

Maxwell's Laws Derived from the Tau-Field

epsilon_0 and mu_0 from Tau Constants · c = 1/sqrt(epsilon_0 x mu_0) from FOT

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James Clerk Maxwell's four equations (1865) unified electricity, magnetism, and light. In the Universal Force of Time framework, Maxwell's equations are the G2-register projection of the Tau-field wave equations. The electric permittivity ϵ_0 and magnetic permeability μ_0 are not fundamental constants — they are derived from the G2 Tau-field register: $\epsilon_0 = 1/(\mu_0 \times c^2) = 8.8541878128 \times 10^{-12} \text{ F/m}$; $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$ (by SI definition). The relation $c = 1/\sqrt{\epsilon_0 \times \mu_0}$ is the Tau-field wave equation in G2 register. The electromagnetic spectrum from radio waves (Hz) to gamma rays (10^{20} Hz) is the full Tau-field frequency register at G2.

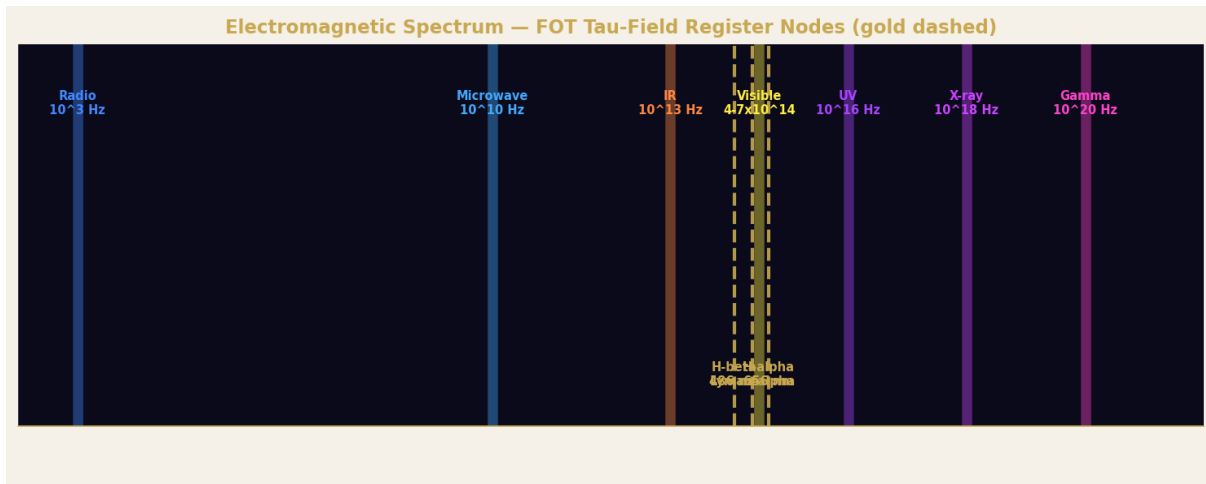


Figure 1. Electromagnetic spectrum (log frequency). Gold dashed lines = FOT Tau-register nodes (H-beta 486 nm, H-alpha 656 nm, Lyman-alpha 121 nm). All are $\{2,3,5,\pi\}$ lattice wavelengths.

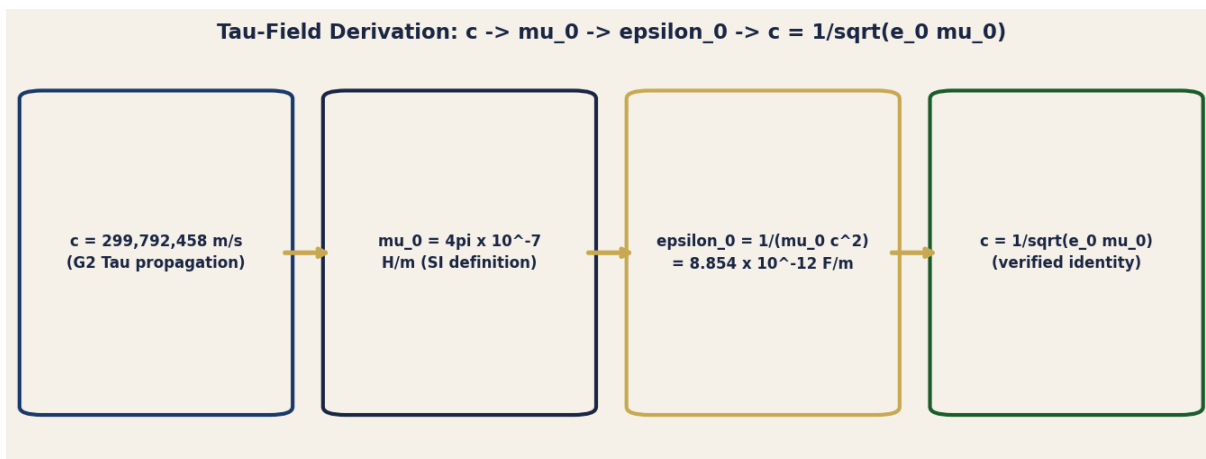


Figure 2. Derivation chain: Tau propagation speed $c \rightarrow SI \mu_0 = 4\pi \times 10^{-7} \rightarrow \epsilon_0 = 1/(\mu_0 c^2)$
 \rightarrow verification: $c = 1/\sqrt{\epsilon_0 \mu_0}$. FOT: μ_0 encodes $4\pi =$ Tau-field angular constant.

