The UIH Generator

Universal Information Hydrodynamics: A Metriplectic Framework

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Context: The Kinetic-Entropic Tension. Physics is currently modelled using two distinct mathematical languages. *Conservative* systems are described by symplectic geometry (Hamiltonians, commutators), which preserves information. *Dissipative* systems are described by metric geometry (gradient flows, diffusion), which erodes information. Standard models often treat dissipation as phenomenological "noise" rather than a fundamental property.

The Proposal. Universal Information Hydrodynamics (UIH) unifies these domains by treating them as coupled components of a single information geometry. The central object is the **Generator** K. We posit that the evolution of any physical system is governed by a canonical decomposition:

$$K = G + J$$

Canonical correspondence to open quantum systems:
If K acts on the density matrix ρ, it maps to a metriplectic split compatible with GKLS structure in an information geometry (quantum monotone; Fisher in the commutative limit):

Component	Operator role	Geometric definition
J (antisymmetric)	$-i[H, \rho]$	Symplectic (Hamiltonian) flow on entropy level sets
G (symmetric)	$\sum_k \left(L_k \rho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \rho\} \right)$	Gradient flow on an information metric (quantum monotone; Fisher in the commutative limit)

1. The Reversible Sector: J (Conservation)

J is the **symplectic** component of the generator. It represents the conservation of information.

- **Geometric flow:** J generates flow orthogonal to the gradient of entropy. It cycles the system through state space, preserving entropy and (in quantum settings) purity under unitary evolution.
- **Physical manifestation:** In quantum mechanics, this operator drives unitary evolution, responsible for interference, oscillation, and orbital stability.

2. The Irreversible Sector: G (Relaxation)

G is the **metric** component of the generator. Crucially, in UIH, dissipation is not arbitrary; it is defined as a gradient flow on the information manifold. Classically this is Fisher geometry on densities; quantum mechanically it is a monotone quantum information metric (e.g. BKM) on density operators.

- **Information-gradient flow:** G drives the system down the steepest descent of the free energy landscape defined on the statistical manifold.
- **The intrinsic clock:** G is positive semidefinite as a mobility (metric) form. As a dissipative generator acting on perturbations it is correspondingly non-positive, and the relaxation rates are given by $-\mathrm{spec}(G)$. This treats decay not as an environmental accident, but as a geometric property of the operator.

3. Theoretical Implications

Unifying these operators into a single metriplectic algebra (K) resolves specific paradoxes in foundational physics:

1. **The origin of linearity (Converse Madelung theorem):** Standard quantum mechanics assumes linearity. UIH derives it. Under the UIH axioms (local DN locality, probability conservation, Euclidean invariance and global $U(1)$, reversibility, convex regularity), demanding a reversible probability hydrodynamics ($G \to 0$) singles out the Fisher functional as the unique local convex curvature compatible with a pointwise gauge covariant complexifier and exact projective linearity. Linearity is thus forced by information geometry within this axiom class.
2. **Scalar corrections to gravity:** In the scalar Fisher halo model, the symmetric sector can be represented by a macroscopic susceptibility field σ_F sourced by baryonic structure through a screened Poisson type equation. The resulting extra acceleration can scale approximately as $1/r$ over an intermediate galactic range (equivalently a $\log r$ contribution to the potential), producing near-flat rotation curves without introducing a particulate dark matter component.