ETA Photon Theory

1 Mathematical Formulation of the ETA Fields

The proposal that electromagnetic phenomena arise from intrinsic properties of space-time requires a precise mathematical formulation. To move beyond conceptual description, we introduce a field representation of this charge-separation capacity.

Let there exist a scalar field defined over space-time,

$$\Psi_c(x^\mu), \tag{1}$$

which represents the local degree of charge separation. In regions where $\Psi_c = 0$, space-time remains in an undifferentiated neutral state. Nonzero values of Ψ_c correspond to local polarization, where complementary charge-like regions are formed. This field is not interpreted as charge density itself, but rather as the state of separation from which observable electromagnetic quantities emerge.

To describe matter, a second field is required. We introduce a mass-localization field,

$$\Psi_m(x^\mu), \tag{2}$$

which represents the degree to which energy is localized in space-time. While Ψ_c governs polarization and propagation, Ψ_m governs confinement and inertia. Matter arises when these two fields form coupled, stable configurations.

The dynamics of the system are determined by a Lagrangian density of the form

$$\mathcal{L} = \frac{1}{2}\partial_\mu\Psi_c\,\partial^\mu\Psi_c - \frac{\lambda}{4}\left(\Psi_c^2 - a^2\right)^2 + \frac{1}{2}\partial_\mu\Psi_m\,\partial^\mu\Psi_m - \frac{1}{2}\mu^2\Psi_m^2 - \frac{\beta}{4}\Psi_m^4 - \frac{\gamma}{2}\Psi_c^2\Psi_m^2. \tag{3}$$

Each term has a clear physical interpretation: the kinetic terms describe propagation through space-time; the $\left(\Psi_c^2 - a^2\right)^2$ term allows spontaneous charge separation; the Ψ_m terms produce localized mass structures; and the coupling term $\Psi_c^2\Psi_m^2$ binds charge and mass.

From this Lagrangian, the field equations follow:

$$\Box\Psi_c + \lambda(\Psi_c^2 - a^2)\Psi_c + \gamma\Psi_c\Psi_m^2 = 0, \tag{4}$$

$$\Box\Psi_m + \mu^2\Psi_m + \beta\Psi_m^3 + \gamma\Psi_c^2\Psi_m = 0. \tag{5}$$

These equations define the full dynamics of the theory.

2 Emergence of Electromagnetic Fields

Observable electric and magnetic fields are not fundamental in this framework, but arise from spatial and temporal variations of Ψ_c. We define

$$\mathbf{E} = k_E \nabla \Psi_c, \qquad \mathbf{B} = k_B \nabla \times (\partial_t \Psi_c). \tag{6}$$

These definitions immediately reproduce key structural properties: $\nabla \cdot \mathbf{B} = 0$, coupling between time-varying electric and magnetic fields, and wave-propagation behavior. Applying differential operators yields equations equivalent to Maxwell's equations in the appropriate limit. Thus classical electromagnetism emerges as an effective theory describing gradients and dynamics of the underlying charge-separation field.

3 Photon as a Propagating Field Solution

We now consider small-amplitude solutions of the Ψ_c field in the absence of strong coupling to Ψ_m. In the linear limit,

$$\Box \Psi_c \approx 0, \tag{7}$$

which admits wave solutions of the form

$$\Psi_c = A e^{i(kx - \omega t)}. \tag{8}$$

These solutions propagate with velocity

$$\omega = ck, \tag{9}$$

where c is determined by the parameters of the field. This corresponds to electromagnetic radiation.

However, not all such solutions are physically realized. Stability considerations restrict the system to discrete modes, giving rise to quantization. Energy is associated with the temporal rate of the underlying process:

$$E \propto \omega. \tag{10}$$

Introducing the empirical proportionality constant h, we recover

$$E = h\nu. \tag{11}$$

Thus photon quantization emerges naturally from stability conditions of the space-time field. A photon is therefore interpreted as a stable propagating excitation of the charge-separation field.

