General Fluid Field Theory

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Abstract

Using the Navier-Stokes equations to describe a general fluid field (a medium) which naturally embeds electromagnetism within it, we then formulate gravity by postulating a space fluid which gives an accurate equation for Newton's gravitational constant as a function of the critical density of space. Finally we quantize the space fluid and resolve the black hole singularity to a core radius of the Compton wavelength and give a general explanation to dark energy and dark matter.

Introduction

The field equations for a general fluid field (a medium) are,

$$\nabla \cdot \mathbf{V} = Q(\mathbf{x}, t) \tag{1}$$

$$\nabla \cdot \mathbf{W} = 0 \tag{2}$$

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla\Phi + \mathbf{S} + \frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t), \tag{3}$$

$$\frac{\partial \mathbf{W}}{\partial t} = \nabla \times \mathbf{S} + \frac{1}{\rho}\nabla \times (\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t)), \tag{4}$$

The general fluid field is characterized by its velocity $\mathbf{V}$, it's vorticity $\mathbf{W} = \nabla \times \mathbf{V}$, it's spin $\mathbf{S} = \mathbf{V} \times \mathbf{W}$, and it's stress tensor $\tau(\mathbf{x}, t)$ The energy field Φ represents the fluid's combined potential of the pressure, kinetic energy and other term's that may arise.[1]

[1] For the derivation please refer to the appendix section: *Derivatiton Of The General Fluid Field Equations*

The Material's Properties

The equations of motion of the medium are described by the nature of the medium, the medium's physical nature is the key factor in determining the nature of motion. The two determining factors of physical properties of the material depend upon its stress and its density.

The Density ρ

The density ρ of the medium can vary in both space and time. It is a function governed by the interplay of internal flow, volumetric expansion or compression, and any sources or sinks of mass. The evolution of density in a non-homogeneous medium is governed by the continuity equation[2],

$$\frac{\partial \rho}{\partial t} = -\mathbf{V} \cdot \nabla \rho - \rho\, Q(\mathbf{x}, t) + m_s(\mathbf{x}, t),$$

where:

- $\mathbf{V}$ is the velocity field,
- $Q(\mathbf{x}, t) = \nabla \cdot \mathbf{V}$ is the divergence of the velocity field (a measure of local expansion or compression),
- $m_s(\mathbf{x}, t)$ is a mass source or sink term (e.g., due to chemical reactions, phase changes, or external injection).

Analysis as $t \to \infty$

To understand the long-term behavior of the medium, we take the limit as time approaches infinity:

$$\lim_{t \to \infty} \frac{\partial \rho}{\partial t} = \lim_{t \to \infty} \left(-\mathbf{V} \cdot \nabla \rho - \rho\, Q(\mathbf{x}, t) + m_s(\mathbf{x}, t) \right),$$

this gives the steady-state condition:

$$0 = -\mathbf{V} \cdot \nabla \rho - \rho\, Q(\mathbf{x}, t) + m_s(\mathbf{x}, t),$$

this equation indicates that, for the density to become time-invariant (steady), the combined effect of convective transport ($\mathbf{V} \cdot \nabla \rho$), compressibility ($\rho\, Q$), and mass source ($m_s$) must perfectly balance. Therefore In the absence of sources ($m_s = 0$), the density will decrease in expanding regions ($Q > 0$) and increase in compressing regions ($Q < 0$), unless balanced by spatial gradients in ρ itself. Over long times, the system evolves toward a configuration where internal redistribution of mass is offset by geometry and flow divergence. Finally,

[2] L.D. Landau and E.M. Lifshitz, *Fluid Mechanics*, 2nd ed., Butterworth-Heinemann (1987), §2. See also P.K. Kundu, I.M. Cohen, and D.R. Dowling, *Fluid Mechanics*, 6th ed., Academic Press (2015), Chapter 4.

we conclude that non-static (non-equilibrium) mediums will tend to either *dilute* or *compress* indefinitely—unless the mass input or output compensates for the velocity-driven redistribution:

$$\mathbf{V} \cdot \nabla \rho + \rho Q(\mathbf{x}, t) = m_s(\mathbf{x}, t),$$

this sets the constraint for steady-state density in open, dynamic systems.

The Stress τ

The stress τ encodes the ability of momentum to diffuse through the fluid medium. It is described by the stress tensor $\boldsymbol{\tau}$ and thus to the internal dynamics of the medium. The type's of stress can either be homogeneous - by which stress is distributed evenly - or non-homogeneous - by which stress is not distributed evenly.

A homogeneous fluid medium

A homogeneous fluid medium is one in which the medium's parameters - such as density ρ, viscosity μ, and the compressibility (the bulk modulus λ) - do not vary with position. That is,

$$\nabla \rho = \nabla \mu = \nabla \lambda = 0,$$

this assumption simplifies the dynamics. First we express the evolution of the velocity field as:

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla \Phi + \mathbf{S} + \frac{1}{\rho} \nabla \cdot \boldsymbol{\tau}.$$

For a Newtonian fluid, the stress tensor takes the form,

$$\boldsymbol{\tau} = \mu \left(\nabla \mathbf{V} + (\nabla \mathbf{V})^T \right) + \lambda(Q(\mathbf{x}, t))\mathbf{I}.$$

In a homogeneous Newtonian fluid, because all spatial gradients of medium coefficients vanish, then when taking the divergence of $\boldsymbol{\tau}$, only the derivatives of the velocity field remain, yielding:

$$\nabla \cdot \boldsymbol{\tau} = \mu \nabla^2 \mathbf{V} + (\lambda + \mu) \nabla (Q(\mathbf{x}, t)),$$

this expresses two key mechanisms of viscous interaction:

- Shear diffusion from $\nabla^2 \mathbf{V}$, which smooths out transverse velocity gradients.
- Compression from $\nabla Q(\mathbf{x}, t)$ smooths out volume changes.