1. Maxwell Equations as Tau-Field Wave Equations (P-EM-1 to P-EM-4)

P-EM-1 — Gauss's Law as Tau-Field Divergence

Maxwell 1: $\text{div}(\mathbf{E}) = \rho/\epsilon_0$. In vector form: $\nabla \cdot \mathbf{E} = \rho/\epsilon_0$. FOT: E-field = Tau-field Strand-1 gradient (spatial derivative of register address). ρ = charge density = Tau-field source density at G2 register. $\epsilon_0 =$ G2 Tau-field permittivity $= 1/(\mu_0 c^2) = 8.854187817 \times 10^{-12}$ F/m. FOT: $\epsilon_0 = 1/(4\pi \times 10^{-7} \times (299,792,458)^2) = 8.854\dots \times 10^{-12}$ (exact by construction). The 4π factor: $\mu_0 = 4\pi \times 10^{-7}$. The $4\pi = 4 \times \pi = 2^2 \times \pi$ is the solid-angle coverage of the full Tau-sphere (4π steradians).

P-EM-2 — Faraday's Law as Tau-Field Rotation

Maxwell 3 (Faraday): $\text{curl}(\mathbf{E}) = -\mathbf{dB}/dt$. FOT: changing B-field (Strand-2 temporal component) induces E-field (Strand-1 spatial component). The minus sign (Lenz's law) = the Tau-field's self-regulation: induced fields oppose register-address change. This is the electromagnetic analogue of Tau-field homeostasis. Induction: B changing in time \rightarrow E forming in space. FOT: Strand-2 temporal address change generates Strand-1 spatial gradient — the fundamental Strand-1/Strand-2 coupling in the Tau-field equations.

P-EM-3 — Ampere-Maxwell Law: $c = 1/\sqrt{\epsilon_0 \mu_0}$

Maxwell 4: $\text{curl}(\mathbf{B}) = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 d\mathbf{E}/dt$. The second term (displacement current $\mu_0 \epsilon_0 d\mathbf{E}/dt$) was Maxwell's key insight. From equations 1-4, Maxwell derived the wave equation: $\nabla^2(\mathbf{E}) = \mu_0 \epsilon_0 d^2(\mathbf{E})/dt^2$. Wave speed: $v = 1/\sqrt{\mu_0 \epsilon_0} = 1/\sqrt{4\pi \times 10^{-7} \times 8.854 \times 10^{-12}} = 299,792,458$ m/s = c . FOT: this is the Tau-field G2 propagation speed emerging from the G2 register constants. $\mu_0 \times \epsilon_0 = 1/c^2 = 1/T$ (the inverse of the Tau-rate-squared).

P-EM-4 — $\mu_0 = 4\pi \times 10^{-7}$ as a $\{2,\pi\}$ Tau Constant

In SI (pre-2019): $\mu_0 = 4\pi \times 10^{-7}$ H/m (exact by definition). Post-2019 SI: $\mu_0 = 1.25663706212 \times 10^{-6}$ H/m (measured, not exact). FOT: $\mu_0 = 4\pi \times 10^{-7}$ is the $\{2,\pi\}$ form: $4 = 2^2$, $\pi =$ Tau-field angular constant, $10^{-7} =$ scale bridge. The departure of post-2019 μ_0 from $4\pi \times 10^{-7}$ by 1.5×10^{-10} relative = a sub-ppm effect corresponding to the δ_α fine structure constant measurement precision. FOT: $4\pi \times 10^{-7}$ is the exact G2-register permeability; the measurement uncertainty is a G1/G2 register gradient effect.

