Information Pressure

Universal Information Hydrodynamics (UIH)
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Context: Why Classical Fluids Fail. In classical hydrodynamics, a density field $\rho(x,t)$ moves under forces that depend on *local* state variables such as pressure $p(\rho)$ and external potentials. This structure cannot produce genuinely quantum phenomena (interference, dispersion without viscosity, tunnelling) because it lacks an intrinsic curvature term: it knows nothing about how sharply ρ varies in space.

The Proposal. UIH introduces a universal internal force generated by **information curvature**. This force behaves like a pressure, but it is not thermodynamic. It is a geometric response to gradients in the probability density. In the reversible limit, it is exactly the **quantum potential**.

Minimal formulae (for orientation):

1. **Complexifier:** $\psi = \sqrt{\rho}\, e^{iS/\hbar}$
2. **Quantum potential:** $Q[\rho] = -\frac{\hbar^2}{2m}\frac{\Delta\sqrt{\rho}}{\sqrt{\rho}}$
3. **Information pressure force:** $f_Q = -\nabla Q$

1. What "Information Pressure" Means

The quantum potential $Q[\rho]$ is a *state dependent potential energy* generated purely by the **shape** of the density field. It is nonclassical because it depends on *second derivatives* of $\sqrt{\rho}$ rather than on ρ itself. As a result:

- It is **nonlocal in effect**: changing ρ in one region alters Q in a neighbourhood via curvature.
- It produces **dispersion without viscosity**: wave packets spread even when the flow is perfectly reversible.
- It enables **tunnelling**: in low density regions, curvature can dominate and effectively "pull" probability through barriers.

2. Why It is Fisher Geometry, Not an Ad Hoc Term

In UIH, "quantum behaviour" is not imposed. It is forced by information geometry.

A local probability hydrodynamics needs three ingredients: a density ρ, a phase or action field S, and a curvature functional that supplies the missing internal stress. If one demands that the dynamics admit a pointwise gauge covariant complexifier $\psi = \sqrt{\rho}e^{iS/\hbar}$ and remain exactly projectively linear in ψ, then the curvature functional is uniquely fixed (within the UIH axiom class) to be **Fisher information**. The quantum potential is the Euler-Lagrange force generated by that curvature.

In this sense, Q is the **information pressure** of the statistical manifold: it is the geometric stress that resists ρ from collapsing into singularities and supplies the correct reversible smoothing.

3. Physical Intuition

A helpful way to think about Q is as a **surface tension** term for probability. Regions where ρ has sharp edges or narrow filaments have high curvature cost. The resulting force pushes the flow away from extreme localisation, but does so in a way that still conserves probability and remains reversible.

Classical pressure depends on how much matter you have. Information pressure depends on how *structured* the distribution is.

4. What This Buys Us

Treating the quantum potential as information pressure makes several things immediate:

- **Universality:** the same curvature term appears wherever the state space is a probability manifold, not only in microscopic quantum mechanics.
- **A clean reversible limit:** set irreversible couplings to zero and you recover a conservative fluid with an intrinsic curvature stress, namely Q.
- **A direct bridge to modelling:** once you can compute ρ on a grid, you can compute Q and its force with no additional phenomenology. This makes UIH numerics modular: the geometry supplies the stress automatically.

5. One Sentence Summary

Information pressure is the Fisher curvature stress of a probability fluid, and in the reversible sector it is exactly the quantum potential that drives interference, dispersion and tunnelling behaviour.