4 Electron as a Localized Field Configuration

While photons correspond to propagating solutions, matter must arise from localized solutions of the coupled system. We seek stationary solutions of the form

$$\Psi_c(r,t) = \psi_c(r), \qquad \Psi_m(r,t) = \psi_m(r). \tag{12}$$

These represent stable spatial structures where gradient terms attempt to spread the field while nonlinear terms confine it.

The total energy is given by

$$E = \int u(x)\, d^3x, \tag{13}$$

where $u(x)$ is the energy density derived from the Lagrangian. A stable solution with

$$E = m_e c^2 \tag{14}$$

corresponds to the electron.

Charge arises from the coupled structure:

$$\rho(x) = q_0 \Psi_c(x)\Psi_m(x), \qquad Q = \int \rho(x)\, d^3x = -e. \tag{15}$$

Thus the electron is not a point particle, but a self-consistent localized field structure.

4.1 Internal Rotation and Spin

To account for spin, the field must support internal rotational structure. A general form is

$$\psi(r,\theta,t) = \Phi(r) e^{i(m\theta - \omega t)}. \tag{16}$$

Quantization of angular momentum arises from phase consistency:

$$\Delta\theta = 2\pi \Rightarrow m \in \mathbb{Z}. \tag{17}$$

To obtain spin-$\frac{1}{2}$, a spinor formulation is required. This leads to an effective Dirac equation emerging from the underlying fields,

$$(i\gamma^\mu \partial_\mu - m)\psi = 0. \tag{18}$$

Spin is therefore interpreted as internal circulation of the space-time field structure, not rotation of a rigid physical object.

5 ETA Hydrogen Derivation

The hydrogen atom provides the first decisive test of whether ETA can function as a genuine physical theory rather than only a reinterpretation of the photon. Any viable framework must

explain three facts simultaneously:

1. hydrogen possesses discrete energy levels,
2. the bound electron does not radiate continuously and collapse into the proton,
3. observed transition energies agree with the known hydrogen spectrum.

In classical mechanics this problem is fatal. A charged particle moving in orbit is accelerated, and accelerated charge radiates. The atom should therefore lose energy and contract rapidly. Standard quantum mechanics resolves the problem by replacing orbits with stationary wavefunctions. ETA adopts the non-radiating stationary-state idea, but gives it a more explicit physical meaning: the bound electron is a real standing field configuration of space-time charge and mass structure.

We begin from the effective bound-state equation for the electron field in the proton potential. In the minimal approximation, this takes the same mathematical form as the ordinary nonrelativistic hydrogen equation,

$$-\frac{\hbar^2}{2m_e}\nabla^2\psi - \frac{e^2}{4\pi\epsilon_0 r}\psi = E\psi. \tag{19}$$

A stable standing configuration must be single-valued after a complete cycle around the nucleus:

$$\psi(\phi + 2\pi) = \psi(\phi). \tag{20}$$

This implies quantization of phase winding and gives

$$m_e v r = n\hbar, \qquad n = 1, 2, 3, \ldots \tag{21}$$

In the minimal approximation, the total energy as a function of scale may be represented schematically by

$$E(r) = \frac{A}{r^2} - \frac{B}{r}, \tag{22}$$

where the $1/r^2$ term represents localization energy and the $1/r$ term represents Coulomb attraction.

Equating the effective inward Coulomb attraction with the field-consistent circular phase relation yields

$$\frac{m_e v^2}{r} = \frac{e^2}{4\pi\epsilon_0 r^2}. \tag{23}$$

Using

$$m_e v r = n\hbar, \tag{24}$$

we solve for v,

$$v = \frac{n\hbar}{m_e r}, \tag{25}$$

and substitute into the balance equation to obtain

$$r_n = \frac{4\pi\epsilon_0\hbar^2}{m_e e^2} n^2. \tag{26}$$

Defining the Bohr radius in the usual way,

$$a_0 = \frac{4\pi\epsilon_0\hbar^2}{m_e e^2}, \tag{27}$$

we obtain

$$r_n = a_0 n^2. \tag{28}$$

The energy levels follow as

$$E_n = -\frac{m_e e^4}{2(4\pi\epsilon_0)^2\hbar^2}\frac{1}{n^2} = -\frac{13.6\,\mathrm{eV}}{n^2}. \tag{29}$$

The no-radiation condition now becomes clear. If we write the field as

$$\psi(\mathbf{r}, t) = \Phi(\mathbf{r})e^{-i\omega t}, \tag{30}$$

then the density is

$$|\psi(\mathbf{r}, t)|^2 = |\Phi(\mathbf{r})|^2, \tag{31}$$

which does not depend on time. This is why the atom does not continuously emit energy.

