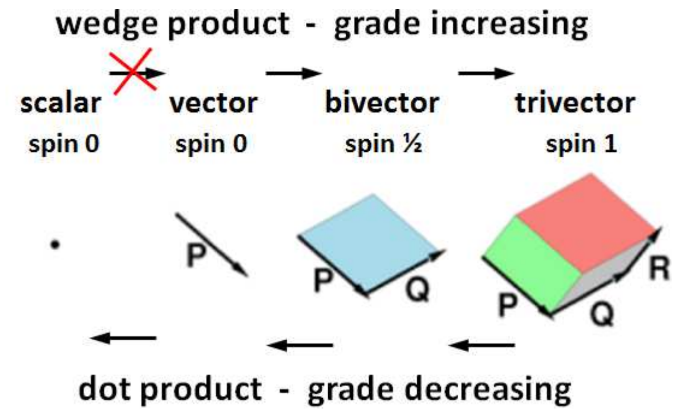
"Geometric Algebra is the universal language for mathematical physics"



- Synthetic Geometry
- Coordinate Geometry
- Complex Variables
- Quaternions
- Vector Analysis
- Matrix Algebra
- Spinors
- Tensors
- Differential Forms

by AAPT division

The 2002 Oersted Medal
was awarded to David Hestenes
by the American Physical Society for
"Reforming the mathematical
language of physics"



dynamic susy!
fermions to bosons, bosons to fermions

Given two vector bosons W and Z, the product WZ changes grades. In the product WZ = W·Z + W^Z, two grade 1 vector bosons transform to grade 0 scalar boson and grade 2 bivector fermion WZ = Higgs + top

Taken together, the four superheavies comprise a minimally complete
2D Clifford algebra – one scalar, two vectors, and one bivector

sum mode $m_Z + m_W = m_{top}$
difference mode $m_Z - m_W = m_{bottomonium}$

no Higgs mass here?

Outline

- defining impedance - *a brief history*
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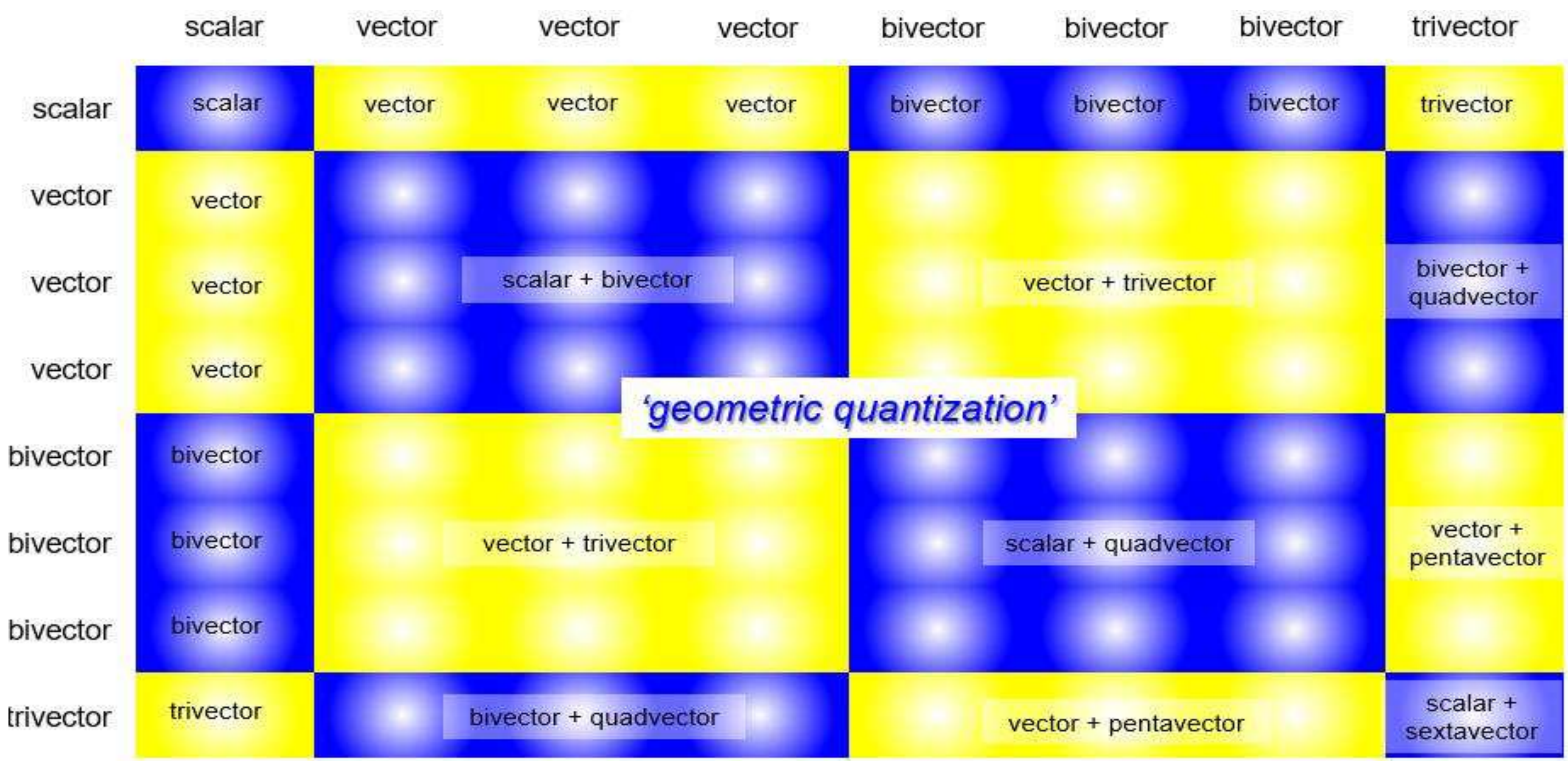
- unstable particle spectrum – *nodes of the quantized impedance network*
- geometric and topological impedances – *scale dependent and invariant*
- parametric impedances – *noiseless nonlinearity essential in QM*
- geometric representation of Clifford algebra – *vacuum wavefunction (1,3,3,1)*
- → wavefunction interactions – *the 'geometric S-matrix'*
- physical manifestation – *the 'electromagnetic S-matrix', origin of inertial mass,…*
- examples – *particle physics, gravitational mass, cosmology,…*
- condensed matter – *the next frontier, lattice impedances, quantum computing,…*

