Section 3 — Collapse Wave Equation: Core CUWF PDE

In C-5, collapse evolution was described geometrically by the entropic geodesic equation:

$$\ddot{X}^I + \Gamma^I{}_j{}^K \dot{X}^j \dot{X}^K = 0$$

This equation describes a single trajectory on the entropic manifold $\mathcal{M}^E$. It gives the law of motion for one collapse path through configuration space, where the path is shaped by the connection induced from entanglement and the metric structure derived from stability.

C-6 generalizes this picture. Instead of following only one geodesic curve, the theory now follows a field of collapse configurations evolving together. This generalization produces the collapse wave equation: a PDE system describing how the full configuration field $X^I(\sigma, \tau)$ evolves over the entropic evolution parameter τ.

Here:

- τ is the entropic evolution variable, or collapse-time. It is analogous to time but is not identical to physical clock time.
- σ is an abstract label for initial conditions, configuration labels, streamlines, or coarse-grained DOF indices.

The goals of this section are to:

- derive the collapse wave equation from the geodesic law;
- promote the equation from an ODE to a field PDE;
- convert the second-order PDE into first-order flow form;
- clarify how free and boundary-constrained evolution modes affect the solution space.

3.1 Derivation from Geodesic Acceleration

Begin with the C-5 entropic geodesic:

$$\ddot{X}^I(\tau) + \Gamma^I{}_j{}^K(X(\tau), \tau)\, \dot{X}^j(\tau)\, \dot{X}^K(\tau) = 0$$

This equation contains three essential ingredients:

- $X^I(\tau)$: the configuration coordinates on $\mathcal{M}^E$;
- $\dot{X}^I = dX^I/d\tau$: the entropic velocity of collapse;
- $\Gamma^I{}_j{}^K(T, \Xi)$: the connection induced by the metric T and the entanglement tensor Ξ, as defined in C-5.

As long as the theory follows a single path, this is a second-order ordinary differential equation on the manifold. To upgrade it into a field equation, C-6 considers not one configuration curve, but a continuous family of collapse streamlines:

$$X^I = X^I(\sigma, \tau)$$

Here σ labels different streamlines of collapse: different initial conditions, different sectors, or different effective regions in configuration space. The τ-derivatives become field derivatives:

$$\dot{X}^I(\sigma, \tau) = \partial X^I/\partial\tau\ (\sigma, \tau)$$

$$\ddot{X}^I(\sigma, \tau) = \partial^2 X^I/\partial\tau^2\ (\sigma, \tau)$$

The geodesic equation therefore becomes:

$$\partial^2 X^I/\partial\tau^2 + \Gamma^I{}_j{}^K(X(\sigma, \tau), \tau)\, (\partial X^j/\partial\tau)(\partial X^K/\partial\tau) = 0$$

This is already a field equation in τ. However, CUWF requires more than free geodesic propagation. Collapse does not merely follow the unforced geometry. It also responds to the entropic potential, curvature feedback, and entanglement redistribution from the evolving fields T, Ξ, and $\mathcal{R}$.

For this reason, C-6 introduces a generalized effective force term F^I that gathers all non-geodesic contributions:

$$\ddot{X}^I + \Gamma^I{}_{jK}\, \dot{X}^j\, \dot{X}^K = F^I(T, \Xi, \mathcal{R}, \nabla E, \ldots)$$

Conceptually:

- part of F^I represents entropic gradient descent;
- part represents curvature-flow feedback;
- part represents entanglement-driven nonlocal adjustment.

This is the origin of the CUWF collapse wave equation.

3.2 CUWF Field Equation (Second-Order Form)

We now write the core CUWF field equation in explicit second-order form. Let $X^I(\sigma, \tau)$ be the collapse configuration field on $\mathcal{M}^E$. The collapse wave equation is:

$$\partial^2 X^I/\partial\tau^2 + \Gamma^I{}_{jK}(X, T, \Xi)\, (\partial X^j/\partial\tau)(\partial X^K/\partial\tau) = F^I(X, T, \Xi, \mathcal{R}, \nabla E, \nabla T, \nabla\Xi, \nabla\mathcal{R})$$

The equation separates into two sides with distinct meanings:

Side	Meaning
Left-hand side	Geodesic acceleration in the evolving geometry: metric structure from T and transport structure from Ξ.
Right-hand side	Effective entropic force, including gradient descent, curvature-flow corrections, entanglement redistribution, and possible damping or driving terms.

The effective force can be decomposed symbolically as:

$$F^I = F^I\_entropic + F^I\_curv + F^I\_ent$$

Component	Role
F^I_entropic $\sim - g^{IJ}\, \partial_j E(X)$	Drives collapse toward lower entropic potential and into basins.

F^I_curv($\mathcal{R}$, $\nabla\mathcal{R}$)	Adjusts motion due to evolving curvature and curvature-flow feedback.
F^I_ent(Ξ, $\nabla\Xi$)	Bends trajectories into or away from entanglement channels.

Geometrically, the geodesic term says: move straight according to the local geometry. The force term says: also descend through E, respond to curvature change, and obey entanglement structure.