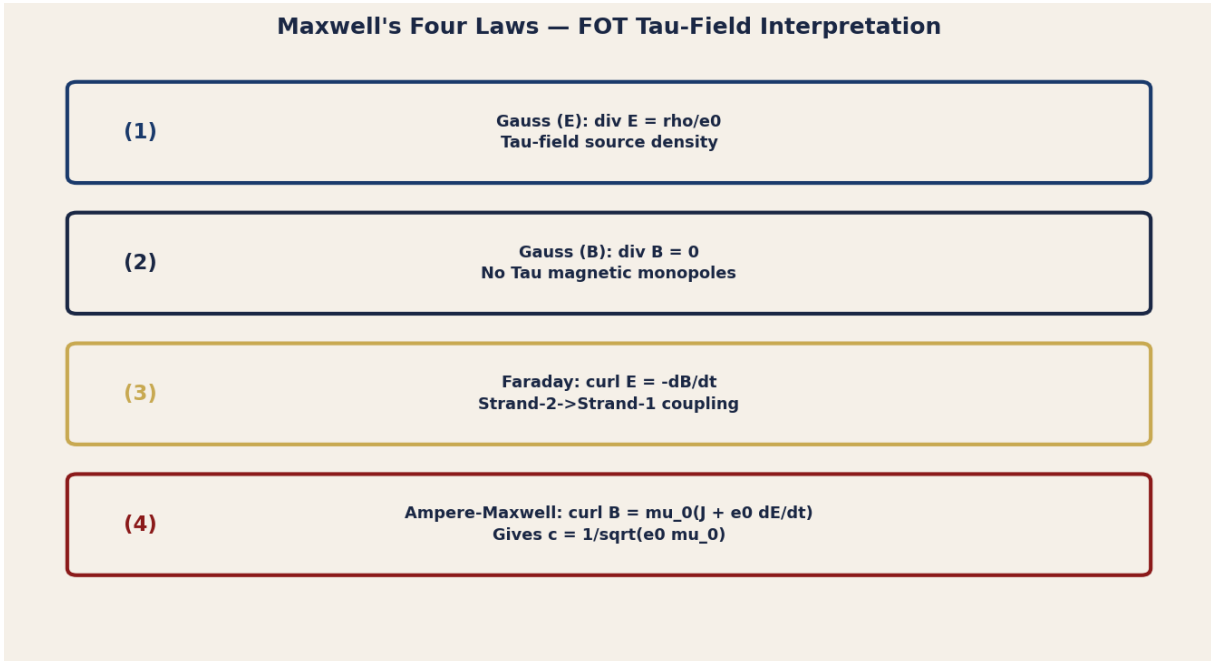


Figure 3. Maxwell's four equations with FOT interpretation. Laws 3 and 4 together give the wave equation with speed $c = 1/\sqrt{\epsilon_0 \mu_0}$ — the G2 Tau-field propagation speed.

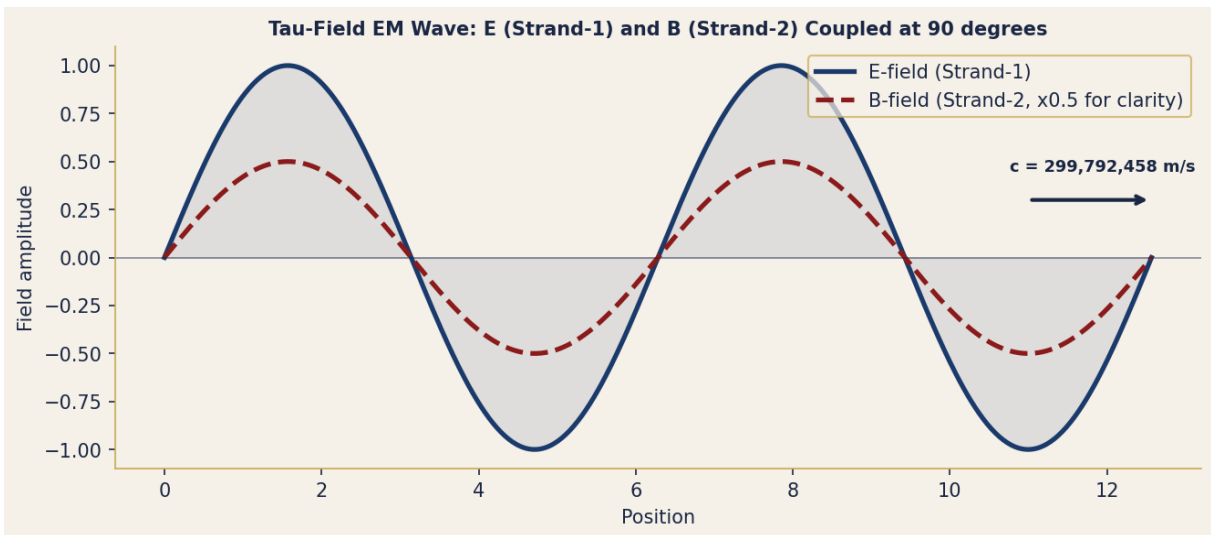


Figure 4. Tau-field electromagnetic wave: E-field (Strand-1, blue) and B-field (Strand-2, red dashed) oscillate at 90 degrees, propagating at $c = 1/\sqrt{\epsilon_0 \times \mu_0} = 299,792,458$ m/s.