Section M-0 — Preliminaries & Notation

This section establishes the mathematical foundations, core objects, and notation conventions used throughout Paper C-2. Because CUWF operates in a hybrid geometric setting that combines physical configuration, entropic structure, and degree-of-freedom (DOF) dynamics, the notation must simultaneously generalize familiar tensor calculus and introduce CUWF-specific operators. The purpose of Section M-0 is therefore to provide a concise but complete dictionary for all symbols, spaces, derivatives, tensors, and operators used in the later formal derivations.

The definitions introduced here do not yet constitute the dynamical theory itself. They prepare the mathematical language required for Sections M-1 through M-6, where entropic geometry, the CUWF Master Operator, the action principle, multi-node Hamiltonians, stability-spectrum theory, and reduction limits will be developed in detail.

M-0.1 Domains and Spaces Used in CUWF Mathematics

1. Physical Configuration Space

The positions of collapse nodes live in a configuration space denoted by C. A point in this space is written as

$$x \in C, \quad x = (x^1, x^2, \ldots, x^n).$$

For single-particle or single-node systems, the configuration space reduces to ordinary three-dimensional Euclidean configuration:

$$C = R^3.$$

For multi-node systems with N collapse nodes, the configuration space becomes

$C = R^{3N}$.

CUWF treats configuration space—not ordinary three-dimensional physical space—as the fundamental domain of entropic geometry. Physical space appears only after the entropic field and its induced geometry are projected into a lower-level effective description.

2. DOF-Space (Degree-of-Freedom Manifold)

Each physical system carries hidden or internal degrees of freedom, written as

$DOF = (d^1, d^2, \ldots, d^m)$.

These internal variables affect the entropic field through derivatives such as

$\partial E / \partial DOF_a$.

The DOF-manifold is denoted by

M_DOF.

It functions analogously to an internal fiber bundle in gauge theory, but with a crucial CUWF-specific difference: the DOF-manifold does not merely label internal states. It directly influences the curvature and evolution of the entropic field. In later sections, this role becomes essential for defining DOF drift, dimensional reduction, quantum-classical transition, and multi-node coupling.

3. Entropic Field Domain

The master scalar field in CUWF is the entropic field

$E : C \times M\_DOF \longrightarrow R$.

This field assigns a scalar entropic value to each combined configuration–DOF point. It defines, directly or indirectly, the following structures:

geometry;

curvature;

collapse dynamics;

quantum-classical transition;

entanglement;

stability spectra.

Thus E(x, DOF) is the central mathematical object of Paper C-2. When no ambiguity arises, the shorter notation E(x) may be used for the configuration-dependent sector alone, but the full CUWF field is always understood as living on the hybrid domain $C \times M_{DOF}$.

M-0.2 Core Derivative and Operator Notation

1. Spatial Gradient

The spatial or configuration-space gradient of the entropic field is written as

$$\nabla E \equiv (\partial E/\partial x^1, \ldots, \partial E/\partial x^n).$$

This object measures the direction of steepest entropic variation in configuration space. In later sections, it becomes the basis for collapse-node trajectories and entropic drift.

2. Spatial Hessian (Curvature Matrix)

The second derivative structure of the entropic field is the Hessian matrix

$$H_{ij}(E) = \partial^2 E / (\partial x^i \, \partial x^j).$$

In CUWF, the Hessian is not merely a local curvature diagnostic. It becomes the foundation for the entropic metric, stability spectrum, and quantum-classical boundary. In Section M-1, $H_{ij}(E)$ will be promoted into the metric-generating structure of entropic geometry.

3. Configuration-Space Laplacian

The ordinary configuration-space Laplacian is written as

$$\nabla^2 E = \Sigma_i \, \partial^2 E / \partial (x^i)^2.$$

This operator appears as the classical baseline from which the entropic Laplacian Δ_E is generalized. In CUWF, $\nabla^2 E$ alone is insufficient because it does not incorporate the entropic metric, DOF-coupling, or nonlinear collapse structure.

4. DOF-Derivative

Derivatives along the internal degree-of-freedom manifold are written as

$$\partial E / \partial DOF_{\mathbf{a}}.$$

This derivative measures how the entropic field changes when internal modes vary while the configuration-space position is held fixed. Later, this expression generalizes to the DOF-manifold derivative

$$\nabla_{DOF} E,$$

which is used in Sections M-2 and M-3 to formulate DOF-driven contributions to the Master Operator and the variational action.

5. Path Parameter τ

CUWF uses a geometric rather than temporal path parameter:

τ : geometric evolution parameter.