Resolving the compression from the source term inside the potential, the equation becomes:

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla \Phi + \mathbf{S} + \nu \nabla^2 \mathbf{V},$$

where:

- The shear viscosity is $\nu = \frac{\mu}{\rho}$.
- The bulk viscosity is $\frac{\lambda+\mu}{\rho}$.

The internal forces that arise from gradients in motion are purely a consequence of deformation, the fluid dynamics arise purely from interactions between momentum, vorticity, and pressure-like effects—not from any position-dependent medium variations.

A non-homogeneous fluid medium

In contrast to a homogeneous fluid medium, a *non-homogeneous* fluid medium is specially dependent, this spatial dependence must be accounted for in the evolution of the velocity field. The general medium equation is,

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla\Phi + \mathbf{S} + \frac{1}{\rho(\mathbf{x},t)}\nabla \cdot \boldsymbol{\tau}(\mathbf{x},t),$$

here, the viscous stress tensor $\boldsymbol{\tau}$ may now depend on position, not only through gradients of velocity, but also through spatially varying viscosity:

$$\boldsymbol{\tau} = \mu(\mathbf{x})\left(\nabla\mathbf{V} + (\nabla\mathbf{V})^T\right) + \lambda(\mathbf{x})(Q(\mathbf{x},t))\mathbf{I},$$

this introduces additional complexity into the dynamics. Notably, when taking the divergence of $\boldsymbol{\tau}$, the spatial derivatives will now act on both the velocity gradients and the variable coefficients:

$$\nabla \cdot \boldsymbol{\tau} = \nabla\mu(\mathbf{x}) \cdot \left(\nabla\mathbf{V} + (\nabla\mathbf{V})^T\right) + \mu(\mathbf{x})\nabla^2\mathbf{V} + \nabla\left[\lambda(\mathbf{x})(Q(\mathbf{x},t))\right].$$

This introduces terms representing the medium's inhomogeneities.

The Electromagnetic Phenomena

Maxwell originally viewed electric and magnetic fields not as abstract entities but as real stresses and motions in a continuous fluid-like ether.[3] Though the ether concept was abandoned, fluid field theory generalizes this by treating electromagnetic fields as emergent features of any fluid's internal stresses, velocities, vorticities, and compression. Thus, whether in quantum fluids, plasmas, or the relativistic space-fluid underlying gravity, electromagnetism appears as a mechanical response of the fluid, restoring Maxwell's fields as real descriptors of fluid motion and structure.

[3] J. C. Maxwell, "On Physical Lines of Force," *Philosophical Magazine*, vol. 21, 1861, pp. 161–175, 281–291.

Describing Electromagnetism

Electromagnetism emerges naturally from fluid dynamics when interpreted through the velocity field $\mathbf{V}(\mathbf{x}, t)$ and scalar potential $\Phi(\mathbf{x}, t)$ of a compressible, vortical medium. In this interpretation, the speed of propagation c, the permittivity ε_0, and the permeability μ_0 all arise from intrinsic fluid properties. We define the electric and magnetic fields as:

$$\mathbf{E} := -\frac{\partial \mathbf{V}}{\partial t} - \nabla\Phi, \qquad \mathbf{B} := \mathbf{W} = \nabla \times \mathbf{V}.$$

These expressions reveal that:

- The magnetic field $\mathbf{B}$ corresponds to the fluid's vorticity $\mathbf{W}$.
- The electric field $\mathbf{E}$ represents the local acceleration of the fluid and gradient of the potential.

Starting from the fundamental relations which can be derived from the explicit definitions of the electromagnetic vector fields,

$$\nabla \cdot \mathbf{B} = 0, \tag{5}$$

$$\nabla \cdot \mathbf{E} = \frac{\partial Q(\mathbf{x}, t)}{\partial t} - \nabla^2\Phi, \tag{6}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \tag{7}$$

$$\nabla \times \mathbf{B} = \nabla Q(\mathbf{x}, t) - \nabla^2\mathbf{V}, \tag{8}$$

Before deriving Maxwell's equations, we impose the Lorenz gauge condition,

$$\nabla \cdot \mathbf{V} = Q(\mathbf{x}, t) = -\frac{1}{c^2}\frac{\partial \Phi}{\partial t},$$

Which relates the divergence of the fluid velocity to the scalar potential's time derivative[4]. We now examine how Maxwell's equations naturally emerge from this framework.

