π_o Branching Ratios from Quantum Impedance Model

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Abstract

One of the important concepts that governs the amplitude and phase of energy transmission is impedance. The other is the concept of geometric wavefunction that arises from geometric algebra. While Pauli sigma matrices form the basis of space in 3D, the Dirac matrices are basis vectors of space-time in the geometric representation. Wavefunction interactions are modeled by geometric products, which turns fermions into bosons and vice-versa. Physical manifestation of vacuum wavefunction interactions follows from assignment of appropriate quantized E and B fields to the eight vacuum wavefunction components. This is utilized to calculate quantized impedance network as a function of energy, with its nodes specified in powers of alpha, the em coupling constant. The particle lifetimes have been multiplied by speed of light to obtain their coherence lengths, which are in turn converted to corresponding energy units and certain particle lifetimes such as that of π_o and η are seen to be matching with the nodes of impedance network. Utilizing the fact that impedances must be matched for the energy transmission essential in a decay, we determine the branching ratios for π_o.

Quantum Impedance Model (QIM)

The impedance of free space is defined as

$$Z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}} = 3.7673031346 \times 10^2\ \Omega$$

Choose the boundary between near and far fields to be the Compton radius of the electron, the scale at which the photon energy is equal to the rest mass of the electron.

The electric and magnetic dipole impedances can be calculated as:

$$Z_{E_n} = Z_o \left| \frac{1 + \frac{\lambda_e}{j.r_n} + \frac{\lambda_e^2}{(j.r_n)^2}}{1 + \frac{\lambda_e}{j.r_n}} \right| \qquad Z_{M_n} = Z_o \left| \frac{1 + \frac{\lambda_e}{j.r_n}}{1 + \frac{\lambda_e}{j.r_n} + \frac{\lambda_e^2}{(j.r_n)^2}} \right|$$

Where λ_e is the Compton wavelength given by

$$\lambda_e = \frac{\hbar}{m_e c} = 3.861592642 \times 10^{-13}\ \text{m}$$

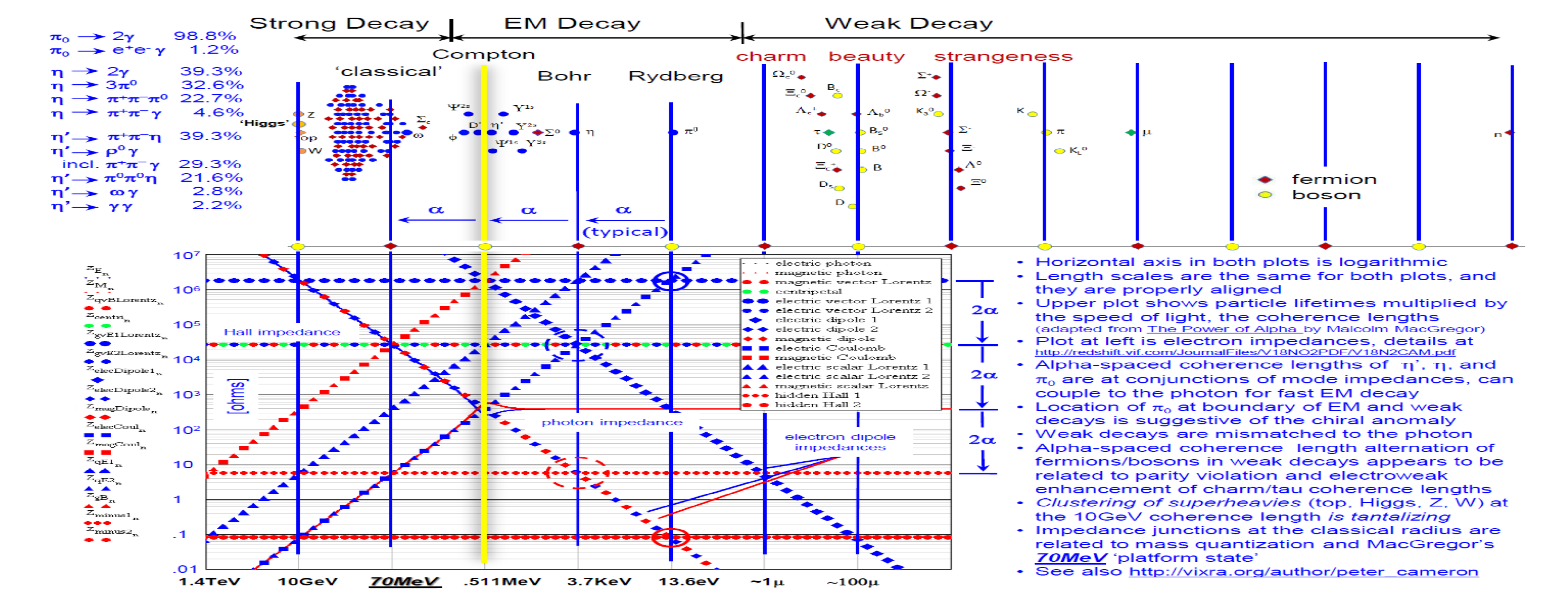
Components of QIM

Vacuum wavefunction is comprised of **eight** fundamental geometric objects:

