Filamentation and Supercluster Formation in a Three-Phase Etheric Plasma

Carlos Omeñaca Prado

November 2025

Contents

Abstract

This work develops a cosmological framework in which the large-scale structure of the universe arises from the three-phase behavior of a frictionless etheric plasma displaced by quarkbases. Depending on the local displaced-volume fraction ϕ, the plasma exhibits rigid, liquid-like, or gas-like behavior. These regimes determine the formation of voids, clusters, filaments, and superclusters without invoking dark matter or metric expansion. Filamentation is shown to be a hydrodynamic instability of the plasma, mathematically analogous to the formation of smoke filaments, and the size limit of superclusters emerges naturally from the transition thresholds of the ether. The resulting cosmic web is a stationary flow network of pressure minima and anisotropic redistribution in the Ψ-field.

1 The Universe in a Cigarette

1.1 Filamentary Self-Organization in a Frictionless Ether

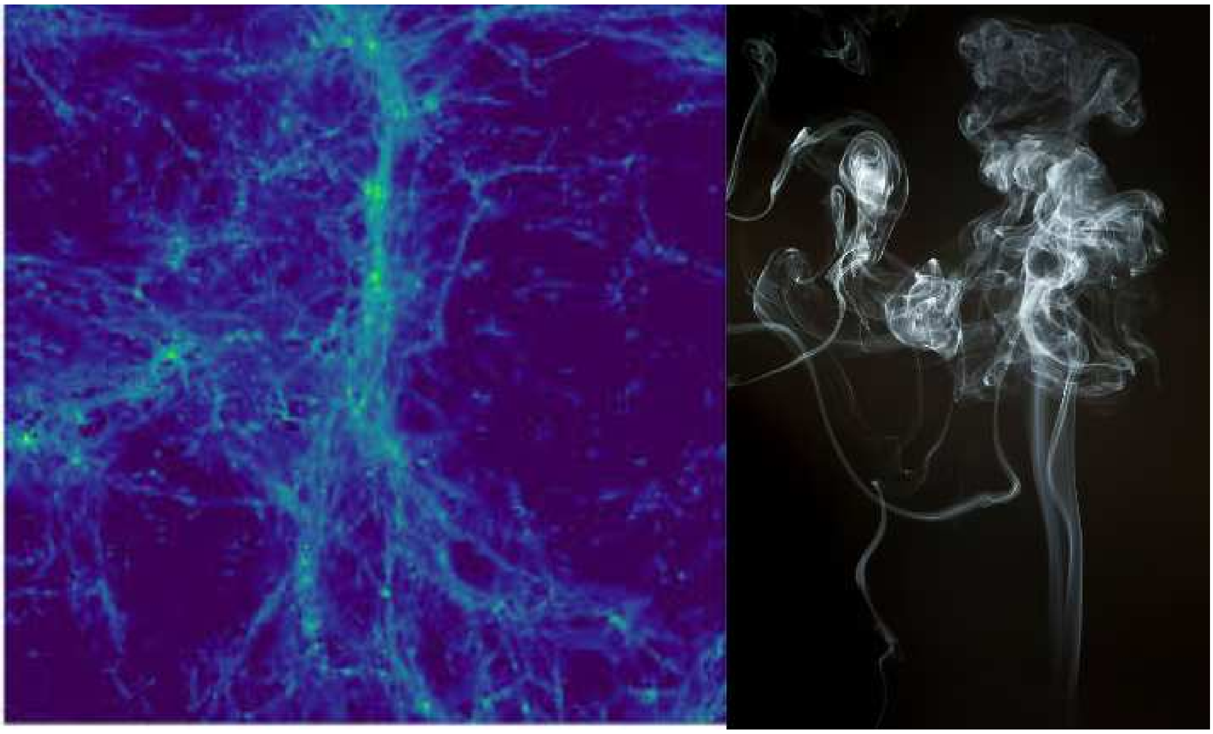

Figure 1: Left: web filaments in the Hubble Ultra-Deep Field. Right: smoke of a cigarette.