If the atom changes from one standing configuration to another, the energy difference must be released or absorbed as a propagating excitation of the charge-separation field, that is, as a photon:

$$\Delta E = h\nu, \tag{32}$$

with

$$\Delta E = 13.6\,\mathrm{eV}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right), \qquad n_i > n_f. \tag{33}$$

6 Nonlinear ETA Hydrogen Extension and Sub-Ground-State Analysis

We modify the effective hydrogen equation by adding an attractive nonlinear term,

$$-\frac{\hbar^2}{2m_e}\nabla^2\psi - \frac{e^2}{4\pi\epsilon_0 r}\psi - g|\psi|^2\psi = E\psi, \tag{34}$$

where $g > 0$ measures the strength of the self-binding.

Using the normalized hydrogen-like trial function

$$\psi(r) = \frac{1}{\sqrt{\pi a^3}}e^{-r/a}, \tag{35}$$

the total energy is

$$E(a) = T(a) + V_C(a) + V_{NL}(a), \tag{36}$$

with

$$T(a) = \frac{\hbar^2}{2m_e a^2}, \qquad V_C(a) = -\frac{e^2}{4\pi\epsilon_0 a}, \qquad V_{NL}(a) = -\frac{g}{16\pi a^3}. \tag{37}$$

Hence

$$E(a) = \frac{\hbar^2}{2m_e a^2} - \frac{e^2}{4\pi\epsilon_0 a} - \frac{g}{16\pi a^3}. \tag{38}$$

Write the scale as

$$a = \frac{a_0}{p}, \tag{39}$$

so that

$$\frac{E_p}{13.6\,\mathrm{eV}} = p^2 - 2p - \eta p^3, \tag{40}$$

where

$$\eta = \frac{g}{16\pi a_0^3 \cdot 13.6\,\mathrm{eV}}. \tag{41}$$

The ordinary ground state corresponds to $p = 1$, so

$$E_1 = -13.6(1+\eta)\,\mathrm{eV}. \tag{42}$$

For the compressed branch $p = 2$,

$$E_2 = -108.8\,\eta\,\mathrm{eV}. \tag{43}$$

If one asks for a state at

$$E_2 = -54.4\,\mathrm{eV}, \tag{44}$$

the required coupling is

$$\eta = 0.5. \tag{45}$$

7 External Fields and Fine Structure in the ETA Hydrogen Model

A uniform external electric field along the z-direction,

$$\mathbf{E} = E_0 \hat{z}, \tag{46}$$

produces the perturbation

$$H_S = eE_0 z. \tag{47}$$

For the ground state,

$$\Delta E^{(1)} = \langle 1s | eE_0 z | 1s \rangle = 0, \tag{48}$$

while the second-order shift is

$$\Delta E^{(2)} = \sum_{n \neq 1} \frac{|\langle n | eE_0 z | 1 \rangle|^2}{E_1 - E_n}. \tag{49}$$

For a uniform magnetic field,

$$\mathbf{B} = B\hat{z}, \tag{50}$$

the effective Hamiltonian becomes

$$H = \frac{1}{2m_e}\left(-i\hbar\nabla - e\mathbf{A}\right)^2 - \frac{e^2}{4\pi\epsilon_0 r}, \tag{51}$$

and the Zeeman term is

$$H_Z = \frac{e}{2m_e}\mathbf{B}\cdot\mathbf{L}. \tag{52}$$

The corresponding energy shift is

$$\Delta E = \mu_B B m, \qquad \mu_B = \frac{e\hbar}{2m_e}. \tag{53}$$

Relativistic fine-structure corrections follow from

$$E = \sqrt{p^2c^2 + m^2c^4} = mc^2 + \frac{p^2}{2m} - \frac{p^4}{8m^3c^2} + \cdots, \tag{54}$$

