

A Fluid Wave Medium with Reversible Phase Change: The Low-Friction Gel as a Candidate Constitutive Model for Folded Geometry, Living Membranes, and Water

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Abstract

Geometric descriptions of physical structure usually choose between two pictures. In one, the structure is a sheet: continuous and able to hold a crease, but rigid. In the other, it is a fluid: it carries waves, but has no memory of form. This paper proposes a third candidate, a fluid wave medium with a reversible phase change, modeled as a low-friction gel. Below a threshold the medium flows without significant drag. Above it, the medium stores elastic shear and holds a fold. A viscous fluid loses folds to dissipation, and an inviscid fluid cannot retain them at all. The low-friction gel is the simplest constitutive class we know of that can both propagate waves and preserve form.

We develop the proposal in three settings. First, as a constitutive model for folded geometry, where Riemannian description supplies the shape and the medium supplies the persistence. Second, in the folded dual membrane of living tissue, including the cortical sheet and the charged bilayer, where folding, resonance, and conduction are coupled. Third, in liquid water, whose transient hydrogen-bond network shows viscoelastic, gel-like response on picosecond timescales. This raises a direct question: how could short-lived structure underwrite the persistent folds the model requires?

We state the model's limits explicitly. Its equation of state at the vacuum has not been worked out. We also name the observations that would refute it. The full working-out appears in the author's book *From Gaia to Geometry*.

Key points

- **Lead claim.** The medium that carries the waves is best described as a fluid wave system with a reversible phase change. The simplest candidate is a low-friction gel.
 - **Why not a sheet or a fluid.** A sheet holds form but does not flow. A viscous fluid flows but loses its folds. An ideal fluid cannot retain a fold at all. The gel is the minimal class that does both.
 - **Geometry.** The Riemannian description gives the shape. The constitutive model explains why the shape persists. Shape and medium are separate claims.
 - **Biology.** Folded, charged dual membranes (cortex, bilayer, axon) are measured cases where form, resonance and conduction are coupled.
 - **Water.** Water's short-timescale viscoelastic response makes it the natural bench test. Whether transient structure can support persistent folds is a stated open question.
 - **Falsifiers.** (1) A fold persists only with bulk viscous loss. (2) No reversible phase boundary is found. (3) The model supplies no quantity that sets its threshold.
 - **Open at the vacuum.** No equation of state for empty space is claimed.
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1. Introduction: two pictures and their failure

Two images have long served geometric accounts of structure. The first is the sheet: a continuous surface draped over geometry, able to hold a crease, carry tension, and show curvature. The second is the fluid: a medium that carries waves, flows around obstacles, and adapts its shape to its boundaries.

Each image fails where the other succeeds. A sheet holds form but cannot flow; a global rigid sheet also imports structure the evidence does not require. A fluid flows, but in its two standard limits it cannot keep a fold. A viscous (Newtonian) fluid dissipates the shear that a fold represents; its swirls decay. An inviscid, irrotational fluid has no shear memory at all, so a fold is not something it can store.

The author's earlier work moved from the sheet to the fluid and then, on closer reading of the constitutive limits used in computational fluid dynamics, to the conclusion that the medium could not be an ordinary fluid. This paper states the

resulting candidate in its simplest form and asks what measurement would tell it apart from both pictures.

2. Established ground borrowed

The proposal borrows, and does not claim, the following results.

Fluids as carriers of effective geometry. Linearised perturbations of an irrotational, barotropic, inviscid fluid obey a wave equation formally identical to that of a massless scalar field on a curved Lorentzian metric built from the background flow [1]. The draining-bathtub flow gives this metric an ergosurface and an acoustic horizon [2]. Low-energy gravity, gauge fields and chiral fermions can emerge together near topological points of a quantum fluid, with the helium-3 phases as laboratory template [3]. These results show that a fluid can carry geometry. They do not show that a fluid can keep a fold, and the first of them assumes the inviscid, irrotational limit in which it cannot.

Torsion is not vorticity. In Einstein–Cartan gravity, torsion is sourced algebraically by intrinsic spin and does not propagate in the standard treatment [4]. Hydrodynamic vorticity is a different object. The proposal keeps them distinct.

Folding of a soft layered medium. A smooth fetal-brain geometry cast in layered gel, with an outer layer growing against a core, develops sulci and gyri with realistic spacing and placement [5]; tension-based accounts of cortical folding are an older companion hypothesis [6]. This is a laboratory gel, not the medium proposed here, but it shows that a soft medium storing elastic shear can make and hold persistent folds.

Membrane geometry sets function. Axonal membranes at rest take a periodic pearls-on-a-string shape governed by membrane mechanics, and that geometry sets conduction velocity [7]. Spiral and concentric traveling waves are reported across the folded human cortex [8].