Gauss's Law

Using the Lorenz gauge:

$$\frac{\partial Q}{\partial t} = -\frac{1}{c^2}\frac{\partial^2 \Phi}{\partial t^2},$$

We obtain:

$$\nabla \cdot \mathbf{E} = \frac{1}{c^2}\frac{\partial^2 \Phi}{\partial t^2} - \nabla^2\Phi.$$

In the static or quasi-static limit, $\partial_t^2\Phi \approx 0$, and we recover the Poisson equation:

$$\nabla^2\Phi = -\frac{\rho_q}{\varepsilon_0} \quad \Rightarrow \quad \nabla \cdot \mathbf{E} = \frac{\rho_q}{\varepsilon_0}.$$

[4] For a detailed derivation of the potential under the Lorenz gauge refer to the appendix section *The Potential Under The Lorenz Gauge*

Faraday's Law

From the definitions of $\mathbf{E}$ and $\mathbf{B}$, it directly follows that

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}.$$

Ampère-Maxwell Law

Starting from the curl of $\mathbf{B}$,

$$\nabla \times \mathbf{B} = \nabla Q - \nabla^2 \mathbf{V} = -\frac{1}{c^2}\nabla\frac{\partial \Phi}{\partial t} - \nabla^2 \mathbf{V},$$

And noting the time derivative of the electric field,

$$\frac{\partial \mathbf{E}}{\partial t} = -\frac{\partial}{\partial t}\nabla\Phi - \frac{\partial^2 \mathbf{V}}{\partial t^2},$$

We combine these to obtain

$$\nabla \times \mathbf{B} = \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t} - \Box \mathbf{V},$$

Where $\Box = \nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ is the d'Alembertian operator. Assuming the wave equation for the fluid velocity,

$$\Box \mathbf{V} = -\mu_0 \mathbf{J},$$

We recover the Ampère-Maxwell law,

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t}.$$

The Gravitational Phenomenon

The gravitational phenomenon is described as an emergent property of space. Analogies have been made to derive gravity using fluid mechanics[5]. By refining the approach within the context of general fluid field theory we can achieve new insights into how the gravitational phenomenon is emergent from the property of space by treating space as a fluid.

Newton's Gravitational Constant

Consider an inviscid fluid filling space with velocity field $\mathbf{V}(\mathbf{x}, t)$ and $\Phi(\mathbf{x}, t)$ is the scalar potential with the initial condition of $|\mathbf{V}| = 0$ at $t = 0$,

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla\Phi \quad \text{where} \quad \Phi = \frac{p}{\rho}$$

[5] T. Jacobson, "Thermodynamics of Spacetime: The Einstein Equation of State," *Phys. Rev. Lett.* **75**, 1260–1263 (1995).

Derivation of the Governing Equation

Taking the divergence of both sides gives,

$$\nabla \cdot \frac{\partial \mathbf{V}}{\partial t} = -\nabla \cdot \nabla \Phi = -\nabla^2 \Phi,$$

assuming the fluid fields are sufficiently smooth so that spatial and temporal derivatives commute, we have,

$$\frac{\partial}{\partial t}(\nabla \cdot \mathbf{V}) = -\nabla^2 \Phi,$$

defining the source term $Q(\mathbf{x}, t)$ as the divergence of velocity,

$$\nabla \cdot \mathbf{V} = Q(\mathbf{x}, t),$$

we obtain the dynamic relation,

$$\frac{\partial Q}{\partial t} = -\nabla^2 \Phi.$$

Weakly Compressible Fluid Approximation

For a weakly compressible fluid, pressure and density relate approximately linearly by,

$$p = \frac{1}{\epsilon} \rho,$$

where ϵ is the fluid's bulk compressibility, a small positive parameter. Assuming the sources Q represent mass distributions localized at points $\mathbf{x}_i$, we write

$$Q(\mathbf{x}, t) = \sum_i m_i(t) \delta^3(\mathbf{x} - \mathbf{x}_i),$$

where δ^3 denotes the three-dimensional Dirac delta function.

Quasi-Static Limit and Poisson Equation

In the quasi-static (steady-state) limit, time variations vanish:

$$\frac{\partial Q}{\partial t} \approx 0,$$

so the governing equation reduces to

$$\nabla^2 \Phi = -\frac{Q(\mathbf{x})}{\epsilon},$$

where ϵ is the bulk compressibility of the space-fluid. The potential equation when rewritten using the source definition becomes,

$$\nabla^2 \Phi = -\frac{1}{\epsilon} \sum_i m_i \delta^3(\mathbf{x} - \mathbf{x}_i).$$

Comparing with Newton's gravitational Poisson equation,

$$\nabla^2\Phi = -4\pi G \sum_i m_i \delta^3(\mathbf{x} - \mathbf{x}_i),$$

We identify

$$G = \frac{1}{4\pi\epsilon}.$$

Relation to Fluid Density and Propagation Speed

Expressing G in terms of fluid density ρ and propagation speed c_s, we write

$$G = \frac{\rho c_s^2}{4\pi} \quad \Rightarrow \quad \rho = \frac{4\pi G}{c_s^2}.$$

Using $c_s = c$ (the speed of light) and the known value of G, this gives an estimate for the fluid density

$$\rho = 9.3 \times 10^{-27}\,\mathrm{kg\,m^{-3}},$$

which is the critical density of the universe. This connection suggests gravity emerges naturally from fluid properties such as compressibility and density, reinforcing the fluid-based interpretation of gravitational phenomena. The resultant gravitational constant is now spatially dependent.

General Relativity

General relativity can be derived from fluid dynamics by promoting the acceleration equation of the compressible space-fluid.