Thus the second-order collapse wave equation has the form:

inertial term + geometric deflection = effective entropic force

3.3 First-Order Reformulation as Flow Map

For analysis and numerical simulation, it is often preferable to rewrite the second-order PDE as a first-order system. Introduce the phase-space field:

- Configuration field: $X^I(\sigma, \tau)$
- Velocity field: $V^I(\sigma, \tau) := \partial X^I/\partial\tau$

The collapse wave equation then splits into two coupled first-order relations.

1) Definition of velocity:

$$\partial X^I/\partial\tau = V^I$$

2) Evolution of velocity:

$$\partial V^I/\partial\tau = -\Gamma^I{}_{jK}(X, T, \Xi)\, V^j\, V^K + F^I(X, T, \Xi, \mathcal{R}, \nabla E, \ldots)$$

Together, these define the first-order flow map:

$$\partial/\partial\tau\ (X^I, V^I) = \mathcal{F}^I(X, V, T, \Xi, \mathcal{R}, \nabla E, \ldots)$$

This reformulation is important because it:

- converts second-order-in-τ dynamics into a standard first-order dynamical system in an extended state space;
- makes CUWF compatible with established dynamical-systems analysis and numerical integrators such as Runge-Kutta, implicit schemes, and adaptive solvers;
- aligns collapse dynamics with the concept of a vector field on a state manifold, where evolution follows flow lines.

Equivalently, define an extended collapse manifold $\tilde{M}$ with coordinates:

$$Y^A = (X^I, V^I) \in \tilde{M}$$

$$dY^A/d\tau = U^A(Y)$$

This is the foundational structure that C-7 will discretize and simulate.

3.4 Boundary vs Free Evolution Modes

The collapse wave equation can be applied in two qualitatively different regimes:

1) Free evolution: the manifold is effectively boundaryless, asymptotically open, or unconstrained over the relevant τ-range.
2) Boundary-constrained evolution: the solution is subject to conditions imposed on submanifolds, representing physical constraints, measurement-like interventions, or environmental clamping.

3.4.1 Free Evolution Mode

In free mode, $\mathcal{M}^E$ is treated as either boundaryless or sufficiently large that boundary effects can be ignored over the timescale considered. The initial-value problem is specified by:

$$X^I(\sigma, \tau_0) = X^I{}_0(\sigma)$$

$$V^I(\sigma, \tau_0) = V^I{}_0(\sigma)$$

The system is then integrated forward using the first-order flow system.

Interpretation:

- The sector evolves according to its intrinsic entropic geometry.
- Basins, bifurcations, and conifolds still occur, but they arise from internal geometry rather than external constraints.

This mode is appropriate for modeling:

- cosmological-scale evolution of CUWF;
- closed sectors of the universe where external intervention is negligible;
- asymptotic regimes far from measurement or constraint surfaces.

3.4.2 Boundary-Constrained Evolution Mode

In many physical contexts, evolution is not free. Some degrees of freedom may be fixed, some fluxes across a surface may be constrained, and some regions may behave as absorbing endpoints where collapse terminates or resets.

Boundary conditions may be imposed on $\partial\mathcal{M}^E$ or on embedded surfaces Σ:

Dirichlet-like boundary:

$$X^I|_{\partial\mathcal{M}^E} = X^I\_fixed$$

This represents constrained configurations, including measurement-imposed values or fixed sector states.

Neumann-like boundary:

$$n_j \nabla^j X^I|_{\partial\mathcal{M}^E} = J^I\_fixed$$

where n is the boundary normal. This represents fixed flux or prescribed flow across the boundary.

Absorbing or terminating boundary:

Once a trajectory reaches a specified region, evolution is halted, reset, or absorbed. This can model hard collapse events, irreversible constraints, or terminal basin capture.

In CUWF interpretation, boundary conditions can correspond to:

- measurement processes;
- environmental clamping of configurations;
- sector isolation where some DOFs no longer participate in entangled evolution.

Thus the same collapse wave equation can describe both an unconstrained cosmic manifold and a constrained subsystem where detectors, environmental walls, or boundary conditions reshape the accessible solution space.

The equation is the same; the solution space changes under boundary choice.

Section 3 Summary

This section established the core collapse PDE of C-6. It:

- promoted the C-5 geodesic law into a field equation for $X^I(\sigma, \tau)$;
- wrote the CUWF collapse wave equation in second-order form;
- converted the equation into a first-order flow system in (X, V), preparing it for dynamical analysis and numerical simulation;
- clarified free versus boundary-constrained evolution, showing how the same PDE can model both unconstrained cosmic sectors and constrained measurement- or environment-bound sectors.

The central equation is:

$$\partial^2 X^I/\partial\tau^2 + \Gamma^I_{jK} (\partial X^j/\partial\tau)(\partial X^K/\partial\tau) = F^I(X, T, \Xi, \mathcal{R}, \nabla E, \ldots)$$

Section 4 will now specify how curvature itself evolves under Ricci-like flow and how that curvature evolution feeds back into the collapse wave equation defined here.