so that

$$H_{\text{rel}} = -\frac{p^4}{8m_e^3c^2}. \tag{55}$$

Spin–orbit coupling is described by

$$H_{SO} = \frac{1}{2m_e^2c^2}\frac{1}{r}\frac{dV}{dr}\,\mathbf{L}\cdot\mathbf{S}, \tag{56}$$

which for hydrogen becomes

$$H_{SO} = \frac{e^2}{8\pi\epsilon_0 m_e^2 c^2 r^3}\,\mathbf{L}\cdot\mathbf{S}. \tag{57}$$

8 The Lamb Shift in a Field-Based ETA Framework

The Lamb shift is interpreted as a short-range modification of the proton–electron interaction due to finite electron structure, self-interaction of the standing field, and response of the surrounding space-time medium. The effective central potential is written as

$$V_{\text{eff}}(r) = -\frac{e^2}{4\pi\epsilon_0 r} + \delta V(r), \tag{58}$$

where $\delta V(r)$ is a small correction concentrated near the nucleus.

The resulting energy shift is

$$\Delta E = \int |\psi(r)|^2\,\delta V(r)\,d^3r. \tag{59}$$

For hydrogenic S-states,

$$|\psi_{nS}(0)|^2 \propto \frac{1}{n^3}, \tag{60}$$

so the shift is strongest for low-n S-states and decreases with increasing n.

A schematic model is

$$\delta V(r) = V_0 e^{-r/r_\eta}, \tag{61}$$

which gives

$$\Delta E = \int |\psi(r)|^2 V_0 e^{-r/r_\eta}\, d^3r. \tag{62}$$

For $r_\eta \ll a_0$, the correction is appreciable for $2S$ and suppressed for $2P$, thereby breaking the degeneracy.

9 Formal Predictions

The preceding sections motivate a field-based description in which electromagnetic phenomena are interpreted as manifestations of an underlying separation structure of space-time. In that framework, the standard Maxwell description is recovered as an effective weak-field limit, while localized and propagating excitations correspond to distinct solution classes of a common underlying dynamics. The purpose of the present section is to state, in a controlled way, the principal physical consequences that would follow if the framework is correct.

9.1 Working assumptions

The discussion below is based on the following assumptions. First, the fundamental degrees of freedom are taken to be described by a smooth space-time field $P^\mu(x)$, interpreted as a separation field whose organized variations underlie electromagnetic behavior. Second, the observed electromagnetic tensor is assumed to arise as an effective quantity constructed from P^μ and its derivatives, with the Maxwell form recovered in an appropriate linearized regime. Third, charged matter is assumed to correspond to stable localized solutions of the same underlying field equations. Fourth, propagating radiation and localized matter-like excitations are assumed to belong to the same dynamical theory, differing by boundary conditions and stability class rather than by ontological category.

9.2 Model equations

To fix notation, let the fundamental field be

$$P^\mu(x). \tag{63}$$

The effective electromagnetic tensor is assumed to be of the form

$$F^{\text{eff}}_{\mu\nu} = \partial_\mu P_\nu - \partial_\nu P_\mu + \mathcal{N}_{\mu\nu}(P, \partial P, \ldots), \tag{64}$$

where $\mathcal{N}_{\mu\nu}$ denotes nonlinear corrections. In the weak-field limit,

$$\mathcal{N}_{\mu\nu} \to 0, \tag{65}$$

so that

$$F_{\mu\nu}^{\mathrm{eff}} \approx \partial_\mu P_\nu - \partial_\nu P_\mu. \tag{66}$$

At the schematic level, the field equations may be written as

$$\mathcal{D}_\mu[P] = J_\mu^{\mathrm{eff}}, \tag{67}$$

and, if an action formulation exists,

$$S[P] = \int \mathcal{L}(P, \partial P, \partial^2 P, \ldots)\, d^4x, \qquad \frac{\delta S}{\delta P^\mu} = 0. \tag{68}$$