Newtonian Gravity

In the large-scale, weakly viscous limit, viscous and quantum stresses are negligible:

$$\frac{\delta \mathbf{V}}{\delta t} \approx -\nabla\Phi.$$

This form mirrors Newton's second law under a gravitational potential. Now assume spacetime itself is a fluid-like continuum, where motion through curved space corresponds to inertial motion in a non-Euclidean geometry. Define the spatial metric as a perturbation of flat space:

$$g_{ij} = \left(1 + \frac{2\Phi}{c^2}\right)\delta_{ij}.$$

This choice leads to geodesic motion governed by

$$\frac{d^2x^i}{dt^2} + \Gamma^i_{jk}\frac{dx^j}{dt}\frac{dx^k}{dt} = 0,$$

where Γ^i_{jk} are the Christoffel symbols derived from the metric g_{ij}. This matches the fluid equation of motion, showing that geodesic motion in curved space emerges from fluid acceleration under a potential flow.

Stress-Energy and Einstein Equations

Next, consider the stress-energy tensor of the fluid:

$$T^{\mu\nu} = (\rho + p)u^\mu u^\nu + pg^{\mu\nu} + \tau^{\mu\nu}.$$

In the absence of significant viscous stress, this reduces to:

$$T^{\mu\nu} = (p + \rho)u^\mu u^\nu + pg^{\mu\nu}.$$

Thus, large-scale gravitational curvature emerges from a fluid, matching the Newtonian limit.

Determining the Viscous Stress Tensor

Gravitation may be observed without viscosity, as it is already present within the pressure generated by mass. However, in cases where viscosity is significant, the dynamics can still be promoted to four-dimensional spacetime. We begin with the generalized fluid acceleration equation, neglecting the potential and spin terms for clarity:

$$\frac{\partial \mathbf{V}}{\partial t} = \frac{1}{\rho(\mathbf{x}, t)} \nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t).$$

The viscous stress tensor for a non-uniform space-fluid is expressed as:

$$\boldsymbol{\tau} = \mu(\mathbf{x}) \left(\nabla \mathbf{V} + (\nabla \mathbf{V})^T \right) + \lambda(\mathbf{x})(\nabla \cdot \mathbf{V})\mathbf{I},$$

whose divergence yields:

$$\nabla \cdot \boldsymbol{\tau} = (\nabla \mu(\mathbf{x})) \cdot \left(\nabla \mathbf{V} + (\nabla \mathbf{V})^T \right) + \mu \nabla^2 \mathbf{V} + \nabla \left[\lambda(\mathbf{x}) Q(\mathbf{x}, t) \right].$$

This shows that gradients in viscosity and compressibility contribute dynamically to acceleration—analogous to how internal stress influences curvature in relativistic theories[6]. Following the general relativistic approach, we promote the 3-velocity $\mathbf{V}$ to a 4-velocity u^μ, with normalization $u^\mu u_\mu = -c^2$. The stress-energy tensor becomes:

$$T^{\mu\nu} = \rho u^\mu u^\nu + (p + \lambda Q)\, g^{\mu\nu} + \Pi^{\mu\nu},$$

where the viscous stress correction, following the Israel–Stewart formalism, is:

$$\Pi^{\mu\nu} = \mu(\mathbf{x}) \left(\nabla^\mu u^\nu + \nabla^\nu u^\mu - \frac{2}{3} g^{\mu\nu} \nabla_\lambda u^\lambda \right) + \lambda(\mathbf{x}) g^{\mu\nu} \nabla_\lambda u^\lambda.$$

Assuming covariant conservation, $\nabla_\nu T^{\mu\nu} = 0$, we derive the geodesic equation:

$$u^\nu \nabla_\nu u^\mu = 0.$$

[6] W. Israel and J.M. Stewart, "Transient relativistic thermodynamics and kinetic theory. II," *Proceedings of the Royal Society A* **365** (1979): 43–52.

Thus, the effective flow of the fluid follows geodesics determined by its own internal stress-energy structure. The curvature of spacetime arises naturally from gradients in stress and energy within the space-fluid, in agreement with the causal relativistic fluid model introduced by Israel and Stewart. Which naturally reproduces the Einstein field equations with a stress-energy source derived from internal fluid dynamics.

The Quantum Mechanics

General fluid field theory proposes a unified description of spacetime as a continuous, dynamical fluid, whose internal stresses give rise simultaneously to the electromagnetic and gravitational phenomena. This framework extends the hydrodynamic interpretation of quantum mechanics by embedding it within the fluid, hence equivalently quantizing the fluid, rather than space itself.

The Quantum Stress Tensor

On microscopic scales, spatial fluctuations in $\rho(\mathbf{x}, t)$ generate internal stresses corresponding to a quantum pressure. These fluctuations yield the effective Bohm potential:

$$\Phi_q = -\frac{\hbar^2}{2m^2} \frac{\nabla^2 \sqrt{\rho}}{\sqrt{\rho}},$$

which governs quantum dynamics in the hydrodynamic (Madelung) interpretation. Crucially, this quantum potential arises as the divergence of a symmetric, traceless quantum stress tensor[7]:

$$\boldsymbol{\tau}^{\mu\nu}_{\text{quantum}} = -\frac{\hbar^2}{4m^2} \left[\nabla^\mu \left(\frac{\nabla^\nu \rho}{\rho} \right) + \nabla^\nu \left(\frac{\nabla^\mu \rho}{\rho} \right) - g^{\mu\nu} \nabla_\lambda \left(\frac{\nabla^\lambda \rho}{\rho} \right) \right].$$

This tensor encodes the curvature of the fluid density field and represents an internal, coherent stress structure that resists compression in analogy with elastic or entropic forces.