Pauli σ matrices are basis vectors of 3D space, Dirac γ matrices those of 4D spacetime

the geometric S-matrix

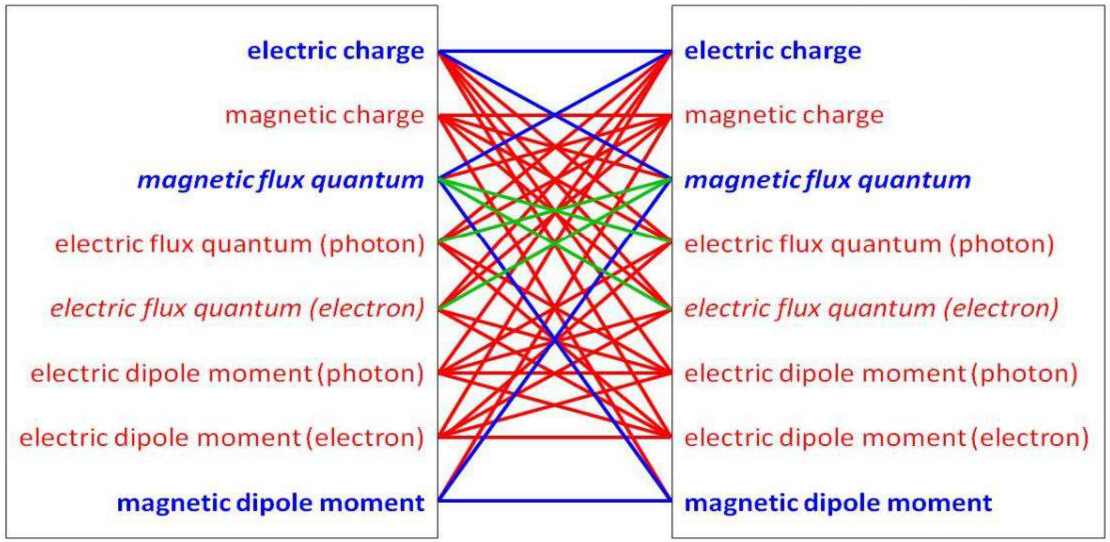


blue background = even dimensions = eigenmodes ~ flavor?
yellow background = odd dimensions = transition modes ~ color?

Apeiron, Vol. 18, No. 2, April 2011

The Gang of Eight

interaction color code
blue is observable
red is not
green is photon



Serendipity – 2011 Gang of Eight matched 2015 discovery of Geometric Algebra octonion

QUANTIZING GAUGE THEORY GRAVITY

equivalence with GR Hestenes and the Cambridge group 1990s

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2015 Barcelona conference on applications of Geometric Algebra

ABSTRACT. The shared background independence of spacetime algebra and the impedance approach to quantization, coupled with the natural gauge invariance of phase shifts introduced by quantum impedances, opens the possibility that identifying the geometric objects of the impedance model with those of spacetime algebra will permit a more intuitive understanding of the equivalence of gauge theory gravity in flat space with general relativity in curved space.