Water is viscoelastic at short scales. Inelastic x-ray scattering shows liquid water departing from Newtonian behaviour in the terahertz range, with a viscoelastic response at nanometre wavelengths [9], and carrying transverse (shear) modes as well as longitudinal ones [10]. Its structure is well described as a transient two-state hydrogen-bond network whose local arrangements interconvert [11], with structural relaxation lengthening from picoseconds as the liquid is cooled [12].

3. The proposal: a fluid wave medium with reversible phase change

We propose that the medium carrying the waves is a fluid wave system with a reversible phase change, and that its simplest constitutive form is a low-friction gel. Its required properties are:

1. **Low friction below threshold.** Under weak or slow loading the medium flows with negligible bulk viscous loss, so waves propagate without being damped.
2. **Elastic shear storage above threshold.** Under sufficient deformation the medium crosses a reversible phase boundary and stores shear elastically, so a fold persists without continuous energy loss.
3. **Reversibility.** The crossing goes both ways. The medium can release a fold as well as hold one.

The low-friction condition is essential. A gel that holds its folds by drag is a viscous fluid by another name and inherits its failure. A “gel” in this paper never means a stiff, viscous, or ordinary laboratory gel.

Shape and persistence are separate claims. Riemannian geometry describes the shape: curvature, folding, the relation of one region to another. The constitutive model is a separate claim about why that shape lasts. Neither claim is used to support the other.

What a fold is here. A fold is a region of the medium on the far side of the phase boundary: locally gel-like, carrying stored shear, embedded in a medium that is elsewhere flowing. Whether such a region can hold its own boundary is the central open question of the model.

4. Three settings for test

4.1 Folded geometry

In geometric terms, the proposal predicts persistent curvature features whose lifetime is set by the phase boundary, not by a dissipation rate. A fold in a viscous medium decays on a viscous timescale. A fold in the proposed medium holds until the loading falls back below threshold, then relaxes. The distinguishing signature is a threshold, with hysteresis, rather than smooth exponential decay.

4.2 Living dual membranes

Living membranes are charged, folded, and resonant. The cortical sheet folds; the bilayer carries charge across two leaflets; the axonal membrane takes a periodic resting shape that sets conduction speed [7]. These are measured systems in which form, resonance and conduction are coupled, and in which soft-matter folding has already been modelled [5]. The proposal suggests a specific question for them: does any membrane fold show a reversible, threshold-type transition between a flowing state and a shape-holding state, with low dissipation on both sides? A reported spectroscopic signal near 71 THz in intact mitochondria [13] is noted only as a candidate site for such questions; it is a single-group, un-peer-reviewed preprint, and the quantum-state interpretation offered there is model-based.

4.3 Water

Water is where the proposal is easiest to probe and hardest to satisfy. Its shear memory exists, but lasts picoseconds across a few nanometres [9, 10, 12]. The folds this model needs last seconds or longer. The question is whether the two-state hydrogen-bond network [11], under confinement, at interfaces, or near a membrane, can extend gel-like shear storage far beyond its bulk timescale while staying low-friction. If it cannot, water is not a direct instance of the medium. If it can, water becomes the natural bench test.

5. Falsifiers

The proposal fails if any of the following holds:

1. **A fold persists only with bulk viscous loss.** If holding a fold in any candidate system is shown to require continuous dissipation, the medium collapses back into the viscous fluid.
2. **No reversible phase boundary is found.** If no candidate medium can store elastic shear and cross back reversibly, it collapses back into the inviscid fluid that cannot remember a fold.
3. **No threshold quantity.** If the model cannot name a measurable quantity that sets the threshold between flowing and holding, it does no work beyond the two pictures it replaces.

6. Limits and open questions

- **The vacuum.** The model's equation of state for empty space has not been worked out. No claim about the vacuum is made here.

- **Earth-based media.** Any medium we can measure, water and laboratory gels included, has a floor beneath it by construction. Naming a further earth-based medium does not reach the medium the model needs. Earth-based cases are offered as tests of the constitutive class, not as the thing itself.
- **Scale.** The gap between water's picosecond shear memory and the lifetime of persistent folds is the largest single unknown.
- **Gravitation.** The model does not yet say which quantity would play the role of mass, or whether it would reproduce the observed light deflection. It is not offered as a theory of gravity.

7. Conclusion

A sheet holds form and cannot flow. A fluid flows and cannot hold form. The low-friction gel with reversible phase change is the simplest medium we can name that does both. It is offered as a candidate constitutive model, with its shape claims and persistence claims kept apart, three settings for test, and three ways to be shown wrong. The full development, including the theoretical history that led to it, appears in the author's book *From Gaia to Geometry* [14].

Statement on AI use

This work was researched, edited and organized with the help of an engineered-intelligence system (an AI language model). The system helped with literature search, drafting, reference checking and cross-checking against the author's manuscript. The theory, its claims and responsibility for the text belong to the author. No AI system is listed as an author.

Competing interests

None declared.

Data availability

No new data were generated. The full manuscript is freely readable at theparallaxidentity.com.

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