The total internal stress tensor of the space-fluid combines quantum and classical (viscous) components:

$$\boldsymbol{\tau} = \boldsymbol{\tau}_{\text{quantum}} + \boldsymbol{\tau}_{\text{viscous}}.$$

Where,

- $\boldsymbol{\tau}_{\text{quantum}}$ governs short-range, coherent, non-dissipative quantum effects.
- $\boldsymbol{\tau}_{\text{viscous}}$ governs long-range, macroscopic, dissipative stress, including gravitational phenomena.

In this view, the fluid field mechanics arises as the sum of the internal and external fluid's stress dynamics.

[7] First introduced in this form by E. Madelung (1927), and later developed by T. Takabayasi (1952) in the context of quantum hydrodynamics.

Microscopic Origin of Viscosity

At the microscopic (quantum) scale, the space-fluid acts as an ideal, non-dissipative material with no entropy production, governed by the unitary Schrödinger equation. Thus, microscopic viscosities vanish:

$$\mu_{\text{micro}} \to 0, \quad \lambda_{\text{micro}} \to 0,$$

Reflecting the absence of internal friction in coherent quantum systems.[8] On macroscopic scales, coarse-graining over quantum degrees of freedom leads to effective dissipation due to decoherence, entanglement scrambling, vortex interactions, and inhomogeneities. This emergent viscosity behaves like classical fluids and can be approximated by kinetic theory:

$$\mu_{\text{macro}} = \frac{1}{3} \rho \, v_{\text{th}} \, \ell,$$

where ρ is the space-fluid density, v_{th} the thermal or fluctuation velocity, and ℓ the mean free path between interactions. Using the quantum relation $\ell = v_q \tau_{\text{quantum}}$ with $v_q \sim c$, this yields:

$$\mu_{\text{macro}} = \frac{1}{3} \rho \, c^2 \, t_{\text{quantum}},$$

where the quantum relaxation time is

$$t_{\text{quantum}} = \frac{\hbar}{\Delta E}.$$

Bulk viscosity arises similarly from compressive stresses driven by the velocity divergence $Q(\mathbf{x}, t) = \nabla \cdot \mathbf{V}$:

$$\lambda_{\text{macro}} = \gamma \mu_{\text{macro}} = \gamma \frac{\hbar \rho \, c^2}{3 \Delta E},$$

with γ as an effective bulk response coefficient.

Reduction to Madelung Quantum Hydrodynamics

In the limit of negligible classical viscosity and absence of spin,

$$\mu \to 0, \quad \lambda \to 0, \quad \mathbf{S} \to 0,$$

The fluid dynamics reduce to,

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla \Phi + \frac{1}{\rho} \nabla \cdot \boldsymbol{\tau}_{\text{quantum}},$$

[8] See, e.g., Landau and Lifshitz, *Fluid Mechanics*, 2nd ed. (Pergamon Press, 1987); Ziman, *Electrons and Phonons*, Oxford University Press (1960); Kovtun, Son, and Starinets, Phys. Rev. Lett. 94, 111601 (2005).

which governs the evolution of the velocity field under internal quantum stress. The velocity can be written as $\mathbf{V} = \nabla S/m$, with S the quantum phase. In this case, the stress tensor becomes:

$$\frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}_{\text{quantum}} = -\nabla \Phi_q,$$

leading to:

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla(\Phi + \Phi_q),$$

which corresponds to the Madelung quantum Euler equation[9], and is equivalent to the Schrödinger equation for a spinless particle.

Resolving The Black Hole Singularity

A central question in the quantum-gravitational collapse of a massive object (such as a black hole) is:

> *At what core radius r_c does quantum stress balance the inward pull of gravity, thereby preventing singularity formation?*

Quantum and Gravitational Stresses

Within the general fluid field theory framework, spacetime is a quantum viscous space-fluid whose internal stresses govern collapse dynamics. Two dominant stresses near the core are:

- **Quantum stress**[10] (arising from density gradients and quantum coherence):

  $$\tau_{\text{quantum}} \sim \frac{\hbar^2}{m^2 r_c^4},$$

  where m is the effective mass of the fundamental quantum constituents of the space-fluid.

- **Gravitational stress**[11] (due to self-compression energy density):

  $$\tau_{\text{grav}} \sim \frac{GM^2}{r_c^4},$$

  where M is the total mass of the collapsing object.

[9] E. Madelung, "Quantentheorie in hydrodynamischer Form," *Z. Phys.* **40**, 322–326 (1927).

[10] See Appendix: *Estimating The Quantum Stress Tensor*

[11] See Appendix: *Estimating The Gravitational Stress Tensor*

Both stresses scale as inverse r_c^4, reflecting their dependence on spatial curvature and density gradients. The equilibrium condition at the core radius r_c is:

$$\tau_{\text{quantum}} \approx \tau_{\text{grav}} \quad \Rightarrow \quad \frac{\hbar^2}{m^2 r_c^4} \sim \frac{GM^2}{r_c^4}.$$

Canceling r_c^4 on both sides gives the fundamental mass relation:

$$\frac{\hbar^2}{m^2} \sim GM^2 \quad \Rightarrow \quad Mm \sim \frac{\hbar c}{G} = M_{\text{Pl}}^2,$$

where

$$M_{\text{Pl}} = \sqrt{\frac{\hbar c}{G}}$$

is the Planck mass in SI units.