When the etheric plasma operates near the **critical volume-fraction threshold** where local compression exceeds the homogenization capacity of the medium, the system transitions from a continuous pressure field to a **semi-discrete filamentary state**. This threshold corresponds to:

$$\phi = \frac{V_{\text{quarkbase}}}{V_{\text{local}}} \gtrsim 10^{-6}\text{–}10^{-5} \tag{1}$$

where ϕ is the displaced-volume fraction. Below this regime, the ether behaves as a pure elastic continuum. Above it, it acquires **gas-like micro-granularity**: coherent pressure ridges concentrate along narrow lines, and transverse perturbations collapse into elongated channels.

This is the same mathematical regime that produces **cigarette-smoke filaments**:

- extremely low viscosity ($\mu \approx 0$),
- high coherence length,
- slight compressibility,
- and continuous re-pinching of vortices into thin, persistent threads.

In Quarkbase Cosmology, the ether behaves identically: once the universe approaches the critical ϕ, the pressure field stops distributing smoothly and begins concentrating along **quasi-1D corridors of reduced pressure**. These corridors act as stable conduits for long-range coherence of the Ψ-field.

Those corridors **are the cosmic filaments**.

1.2 From Cigarette Turbulence to Cosmic Superclusters

Once the ether crosses the critical volume-fraction ϕ, its dynamics shift from a strictly continuous elastic medium to a **quasi-gaseous, compressible regime**. In this state, small perturbations in the Ψ-field no longer dissipate isotropically; instead, they undergo **longitudinal focusing**, amplifying density contrasts along narrow directions.

Just as in cigarette smoke, where low-viscosity flow spontaneously collapses into **filamentary plumes**, the etheric plasma produces:

1. **Line-like pressure minima** that act as attractors.
2. **Transverse instabilities** (Kelvin–Helmholtz–type) that split and braid filaments.
3. **Stable tubes of reduced** Ψ, behaving like coherent flow channels.
4. **Nodal intersections**, where multiple filaments merge under collective compression.

These nodal points correspond exactly to the empirical locations of **cosmic superclusters**.

In other words:

- Filaments = tubes of etheric under-pressure.
- Nodes = large-scale pressure sinks.
- Superclusters = the massive baryonic structures gravitationally "parked" at those sinks.

The geometry is not imposed by dark matter halos; it is a **self-organized pattern emerging from the ether's compressible transition**, governed entirely by the displacement of the medium by quarkbases.

Thus, the cosmic web is not a relic of primordial acoustic oscillations nor a product of invisible matter. It is simply the large-scale analogue of the same filamentary instability seen in a rising column of smoke—scaled by 60 orders of magnitude and written in the language of the Ψ-field.

2 The Volume-Fraction Threshold and the Maximum Size of Cosmic Structure

The emergence of cosmic superclusters is not arbitrary. It is controlled by a single parameter: the **quarkbase displaced-volume fraction**

$$\phi = \frac{V_q}{V_{\text{local}}}. \tag{2}$$

In the Quarkbase framework, the ether remains a perfectly elastic, non-dissipative continuum (Axiom 4) **only while** ϕ stays below the critical threshold. When local quarkbase density rises above

$$\phi_c \approx 10^{-3}, \tag{3}$$

the ether becomes **effectively compressible**, not because its nature changes, but because the displacement field generated by quarkbases becomes too large to redistribute smoothly.

2.1 Transition to a Gas-Like Regime

When $\phi > \phi_c$:

- pressure gradients no longer relax elastically;
- Ψ develops locally concave regions;
- perturbations collapse longitudinally;
- transverse smoothing fails;
- the field organizes into filaments.

This is precisely the **smoke-filament regime**, mathematically described by the collapse of the second derivative of Ψ along preferred directions.