1. **One scalar:** **electric charge** (e)
2. **Three vector line elements:** Vectors are dipoles in the model, two *electric* and *one magnetic*.
   - **Electric dipole 1:** $dE_1 = \frac{\varepsilon_o h^2}{4\pi e m_e}$
   - **Electric dipole 2:** $dE_2 = \frac{eh}{2\pi m_e c}$
   - **Magnetic field quantum:** $\Phi_B = \frac{h}{2e}$
3. **Three bivector area elements:**
   - **Electric flux quantum 1:** $\Phi_{E_1} = \frac{hc}{2e}$
   - **Electric flux quantum 2:** $\Phi_{E_2} = \frac{e}{\varepsilon_o}$
   - **Magnetic moment:** $\mu_B = \frac{eh}{4\pi m_e}$
4. **One trivector:**
   - **Magnetic charge:** $g = \frac{h}{2e}$

Sr. No.	Quantities	Value
1	e	1.60217648× 10^{-19}As
2	dE_1	1.46062× 10^{-26} mC
3	dE_2	2.12× 10^{-30} mC
4	ϕ_B	9.27401× 10^{-24}Tm²
5	ϕ_{E_1}	6.19921× 10^{-7} Vm
6	ϕ_{E_2}	1.80951× 10^{-24} Tm²
7	μ_B	2.06783× 10^{-15}JT⁻¹
8	g	2.06783× 10^{-15} Tm²

Electromagnetic Impedance Network



Impedance due to electric and magnetic dipole

- **Impedance due to electric dipole 1:**

$$Z_{elec1} = \frac{m_e (dE_1)^2}{\varepsilon_o e^2 \hbar \lambda}$$

- **Impedance due to electric dipole 2:**

$$Z_{elec1} = \frac{m_e (dE_2)^2}{\varepsilon_o e^2 \hbar \lambda}$$

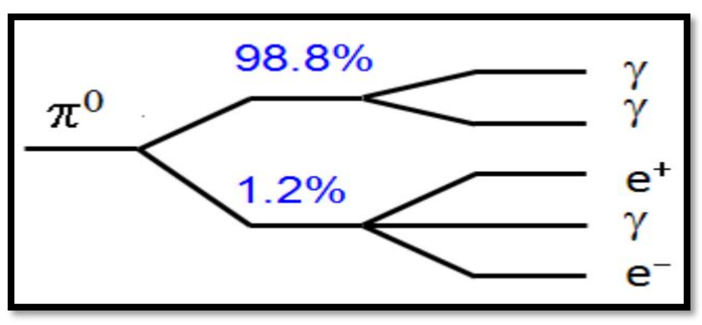
- **Impedance due to magnetic dipole:**

$$Z_{mag} = \frac{\mu_o m_e (\mu_B)^2}{e^2 \hbar \lambda}$$

Impedance	Value
Z_{elec_1}	1.872921Ω
Z_{elec_2}	88938885Ω
Z_{mag}	0.000398Ω

π_o Branching Ratios

As the image suggests, the impedance calculation is done taking the paths in parallel. The π_o coherence length coincides with the (inverse) Rydberg, where there is an impedance match via the dipole mode.



The impedance of the two-photon decay can be given as

$$Z_{\gamma\gamma} = \frac{1}{\frac{1}{Z_o} + \frac{1}{Z_o}}$$

and that of the $e^- e^+ \gamma$ mode as:

$$Z_{e^-e^+\gamma} = \frac{1}{\left(\frac{1}{R_H}\right) + \left(\frac{1}{R_H}\right) + \left(\frac{1}{Z_{elec1} + Z_{elec2} + Z_{mag}}\right)}$$

So, the impedance of π_o is given as:

$$Z_{\pi_o} = \frac{1}{\frac{1}{Z_{\gamma\gamma}} + \frac{1}{Z_{e^-e^+\gamma}}}$$

and the branching ratios are: $\boldsymbol{\Gamma_{\gamma\gamma} = \frac{Z_{\pi_o}}{Z_{\gamma\gamma}}}$ $\boldsymbol{\Gamma_{e^-e^+\gamma} = \frac{Z_{\pi_o}}{Z_{e^-e^+\gamma}}}$

Calculations

Sr. No.	Decay mode	Branching Ratio (Exp)	Branching Ratio(QIM)	Percentage error
1	$\pi_o \rightarrow \gamma + \gamma$	0.988	0.986	0.2%
2	$\pi_o \rightarrow e^+ + e^- + \gamma$	0.012	0.014	16.7 %

Conclusion

The Quantum Impedance Model uses the concept of geometric wavefunction that arises from geometric algebra. This model allows us to calculate the branching ratios of different particles. Here, we calculate the branching ratio of π_o from the electromagnetic impedance network by matching the dipole impedance. We obtained the branching ratios for decay of $\pi_o \rightarrow \gamma + \gamma$ and $\pi_o \rightarrow e^+ + e^- + \gamma$ as 0.986 and 0.014 respectively which is in good agreement with experimental branching ratios.

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