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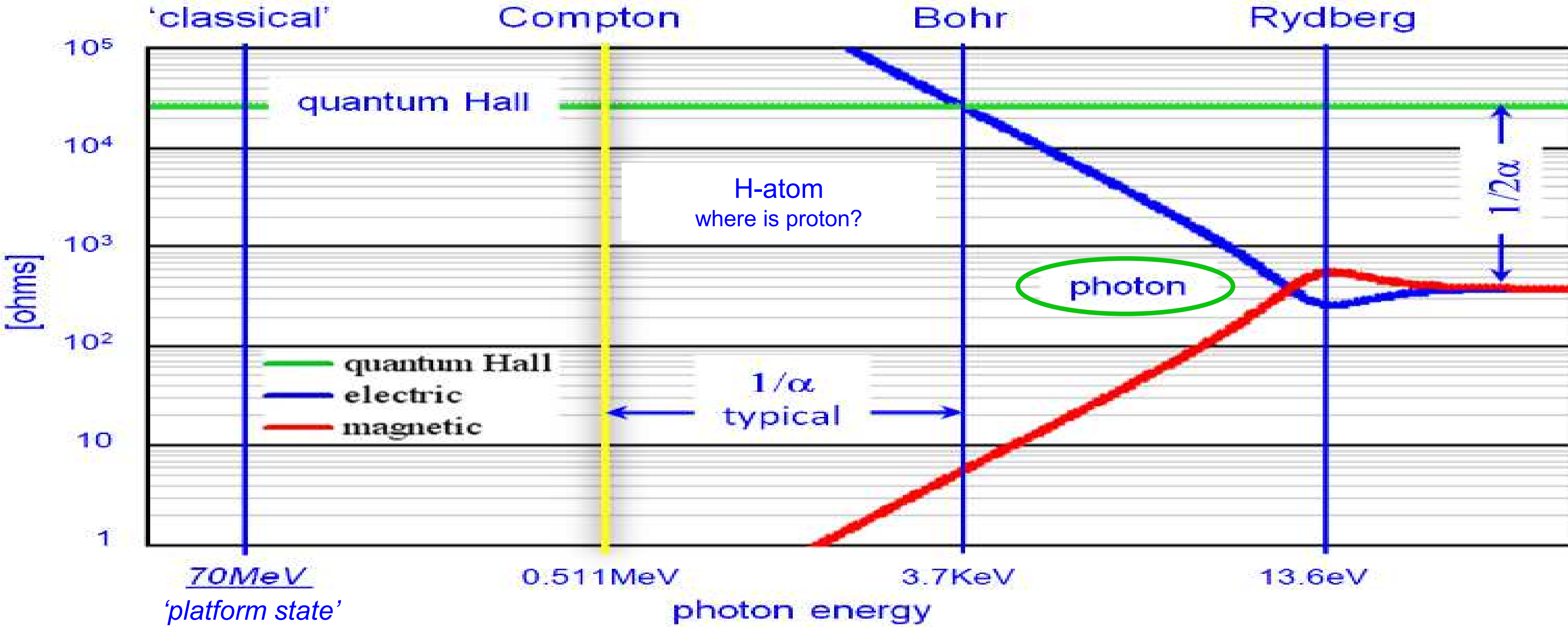
$$\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} \approx 0.0073$$

$$1/\alpha \approx 137$$

physical manifestation – coupling constant

electric charge		$e := 1.602176487 \cdot 10^{-19} \cdot \text{coul}$
magnetic charge	$g := \frac{h}{e}$	$g = 4.1356673326 \times 10^{-15}\ \text{tesla} \cdot \text{m}^2$
magnetic flux quantum (photon)	$\Phi_B := \frac{h}{e}$	$\Phi_B = 4.1356673326 \times 10^{-15}\ \text{tesla} \cdot \text{m}^2$
large electric flux quantum (photon)	$\Phi_{E1} := \frac{h \cdot c}{e}$	$\Phi_{E1} = 1.2398418751 \times 10^{0}\ \text{mvolt} \cdot \text{mm}$
small electric flux quantum (electron)	$\Phi_{E2} := \frac{e}{\varepsilon_0}$	$\Phi_{E2} = 1.809512651 \times 10^{-2}\ \text{volt} \cdot \mu\text{m}$
Bohr magneton	$\mu_B := \frac{e \cdot \lambda\text{bar}_e \cdot c}{2}$	$\mu_B = 9.2740091365 \times 10^{-24}\ \frac{\text{joule}}{\text{tesla}}$
large EDM	$d_{Bohr1} := \frac{g \cdot \text{hbar}}{\mu_0 \cdot m_e \cdot c^2}$	$d_{Bohr1} = 4.2391764 \times 10^{-30}\ \text{mcoul}$
small EDM	$d_{Bohr2} := e \cdot \lambda\text{bar}_e$	$d_{Bohr2} = 6.1869529329 \times 10^{-32}\ \text{mcoul}$