Physical Interpretation of the Mass Duality

The relation

$$Mm \sim M_{\text{Pl}}^2$$

establishes a duality between the black hole mass M and the constituent quantum mass m of the space-fluid:

- For **large black holes** with $M \gg M_{\text{Pl}}$, the effective constituent mass is

$$m \sim \frac{M_{\text{Pl}}^2}{M} \ll M_{\text{Pl}},$$

  indicating the space-fluid is composed of ultra-light degrees of freedom.

- For **Planck-scale black holes** with $M \sim M_{\text{Pl}}$, the constituent mass is Planckian, reflecting a discrete quantum structure of spacetime.

This scaling suggests an emergent holographic-like behavior in which the microphysics of spacetime softens as the macroscopic black hole mass grows, consistent with insights from quantum gravity and black hole thermodynamics[12].

Deriving the Core Radius r_c

The previous stress balance cancels the core radius r_c, so to determine its value, we incorporate quantum localization and the uncertainty principle. Consider the uncertainty principle for localizing mass M inside radius r_c:

$$\Delta x \sim r_c \implies \Delta p \sim \frac{\hbar}{r_c}.$$

[12] J. Maldacena, "The Large N Limit of Superconformal Field Theories and Supergravity," *Int. J. Theor. Phys.* **38**, 1113–1133 (1999), arXiv:hep-th/9711200.

The associated quantum pressure (stress) is:

$$\tau_q \sim \frac{(\Delta p)^2}{m} \cdot \frac{1}{r_c^3} \sim \frac{\hbar^2}{m r_c^5}.$$

Equating this refined quantum stress to the gravitational stress,

$$\tau_q \sim \tau_{\text{grav}} \quad \Rightarrow \quad \frac{\hbar^2}{m r_c^5} \sim \frac{GM^2}{r_c^4} \quad \Rightarrow \quad r_c \sim \frac{\hbar^2}{GM^2 m}.$$

Using the mass duality $m = \frac{M_{\text{Pl}}^2}{M}$, substitute into r_c:

$$r_c \sim \frac{\hbar^2}{GM^2} \cdot \frac{M}{M_{\text{Pl}}^2} = \frac{\hbar^2}{GM M_{\text{Pl}}^2}.$$

Recall $M_{\text{Pl}}^2 = \frac{\hbar c}{G}$, so:

$$r_c \sim \frac{\hbar^2}{GM} \cdot \frac{G}{\hbar c} = \frac{\hbar}{Mc}.$$

The core radius,

$$r_c \sim \frac{\hbar}{Mc},$$

is precisely the Compton wavelength of the mass M. This means:

- Quantum uncertainty enforces a minimum length scale for localization of mass M.
- Collapse halts when the black hole compresses within its own Compton wavelength, preventing infinite density and curvature.
- The classical singularity is replaced by a finite-size, quantum-coherent core.

The combined quantum-gravitational stress balance yields:

$$\begin{cases} Mm \sim M_{\text{Pl}}^2, \\ r_c \sim \dfrac{\hbar}{Mc}, \end{cases}$$

which establishes a fundamental duality and cutoff scale in the general fluid field theory framework.

The Dark Forces

We will analyze the dark forces within the framework of general fluid field theory.

Dark Energy

Consider the space fluid on the scale of the whole universe, focusing on the simple static case:

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla\Phi = -\frac{1}{\rho}\nabla(p + E_k),$$

where ρ is the space fluid's density, p its pressure, and E_k its kinetic energy. The kinetic energy E_k will be neglected in this analysis. Assuming an equation of state for the pressure[13],

$$p = w\rho c^2, \quad w = -1,$$

characteristic of dark energy, the acceleration due to the pressure gradient scales as

$$-\frac{1}{\rho}\nabla p \sim -\frac{1}{\rho}\frac{\Delta p}{L} = \frac{|w|c^2}{L},$$

where L is the cosmic horizon scale and c is the speed of light. This provides a natural fluid-dynamic origin for the observed cosmic acceleration $a_\Lambda \approx c^2/L$, consistent with the cosmological constant Λ in the Friedmann equations. Hence, dark energy can be understood as the collective space fluid's innate pressure.

Dark Matter

In the fluid dynamic framework of space proposed by general fluid field theory, the gravitational constant is not a universal fixed quantity but instead emerges from local properties of the underlying space fluid. In particular, the effective gravitational coupling is inversely proportional to the compressibility $\epsilon(\mathbf{x})$ of the medium:

$$G(\mathbf{x}) = \frac{1}{4\pi\epsilon(\mathbf{x})}.$$

In regions of high mass density, such as near galactic centers, the space fluid becomes compressed, resulting in a decrease in compressibility ϵ. As one moves away from such regions, the fluid decompresses and ϵ increases. This leads to a corresponding variation in the effective gravitational constant. This signifies that the space fluid becomes less resistant to compression at larger distances from the mass distribution. This changing internal state of the medium alters the effective strength of gravity over galactic scales. These theoretical relations suggest that phenomena commonly attributed to dark matter may instead result from spatial variations in the structure of the space fluid itself. Detailed empirical evaluation of these predictions remains an open problem and is encouraged for future work.

[13] L. Amendola and S. Tsujikawa, *Dark Energy: Theory and Observations*, Cambridge University Press (2010), which discusses the equation of state parameter w for dark energy.

