Section 9. Mapping to Standard Physics (QED/Dirac/Pauli as Effective Projection

This section provides an explicit dictionary layer between the CUWF ontology developed in Sections 3–8 and the standard language of quantum electrodynamics (QED), Dirac theory, and the Pauli formalism. The aim is pragmatic rather than revisionist: readers trained in standard physics need a clear mapping that identifies what CUWF reproduces at the effective level, which textbook structures arise as projections of phase–torsion transport, and where CUWF departs from standard ontology while retaining operational equivalence.

Throughout this section, the expression effective projection has a precise meaning. It refers to the low-energy, coarse-grained representation of CUWF transport constraints as linear operator dynamics on a Hilbert-space description. CUWF therefore does not reject the usefulness of the standard formalism. It relocates its status from fundamental law to effective coordinate chart on a deeper phase–torsion manifold.

9.1 Charge Winding to QED Coupling Language

9.1.1 CUWF Charge: Winding Stability of Phase Orientation

In CUWF, electric charge is not a primitive label. It is a topological invariant of the phase field $\theta(x)$ around defects, that is, collapse-node punctures of the underlying manifold. The core statement is:

$$q \propto n, \quad n = (1/2\pi) \oint \nabla\vartheta \cdot dl \in \mathbb{Z}$$

Charge conservation then follows as phase-transport compatibility: phase circulation cannot change continuously without a defect-creation, defect-annihilation, or reconnection event, each of which requires passage through an entropically costly configuration.

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9.1.2 The U(1) Connection as QED Gauge Potential

Section 4 introduced a U(1) connection A_μ as the minimal compatibility field required by local rephasing. The standard QED statement that a charged excitation couples to the electromagnetic potential is therefore reinterpreted in CUWF as follows: A_μ is the effective compatibility connection that specifies how phase orientation must be transported locally in order to remain entropically consistent.

$$\partial_\mu \to D_\mu = \partial_\mu + i q A_\mu$$

In this reading, minimal coupling is not an axiom appended to the theory. It is the effective operator expression of consistent phase transport under local re-description.

9.1.3 Field Strength and Maxwell Dynamics

The standard electromagnetic curvature

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

corresponds in CUWF to the curvature of phase-transport compatibility. Sources in Maxwell's equations are therefore mapped to phase defects and to their motion. What is preserved is the operational gauge structure, the continuity equation, and the effective field dynamics. What changes is the ontology: A_μ and $F_{\mu\nu}$ are not treated as fundamental substances, but as the encoded description of how phase orientation can move consistently on the entropic manifold.

9.2 Torsion Classes to Spinor Formalism

9.2.1 CUWF Spin: Torsional Topology Class and Holonomy

Section 6 defined spin as a torsional wave-topology class anchored at collapse nodes. For the spin-1/2 case, the defining structural feature is the existence of Z_2 holonomy around a nontrivial loop C:

$$U[C] = -I$$

This implies 4π periodicity in internal transport: a 2π rotation does not return the state to itself, whereas a 4π rotation does.

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9.2.2 Why Spinors Appear

The standard spinor formalism represents SU(2) transport on a two-component complex vector space. In CUWF, the two-component spinor is not fundamental ontology. It is the minimal effective coordinate chart for tracking torsion-transport classes.

CUWF object	Effective standard representation
Torsion state class	Equivalence class of spinors under global phase
Torsion transport holonomy	SU(2) action on the spinor
Measurement “up/down”	Basis choice for projection onto a chosen axis

9.2.3 Pauli Matrices as Effective Generators

In standard theory, the Pauli matrices σ_i generate SU(2) rotations. In CUWF, they arise as the effective generators of torsion-frame transport in the linearized description. They quantify how an infinitesimal torsion rotation, expressed in the effective SU(2) chart, changes the projected state. Accordingly, $\sigma \cdot n$ is interpreted as an effective measurement operator for torsion-axis projection, not as a statement about literal spinning or classical arrows carried through space.

9.3 Dirac and Pauli Equations as Linearized Effective Dynamics

9.3.1 Why Linear Operator Dynamics Appears at Low Energy

CUWF begins with nonlinear structural constraints: entropic stability, defect topology, and compatibility of transport. Yet when one studies small disturbances around a stable defect configuration, the dynamics of deviations can be linearized. This is not a retreat to standard ontology. It is the ordinary mathematical fact that stable equilibria admit local tangent-space dynamics. The linear equations of standard physics therefore appear, in CUWF, as tangent-space approximations to phase–torsion transport near stable anchors.

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9.3.2 The Pauli Equation as the Nonrelativistic Projection

When the effective description uses a two-component spinor chart for torsion and a U(1) connection for phase transport, the leading-order Hamiltonian of a charged spin-1/2 excitation takes the Pauli form:

$$H = (1/2m)(-i\hbar\nabla - qA)^2 - (q/2m)\, g\, S \cdot B + q\varphi + \dots$$

Within CUWF, the kinetic covariant term encodes phase-transport compatibility under local rephasing; the S · B term encodes the lowest-order phase–torsion compatibility coupling developed in Section 7; and the baseline value $g \approx 2$ reflects the minimal topology value for spin-1/2 torsion anchors, with deviations assigned to correction channels. The Pauli equation is therefore retained as a compact linear summary of local transport constraints.

9.3.3 The Dirac Equation as Relativistic Linearization

The Dirac equation introduces a four-component spinor and gamma matrices in order to enforce Lorentz covariance while incorporating spin consistently. In CUWF, the Dirac structure is interpreted as the relativistically covariant linearization of the coupled phase–torsion transport system. The claim is not that Dirac theory is fundamental, but that it is the most efficient covariant operator package for reproducing the transport constraints of a charged spin-1/2 torsional anchor in the relativistic regime. Its tree-level prediction $g = 2$ aligns naturally with the CUWF topology baseline because both encode the SU(2) double-cover structure that distinguishes 2π from 4π at the internal-transport level.

9.4 What CUWF Preserves and What It Changes

The mapping can be summarized by separating what CUWF preserves at the effective level from what it changes at the ontological level.

Preserved (effective level)	Changed (ontological level)
Conservation laws: charge conservation and spin-class conservation remain valid in the absence of topology-changing events.	Topology first: charge and spin originate as topological invariants of phase and torsion transport.

Preserved (effective level)	Changed (ontological level)
Gauge structure: the effective U(1) connection and curvature behave like the electromagnetic potential and field strength. Operator formalism: spinors and linear equations remain valid as tangent-space approximations. Empirical targets: quantization, 4π periodicity, magnetic coupling, and Maxwell-like dynamics are preserved in the mapped language.	Particles second: particle properties are labels assigned to stable defect classes rather than primitive constituents. Fields as compatibility charts: electromagnetic and spinor fields are effective coordinate descriptions of transport compatibility, not fundamental substances. Symmetry as consequence: U(1) and SU(2) are selected by entropic stability and transport compatibility rather than imposed axiomatically.

In short, CUWF seeks to preserve what works in standard physics while shifting what is assumed. The standard equations remain operationally valid as effective projections, but the origin of their structure is relocated to the topology and entropic stability of the underlying manifold.

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