'platform state'
Malcolm MacGregor

Origin of inertial mass: S-matrix mode flux quanta field energies at a given length scale

$$d_{Bohr1} \cdot E_1 = 7.0025246458 \times 10^1 \text{ MeV}$$

$$\frac{g}{\mu_0} \cdot B \cdot \lambda bar_e = 7.0025246458 \times 10^1 \text{ MeV}$$

$$\pi \cdot \varepsilon_0 \lambda bar_e^{\,3} \cdot E_1^{\,2} = 7.0025246458 \times 10^1 \text{ MeV}$$

$$\pi\, \lambda bar_e^{\,3} \sqrt{\frac{\varepsilon_0}{\mu_0}}\, E_1 \cdot B = 7.0025246458 \times 10^1 \text{ MeV}$$

$$\frac{\pi\, \lambda bar_e^{\,3}}{\mu_0} \cdot B^2 = 7.0025246458 \times 10^1 \text{ MeV}$$

$$2\mu_B \cdot B = 1.02199782 \times 10^0 \text{ MeV}$$

$$d_{Bohr1} \cdot E_2 = 1.02199782 \times 10^0 \text{ MeV}$$

$$d_{Bohr2} \cdot E_1 = 1.02199782 \times 10^0 \text{ MeV}$$

$$e \cdot E_1 \cdot \lambda bar_e = 1.02199782 \times 10^0 \text{ MeV}$$

$$\pi \cdot \varepsilon_0 \lambda bar_e^{\,3} \cdot E_1 \cdot E_2 = 1.02199782 \times 10^0 \text{ MeV}$$

$$\pi\, \lambda bar_e^{\,3} \sqrt{\frac{\varepsilon_0}{\mu_0}}\, E_2 \cdot B = 1.02199782 \times 10^0 \text{ MeV}$$

$$d_{Bohr2} \cdot E_2 = 1.4915756772 \times 10^1 \text{ KeV}$$

$$e \cdot E_2 \cdot \lambda bar_e = 1.4915756772 \times 10^1 \text{ KeV}$$

$$\pi \cdot \varepsilon_0 \lambda bar_e^{\,3} \cdot E_2^{\,2} = 1.4915756772 \times 10^1 \text{ KeV}$$

	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.