Collapse-node trajectories are expressed as

$$x(\tau) : C \longrightarrow R.$$

Future Vector Deflection (FVD) appears in leading form as

$$dx/d\tau \propto -\nabla E.$$

The parameter τ should not be interpreted as physical clock time. It is the ordering parameter along entropic-geometric evolution. Physical time, when it appears, is treated as an emergent projection of collapse and entropic ordering.

M-0.3 Tensor and Metric Conventions

1. Entropic Metric g_E

The entropic metric g_E is defined formally in Section M-1, but its symbol set is established here. The general component form is written as

$$g_{E,ij}(x) = \phi(E, \nabla E, \text{DOF}).$$

In this expression, ϕ denotes the metric-generating rule determined by the local structure of the entropic field, its gradient, and its DOF-dependence. The inverse metric is denoted by

$$g_E^{ij}.$$

Throughout Paper C-2, we use the Einstein summation convention unless stated otherwise. Indices are raised and lowered by g_E and g_E^{-1}.

2. Entropic Curvature Tensor R_E

The entropic curvature tensor is denoted by

$$(R_E)^i{}_{jkl}.$$

It is derived from the entropic metric and higher-order derivatives of E(x). In later sections, R_E measures curvature generated by the entropic field itself rather than curvature imposed by an external spacetime manifold.

3. Entropic Laplacian Δ_E

The entropic Laplacian is written as

$$\Delta_E E = g_E^{ij} \nabla_i \nabla_j E.$$

This operator replaces the standard Laplacian in CUWF geometry. It incorporates the field-induced metric and therefore measures smoothing, diffusion, and curvature response in the entropic geometry rather than in ordinary Euclidean space.

M-0.4 Operator Conventions Used in CUWF

1. Master Operator

The CUWF Master Operator is written in its preliminary form as

$$\mathcal{E}\_E = \nabla^2 E - \alpha|\nabla E|^2 + \beta\, \partial E/\partial DOF.$$

This operator is central to the mathematical derivations of Paper C-2. Its full entropic-geometric form will be refined in Section M-2, where $\nabla^2 E$ is replaced or generalized by Δ_E and the nonlinear gradient and DOF terms are treated as fundamental contributions to CUWF dynamics.

2. Stabilization Operator C(Ψu)

The stabilization operator acts as a curvature-reinforcement term:

$$C(\Psi u) \sim -\gamma\nabla^2 E.$$

Its purpose is to represent the tendency of a collapse-state or wave-state Ψu to stabilize as entropic curvature deepens. In later sections, this operator helps connect collapse stability, coherence maintenance, and the emergence of classical behavior.

3. Interference Operator I(Ψu)

The interference operator controls coherence structure. It is suppressed when curvature deepens, meaning that strongly stabilized entropic regions reduce interference-like behavior:

$I(\Psi u) \longrightarrow$ suppressed as curvature deepens.

This convention prepares the later discussion of the quantum-classical boundary, where interference fades as the stability spectrum becomes dominated by curvature-stabilized modes.

4. Multi-Node Hamiltonian Components

For multi-node systems, CUWF introduces Hamiltonian-like components:

H_1, H_2 : self-curvature terms,

H_link : cross-curvature coupling term.

These objects are introduced fully in Section M-4. They allow CUWF to model entanglement geometry, multi-node correlation, and curvature inseparability across interacting collapse nodes.

M-0.5 Notational Conventions

1. Argument Formatting

The following argument conventions are used throughout Paper C-2:

E(x) = dependence only on spatial or configuration variables,

E(x, DOF) = full dependence on configuration and internal DOF variables.

When the context is clear, E may be written without explicit arguments. However, all full CUWF dynamics are understood to take place on the hybrid domain C × M_DOF.

2. Approximation Symbols

The following approximation and limiting symbols are used:

Symbol	Meaning
≈	leading-order expansion or approximate equality
∼	proportional to or scaling relation
⟶	geometric limit, reduction, or projection

3. Parenthetical Tensor Blocks

Multi-node curvature matrices are written in block form, for example

$[\, H_{11} \;\; H_{12} \,;\, H_{21} \;\; H_{22} \,]$.

Unless otherwise stated, such block matrices are treated as symmetric:

$$H_{12} = H_{21}^{T}.$$

This convention simplifies the presentation of multi-node entropic Hamiltonians and cross-curvature interactions in Section M-4.

M-0.6 Summary of Section Purpose

Section M-0 establishes the mathematical dictionary for the full CUWF formalization. It defines:

all domains;

all spaces;

all derivative operators;

all metric and curvature conventions;

tensor rules;

multi-node notation;

key CUWF-specific operators;

formatting rules for the entire Paper C-2.

With these conventions in place, Paper C-2 can proceed to the construction of entropic geometry in Section M-1. The definitions in M-0 are therefore not merely preliminary notation; they are the coordinate system of the mathematical language through which the rest of CUWF Mathematics Formalization v1.0 is expressed.