Section 4. Electromagnetism as Connection–Curvature of Phase Structure

This section reformulates electromagnetism within the CUWF framework as the effective geometry of phase transport on the entropic manifold. Gauge structure is not introduced as a primitive axiom. It appears because local descriptions of phase must remain mutually compatible when the same underlying configuration is expressed in different local reference frames. In this sense, electromagnetism is interpreted as the connection–curvature structure required for consistent phase comparison across the manifold.

4.1 Gauge Freedom as a Compatibility Requirement

In conventional field theory, local U(1) gauge invariance is postulated from the start: the field may be rephased locally as $\Psi(x) \longrightarrow e^{i\alpha(x)}\Psi(x)$, and a gauge field A_μ is then introduced so that the theory remains invariant. CUWF reverses this order of explanation. A local rephasing is not treated as a fundamental metaphysical symmetry, but as a change of local description of the same underlying phase configuration.

The problem is immediate. If neighboring patches of description adopt different local phase references $\alpha(x)$, then the raw derivative $\partial_\mu\theta$ is no longer sufficient to compare phase transport between them. Without an additional compensating structure, transport would depend on arbitrary descriptive choices rather than on the underlying physical configuration. To preserve compatibility, the manifold must provide a phase-connection field that compensates for these local re-descriptions. What appears in standard theory as gauge freedom is therefore reinterpreted in CUWF as the family of local re-descriptions that leave the compatibility class of phase transport unchanged.

4.2 Covariant Derivative as Effective Projection

Once local compatibility is required, the ordinary derivative must be replaced by a covariant derivative of the form

$$D_\mu = \partial_\mu + i\, q\, A_\mu.$$

Here, A_μ is not added by fiat to mimic electromagnetism. It is the effective projection, into spacetime language, of the deeper phase-connection structure required to compare local phase frames consistently. The parameter q plays the role of coupling, but in the CUWF interpretation it is not an arbitrary label attached to a particle; it reflects the winding class of the underlying topological defect. The covariant derivative is therefore the unique local operator, in this construction, that preserves phase compatibility under local re-description.

4.3 Field Strength as Curvature of Phase Transport

The corresponding field strength is

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

In CUWF, $F_{\mu\nu}$ is interpreted as the curvature of phase transport rather than as a primitive physical field. A nonzero curvature means that phase comparison around an infinitesimal closed loop fails to return the local frame to itself. The geometric content is therefore analogous to curvature in differential geometry, but the relevant structure is phase transport on the entropic manifold rather than curvature of spacetime itself.

Away from defects, local phase transport is compatible and the effective curvature may vanish or remain small. Near defects, however, compatibility is frustrated, and curvature becomes nontrivial. Defects therefore act as localized sources of phase-connection curvature.

4.4 Maxwell-Like Dynamics in CUWF Language

At the effective level, the curvature structure obeys equations equivalent in form to Maxwell's equations, but their interpretation changes substantially. Sources are not primitive charged particles; they are topological defects carrying winding class. Fields are not ontologically independent substances; they are large-scale relaxation patterns of the phase-connection structure responding to entropic incompatibility localized at defects.

Within this picture, Gauss's law expresses the constraint imposed by phase winding around defects. Faraday-like induction reflects the fact that time-dependent changes in phase structure generate circulating connection patterns. The homogeneous Maxwell equations arise as geometric identities of the connection–curvature framework itself. Electromagnetism is thus reinterpreted as the effective compatibility theory of phase transport, projected into spacetime form.

4.5 Radiation as Propagating Phase-Disturbance Modes

Electromagnetic radiation is interpreted in CUWF as a propagating disturbance mode of the phase-connection structure. When defects move, oscillate, or rapidly reconfigure, they generate time-dependent distortions in the connection field A_μ. These distortions propagate through the entropic manifold and appear, in the effective spacetime description, as electromagnetic waves.

This view unifies static charge and radiation within one structural scheme. Stable winding gives rise to static phase-connection structure, whereas time-dependent reconfiguration produces propagating modes of the same underlying system. Photons, in this interpretation, are not ontologically separate entities added on top of charge; they are the quantized oscillatory excitations of the phase-connection structure itself.