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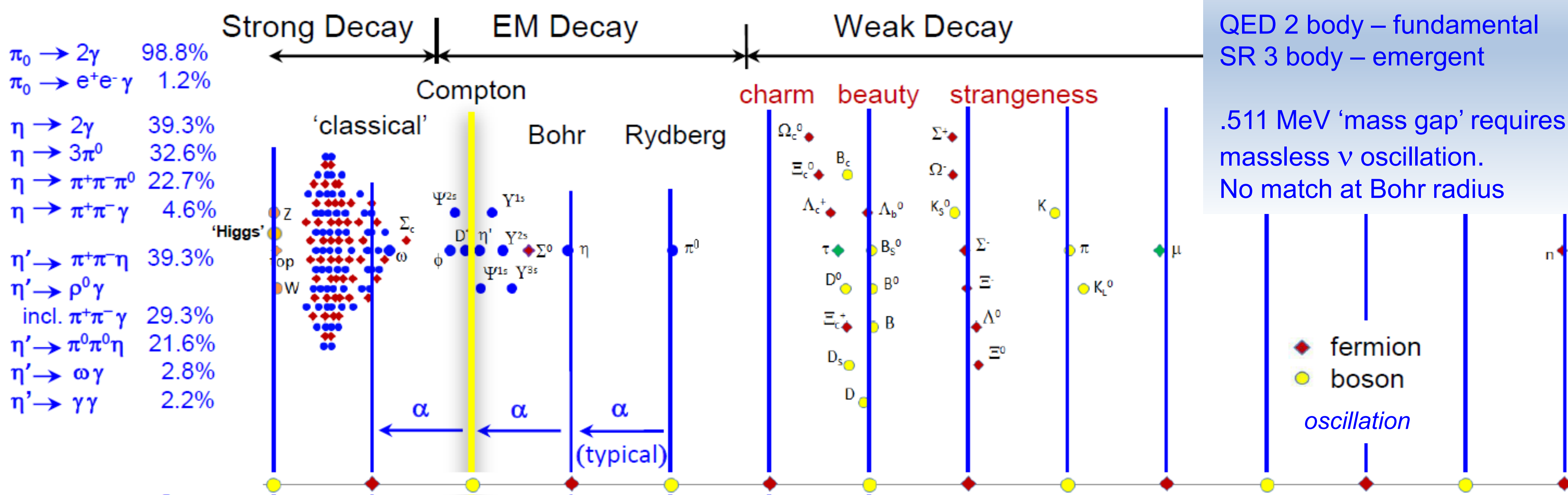
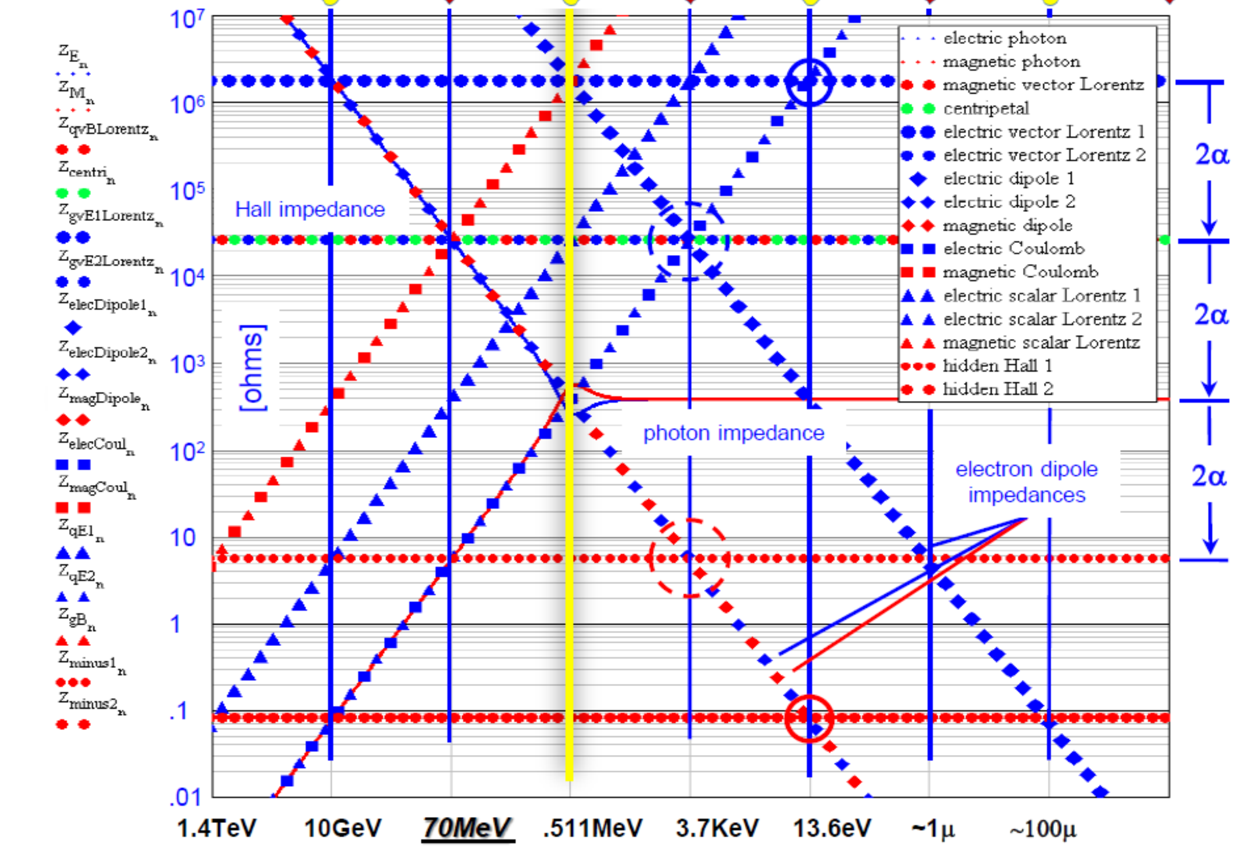
QED 2 body – fundamental
SR 3 body – emergent