9.3 Primary prediction: finite electron extent

The leading prediction is that the electron is not an exact geometric point, but is instead associated with a stable localized configuration of the underlying field,

$$P^\mu(x) = P_e^\mu(x), \tag{69}$$

with finite total energy,

$$E_e = \int T^{00}[P_e]\, d^3x < \infty. \tag{70}$$

A characteristic electron scale may be defined by

$$r_e^* = \left(\frac{\int |\mathbf{x}|^2 \rho_P(\mathbf{x})\, d^3x}{\int \rho_P(\mathbf{x})\, d^3x} \right)^{1/2}, \tag{71}$$

with the central claim

$$r_e^* > 0. \tag{72}$$

In any regime satisfying

$$q\, r_e^* \ll 1, \tag{73}$$

the usual point-particle description remains an excellent approximation.

9.4 Consequence for high-momentum structure

A finite electron structure implies a nontrivial form factor:

$$\mathcal{M}(q^2) = \mathcal{M}_{\mathrm{point}}(q^2)\, F_e(q^2), \qquad F_e(0) = 1. \tag{74}$$

For small q^2,

$$F_e(q^2) = 1 - \frac{1}{6}\langle r^2 \rangle_e q^2 + O(q^4), \tag{75}$$

so

$$F_e(q^2) \neq 1 \quad \text{for sufficiently large } q^2. \tag{76}$$

The differential cross section is correspondingly modified:

$$\frac{d\sigma}{d\Omega} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{point}} |F_e(q^2)|^2 + \Delta_{\text{nl}}(q^2, \theta). \tag{77}$$

9.5 Relation between localized and propagating excitations

Localized matter-like states and propagating radiative states are predicted to belong to a common solution space. Let

$$P_e^\mu(x) \tag{78}$$

denote a stable localized solution and

$$P_\gamma^\mu(x) \tag{79}$$

a stable propagating one. Then

$$\mathcal{S}_{\text{ETA}} = \mathcal{S}_{\text{bound}} \cup \mathcal{S}_{\text{prop}}. \tag{80}$$

In a mature formulation, one expects a relation of the schematic form

$$r_e^* = \Phi(\alpha, \Lambda_{\text{ETA}}, \lambda_0, \ldots). \tag{81}$$

9.6 Polarization and stability classes

A radiative solution may be written schematically as

$$P_\gamma^\mu(x) = \Re\Big[\epsilon^\mu(\mathbf{k}) A(x) e^{i\phi(x)}\Big]. \tag{82}$$

The theory suggests that only certain mode geometries are dynamically stable:

$$\mathcal{G}[\epsilon^\mu, A, \phi, \Lambda_{\text{ETA}}] = 0. \tag{83}$$

Because the theory is nonlinear, stable matter-like and radiation-like excitations are expected to correspond to distinguished solution classes,

$$\{P_n^\mu\}, \qquad n = 1, 2, 3, \ldots \tag{84}$$

selected by regularity, localization, propagation stability, and energy conditions.

9.7 Emergent discreteness of exchange

A further possibility is that discrete interaction outcomes may emerge from continuous underlying fields when only certain transfer conditions are dynamically stable:

$$\mathcal{C}(P^\mu_{\text{source}}, P^\mu_{\text{detector}}) = n h_{\text{eff}}, \qquad n \in \mathbb{Z}^+. \tag{85}$$

9.8 Conditions for failure

At minimum, the program requires solutions satisfying

$$r_e^* > 0, \qquad E_e < \infty, \qquad F_e(q^2) \to 1 \text{ as } q^2 \to 0, \tag{86}$$

and

$$F_{\mu\nu}^{\text{eff}} \to \partial_\mu A_\nu - \partial_\nu A_\mu \quad \text{in the weak-field limit.} \tag{87}$$

9.9 Summary

The central prediction is

$$\boxed{\text{electron} = \text{stable localized field configuration with } r_e^* > 0.} \tag{88}$$

From this follow associated expectations: nontrivial high-momentum structure, a common dynamical origin for propagating and localized excitations, geometric constraints on polarization stability, and the possibility that effective discreteness emerges from nonlinear continuous dynamics.