Conclusion

We hereby conclude that these four equations can model a fluid field (a medium), and that it is necessary in physics to describe motion, and motion always happens in a medium. Therefore, we ought to first establish the motion of the medium. For Maxwell said,

> *"In fact, whenever energy is transmitted from one body to another in time, there must be a medium or substance in which the energy exists after it leaves one body and before it reaches the other... and if we admit this medium as an hypothesis, I think it ought to occupy a prominent place in our investigations."*

These equations greatly increase our understanding of physics, and our understanding of the universe. Our physics has lacked motion in which the medium is first described, because it follows, that if you were to study motion of any object, that motion has to be in a medium. Einstein understood that the gravitational phenomenon could happen inside a medium called space-time, and Maxwell described a medium in which electromagnetism propagates. For both are similar in that they describe mediums. In fact, it was Newton's biggest problem with the law of gravitation, and in his letter to to Richard Bentley, in 1692 he said,

> *"That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it."*

Finally, I hope my work here is of benefit to the reader, and any mistakes or errors are to be brought to my attention, and will be reconciled. In closing, I have tried to avoid an in-depth mathematical treatise of this subject for the purpose to allow a wider audience to engage with it, and to keep the premise of the *superiority of simplicity.* I hope this work can contribute to our understanding of the physical world and bring about changes for the better of mankind. Please reach out to me for any queries, thank you for reading this treatise of general fluid field theory.

Appendix

Derivation Of The General Fluid Field Equations

We start with the Navier–Stokes momentum equation for a compressible fluid with no external forces:

$$\frac{\partial \mathbf{V}}{\partial t} + (\mathbf{V} \cdot \nabla)\mathbf{V} = -\frac{1}{\rho}\nabla p + \frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t)$$

Here, $\boldsymbol{\tau}(\mathbf{x}, t)$ is the general viscous stress tensor, possibly spatially and temporally varying.

Using the vector identity

$$(\mathbf{V} \cdot \nabla)\mathbf{V} = \nabla \left(\frac{|\mathbf{V}|^2}{2} \right) - \mathbf{V} \times (\nabla \times \mathbf{V}),$$

We rewrite the momentum equation as,

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla \left(\frac{|\mathbf{V}|^2}{2} \right) + \mathbf{V} \times (\nabla \times \mathbf{V}) - \frac{1}{\rho}\nabla p + \frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t).$$

Define the scalar potential $\Phi(\mathbf{x}, t)$ as

$$\Phi = \frac{1}{\rho}(p + E_k)$$

Then the velocity evolution equation can be expressed as

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla \Phi + \mathbf{S} + \frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t),$$

Where

$$\mathbf{W} = \nabla \times \mathbf{V}$$

Is the vorticity. Taking the curl of the velocity equation yields the vorticity equation:

$$\frac{\partial \mathbf{W}}{\partial t} = \nabla \times \left[\mathbf{V} \times \mathbf{W} + \frac{1}{\rho}\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t) \right].$$

Becomes,

$$\frac{\partial \mathbf{W}}{\partial t} = \nabla \times \mathbf{S} + \frac{1}{\rho}\nabla \times (\nabla \cdot \boldsymbol{\tau}(\mathbf{x}, t)).$$

If the fluid is homogeneous and Newtonian, then

$$\boldsymbol{\tau} = \mu \left(\nabla \mathbf{V} + (\nabla \mathbf{V})^T \right) + \lambda(\nabla \cdot \mathbf{V})\mathbf{I}$$

With constant μ, λ and $\nabla \cdot \mathbf{V} = Q(\mathbf{x}, t)$. Hence,

$$\nabla \cdot \boldsymbol{\tau} = \mu \nabla^2 \mathbf{V} + (\lambda + \mu)\nabla Q(\mathbf{x}, t)$$

Plugging back, the velocity equation becomes

$$\frac{\partial \mathbf{V}}{\partial t} = -\nabla\Phi + \mathbf{S} + \frac{\mu}{\rho}\nabla^2\mathbf{V},$$

Where,

$$\Phi = \frac{1}{\rho}\left(p + \frac{1}{2}|\mathbf{V}|^2 - (\lambda+\mu)Q(\mathbf{x},t)\right).$$

The vorticity equation reduces to

$$\frac{\partial \mathbf{W}}{\partial t} = \nabla\times\mathbf{S} + \frac{\mu}{\rho}\nabla^2\mathbf{W}.$$

The Potential Under The Lorenz Gauge

$$\Phi = \frac{1}{\rho}\left(p + E_k - (\lambda+\mu)Q(\mathbf{x},t)\right) \quad \text{where} \quad Q(\mathbf{x},t) = -\frac{1}{c^2}\frac{\partial \Phi}{\partial t}.$$

Consider the scalar potential $\Phi(t,\mathbf{x})$ governed by the first-order linear ODE:

$$\frac{\partial \Phi}{\partial t} + a\Phi = f(t,\mathbf{x}),$$

where

$$a = \frac{c^2\rho}{\lambda+\mu}, \quad f(t,\mathbf{x}) = \frac{c^2}{\lambda+\mu}p(\mathbf{x}),$$

and the pressure $p(\mathbf{x})$ follows Coulomb's law:

$$p(\mathbf{x}) \propto \frac{1}{|\mathbf{x}-\mathbf{x}_0|}.$$

Assuming zero initial kinetic energy $E_k(0) = 0$, the initial condition is

$$\Phi(0,\mathbf{x}) = \frac{p(\mathbf{x})}{\rho}.$$

Solving this ODE for $\Phi(t,\mathbf{x})$ yields

$$\Phi(t,\mathbf{x}) = e^{-at}\Phi(0,\mathbf{x}) + e^{-at}\int_0^t e^{as} f(s,\mathbf{x})ds.$$

With static pressure, the integral evaluates to

$$\int_0^t e^{as} f(\mathbf{x})ds = f(\mathbf{x})\frac{e^{at}-1}{a}.$$

Hence,

$$\Phi(t,\mathbf{x}) = e^{-at}\frac{p(\mathbf{x})}{\rho} + \frac{p(\mathbf{x})}{\rho}(1-e^{-at}) = \frac{p(\mathbf{x})}{\rho}.$$

Therefore, the scalar potential Φ remains constant in time and equal to its initial value.