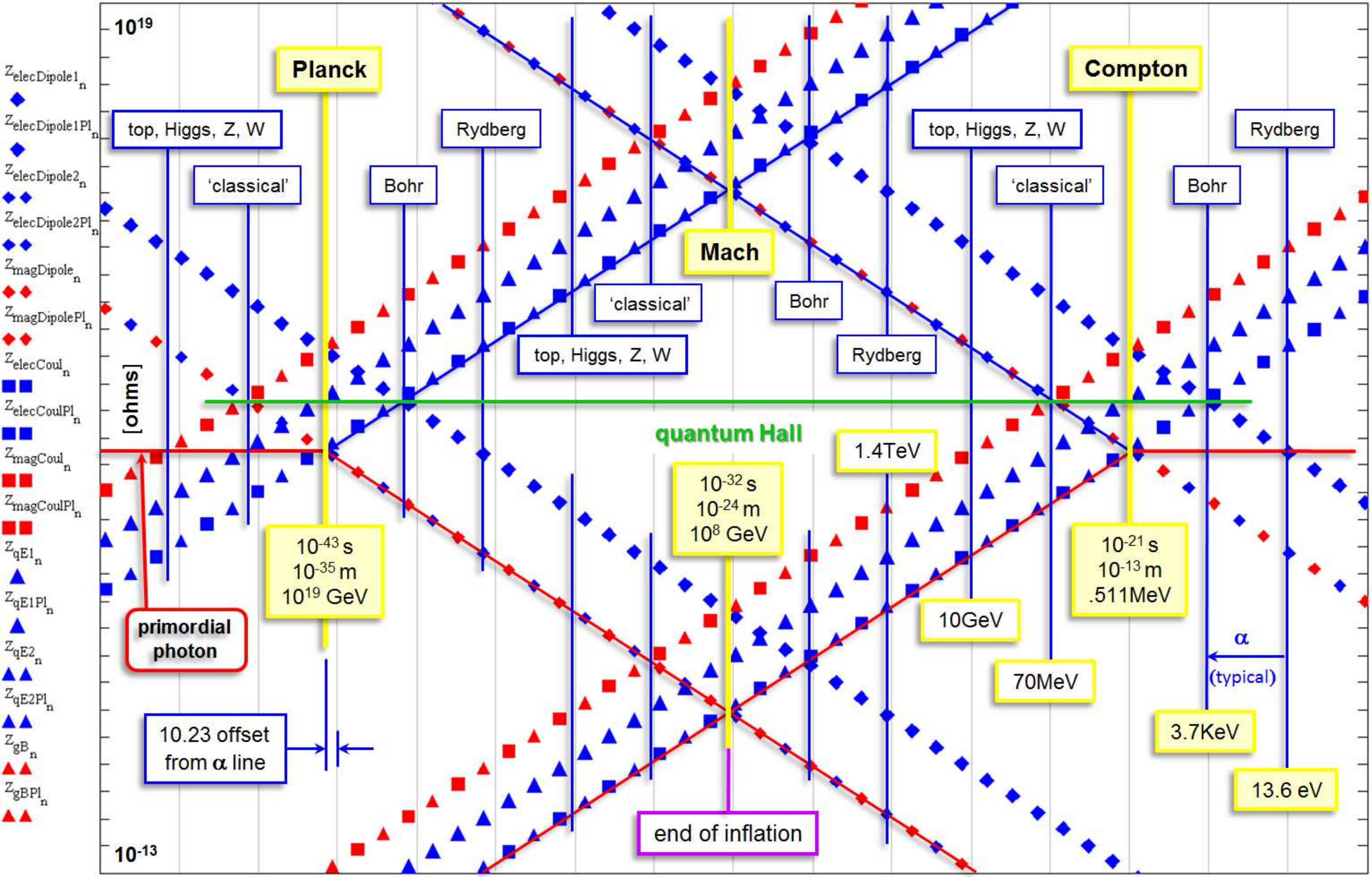
.511 MeV 'mass gap' requires massless ν oscillation.
No match at Bohr radius





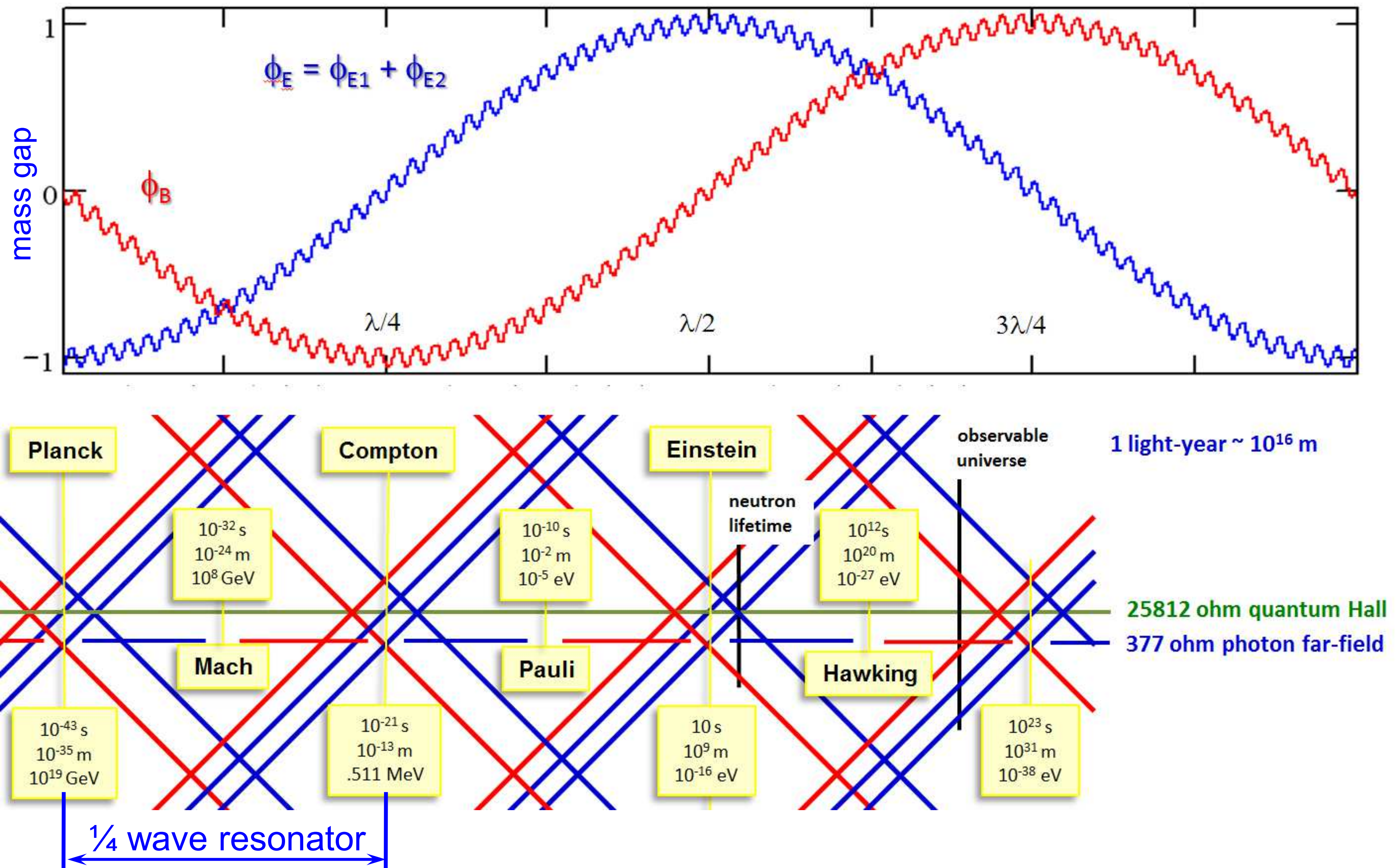
- Horizontal axis in both plots is logarithmic
- Length scales are the same for both plots, and they are properly aligned
- Upper plot shows particle lifetimes multiplied by the speed of light, the coherence lengths
  (adapted from The Power of Alpha by Malcolm MacGregor)
- Plot at left is electron impedances, 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 example 2 – origin of gravitational mass, inflation, chirality, baryon asymmetry,…