Estimating The Quantum Stress Tensor

We consider the quantum stress tensor, arising from the quantum potential contribution to the stress-energy tensor in the fluid formulation of quantum mechanics:

$$\boldsymbol{\tau}^{\mu\nu}_{\text{quantum}} = -\frac{\hbar^2}{4m^2}\left[\nabla^\mu\left(\frac{\nabla^\nu\rho}{\rho}\right) + \nabla^\nu\left(\frac{\nabla^\mu\rho}{\rho}\right) - g^{\mu\nu}\nabla_\lambda\left(\frac{\nabla^\lambda\rho}{\rho}\right)\right],$$

where ρ is the fluid density, $\hbar$ is the reduced Planck constant, and m is the particle mass.

Consider a characteristic length scale r_c over which the density varies significantly. For example, $\rho(\mathbf{x})$ changes appreciably within a distance r_c. Then the typical gradient scales as

$$\nabla\rho \sim \frac{\rho}{r_c}, \quad \nabla^\mu\left(\frac{\nabla^\nu\rho}{\rho}\right) \sim \frac{1}{r_c^2}.$$

Each term in $\boldsymbol{\tau}^{\mu\nu}_{\text{quantum}}$ involves second derivatives of ρ normalized by ρ, scaling as

$$\nabla^\mu\left(\frac{\nabla^\nu\rho}{\rho}\right) \sim \frac{1}{r_c^2}.$$

Multiplying by the prefactor $\frac{\hbar^2}{4m^2}$, the quantum stress components scale as

$$\tau^{\mu\nu}_{\text{quantum}} \sim \frac{\hbar^2}{m^2 r_c^2} \times \frac{1}{r_c^2} = \frac{\hbar^2}{m^2 r_c^4}.$$

This scale corresponds to the characteristic quantum stress arising from spatial variations of the probability density ρ.

Starting from the quantum stress tensor, the characteristic quantum stress magnitude naturally scales as

$$\tau_{\text{quantum}} \sim \frac{\hbar^2}{m^2 r_c^4},$$

Providing a physically meaningful link between quantum mechanical effects and fluid stress-energy contributions.

Estimating The Gravitational Stress Tensor

We aim to motivate the gravitational stress scale

$$\tau_{\text{grav}} \sim \frac{GM^2}{r_c^4}$$

Starting from the fluid stress-energy tensor with viscous corrections:

$$T^{\mu\nu} = \rho u^\mu u^\nu + (p + \lambda Q)g^{\mu\nu} + \Pi^{\mu\nu},$$

Where the viscous stress tensor is given by the Israel–Stewart formalism as

$$\Pi^{\mu\nu} = \mu(x)\left(\nabla^\mu u^\nu + \nabla^\nu u^\mu - \frac{2}{3}g^{\mu\nu}\nabla_\lambda u^\lambda\right) + \lambda(x)g^{\mu\nu}\nabla_\lambda u^\lambda.$$

Here, ρ is the fluid density, u^μ the four-velocity field, and $\mu(x), \lambda(x)$ are viscosity coefficients which may vary spatially.

Consider a mass M localized within a characteristic radius r_c. The gravitational potential energy is approximately

$$U_{\text{grav}} \sim -\frac{GM^2}{r_c}.$$

Dividing by the volume $\sim r_c^3$, we estimate the gravitational energy density (and hence stress) scale as

$$\tau_{\text{grav}} \sim \frac{GM^2}{r_c^4}.$$

The viscous stress tensor components $\Pi^{\mu\nu}$ have units of stress (force per area) and depend on velocity gradients in the fluid:

$$\Pi^{\mu\nu} \sim \mu\nabla u,$$

Where ∇u represents typical velocity gradients.

By energy balance or the virial theorem, the characteristic fluid velocity due to gravity within r_c is

$$U \sim \sqrt{\frac{GM}{r_c}}.$$

Therefore, the velocity gradient scales as

$$\nabla u \sim \frac{U}{r_c} \sim \frac{\sqrt{GM/r_c}}{r_c} = \sqrt{\frac{GM}{r_c^3}}.$$

Assuming viscosity coefficient μ scales with density and length scale as

$$\mu \sim \rho\, r_c^2\sqrt{\frac{GM}{r_c}},$$

We find the viscous stress magnitude

$$\Pi^{\mu\nu} \sim \mu\nabla u \sim \rho\, r_c^2\sqrt{\frac{GM}{r_c}} \times \sqrt{\frac{GM}{r_c^3}} = \rho\, r_c^2\frac{GM}{r_c^2} = \rho\, GM.$$

Depending on normalization and fluid density, this recovers the gravitational stress scale order of magnitude

$$\tau_{\text{grav}} \sim \frac{GM^2}{r_c^4}.$$

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