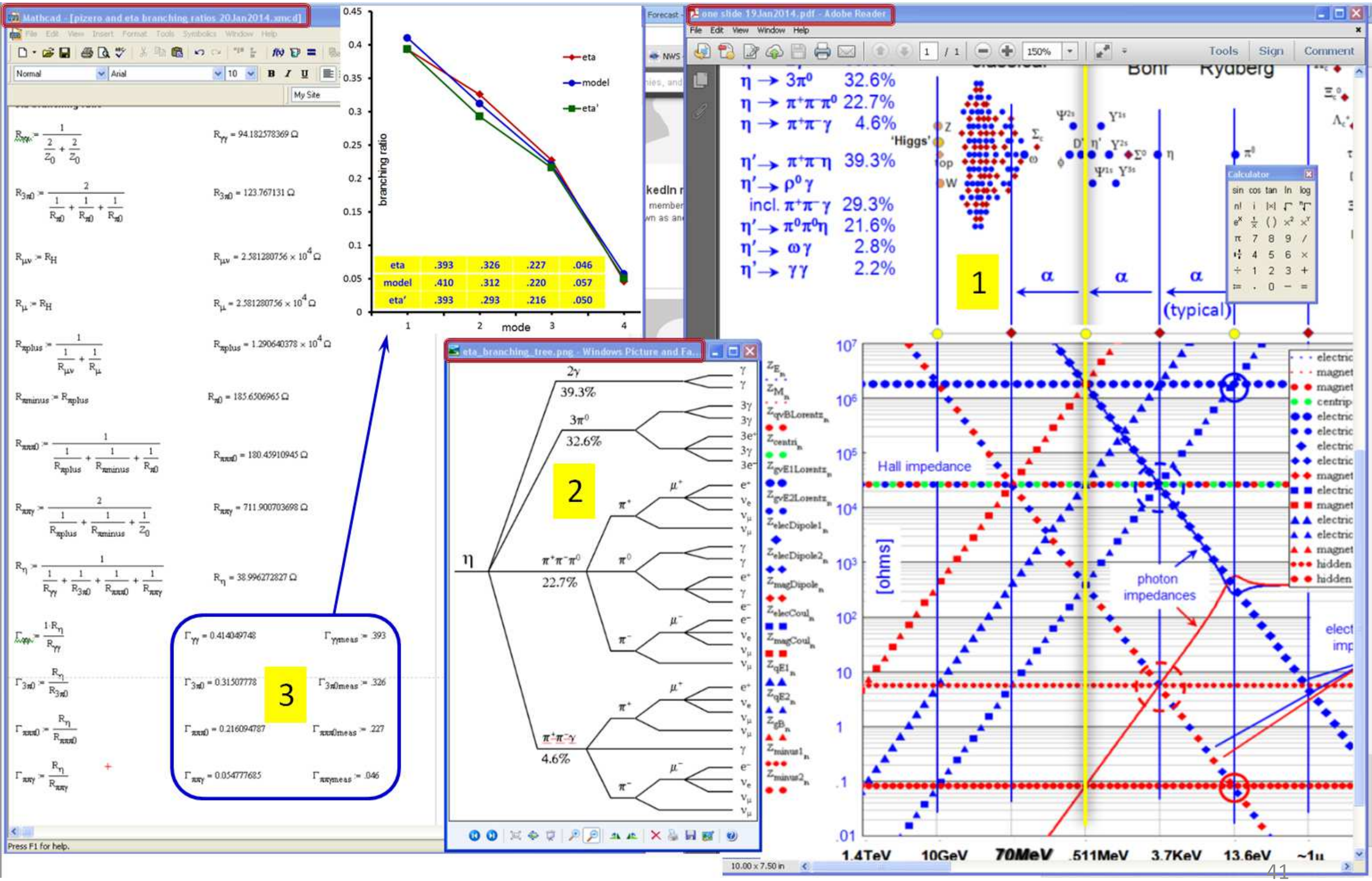
https://www.osapublishing.org/abstract.cfm?uri=QIM-2013-W6.01

BSM example 3 mismatch attenuated Hawking photon ('graviton' is full 8-component wavefunction?)



Where in this network do we want to match for SRGW? How?

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



[An Impedance Approach to the Chiral Anomaly]

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condensed matter – the next frontier

- deBroglie frequency is Doppler shift of Compton frequency $v=0 \rightarrow \lambda_{dB} = h/mv \rightarrow \infty$
  - match to deBroglie, not Compton
  - vacuum wavefunction is the same at all scales
- how to calculate lattice impedances?
  - Feynman and Hibbs path integral book mentions matching in 1D
  - start with Hydrogen atom, then molecular Hydrogen? need proton wavefunction?
  - then carbon nanowire, graphene, diamond,…?
- already in the jump from wavefunction interaction two-body modes to three-component neutrino oscillation, octonion algebra is fertile. Failure of three component associativity yields chiral symmetry breaking, left-handed universe.
- we want to go to N-body.
- impedance matching is absolutely essential in computers as we know them.

  Is *quantum* impedance matching essential in *quantum* computers?
- primary decoherence in quantum computing is the stochastic thermal background.
- weak measurement theory?
  - To close a phase loop within the wavefunction, to excite then lock and track, would seem to require quantum impedance matching to a low energy coupled mode.
  - What does a quantum network analyzer look like?

thank you