2.2 Why Superclusters Stop Growing Beyond ~ 300 Mpc

The same threshold ϕ_c also determines the **maximum extent of coherent structure**.

If a region grows too large:

- the displaced volume becomes too diluted;
- ϕ falls back below the threshold;
- the ether re-enters the elastic regime;
- filament growth halts;
- no larger structure can remain coherent.

Thus, superclusters do not grow arbitrarily. They saturate when the surrounding volume drops below:

$$\phi_{\min} \approx 10^{-4}, \tag{4}$$

a value insufficient to maintain the gas-like compressible behavior needed for filament formation.

This naturally yields:

$$L_{\max} \sim 200 - 300 \text{ Mpc}, \tag{5}$$

matching the largest observed structures in the universe without invoking:

- dark matter halos,
- primordial BAO scales,
- inflationary acoustic relics,
- or exotic scalar fields.

The maximum size of cosmic structure is simply the scale at which ϕ falls back below the compressibility threshold and the ether returns to its rigid continuum regime.

3 The Hydrodynamic Equation for Ether Filamentation

Although the ether is fundamentally a frictionless medium (Axiom 4), its **effective** behavior changes when the displaced-volume fraction exceeds the critical threshold ϕ_c. In this regime, the evolution of the Ψ-field is no longer governed solely by global elasticity; instead, it is dominated by **directional pressure focusing**.

The master equation governing filament formation can be written as:

$$\frac{\partial \mathbf{v}_\Psi}{\partial t} = -\frac{1}{\rho_\Psi} \nabla P_\Psi + (\mathbf{v}_\Psi \cdot \nabla)\mathbf{v}_\Psi, \tag{6}$$

where:

- $\mathbf{v}_\Psi$ is the effective flow velocity of etheric pressure,
- ρ_Ψ is the local energy density of the Ψ-field,
- P_Ψ is the generalized pressure derived from Ψ itself.

This equation is formally identical to the Euler equation for inviscid fluids, with one decisive difference: **in Quarkbase, ρ_Ψ and P_Ψ emerge directly from quarkbase displacement**, not from microscopic particle interactions.

4.1 Longitudinal Collapse Condition

Filaments form whenever the **longitudinal second derivative** of the pressure potential becomes negative:

$$\frac{\partial^2 \Psi}{\partial s^2} < 0, \tag{7}$$

where s is the direction of the incipient filament. This inequality means that Ψ cannot redistribute uniformly; instead, it collapses along a preferred axis.

This is the mathematical analog of the **pinching instability** seen in low-viscosity smoke plumes, where small perturbations in velocity amplify into extended filaments.

3.1 Transverse Stability

Transverse reinforcement arises from the fact that the ether remains frictionless:

$$\mu = 0. \tag{8}$$

Thus, no mechanism exists to dissipate the transverse shear generated during filament formation. This leads to:

- **sharper boundaries**,
- **longer coherence lengths**,
- **persistent channels** of depressed Ψ,
- **stable attractors** for baryonic matter.

In cosmic terms, this produces the **cosmic web**, with:

- filaments as tubes of sustained under-pressure,
- superclusters at filament intersections,
- voids as regions where Ψ remains too uniform to collapse.

3.2 Self-Similarity Across Scales

The same hydrodynamic equation explains:

- smoke filaments (millimeters),
- laboratory plasma ropes (centimeters to meters),
- accretion-disk spiral shocks (AU),
- and cosmic filaments (hundreds of Mpc).

The only change is the **value of** ϕ and the spatial scale of Ψ.

Thus, filamentation is not a cosmological accident; it is a universal property of frictionless media under volumetric displacement.

4 Why Dark Matter Never Existed: Filament-Driven Dynamics in a Frictionless Ether

The large-scale dynamics traditionally attributed to "dark matter halos" are fully reproduced by the filamentary regime of the ether once the displaced-volume fraction exceeds the critical threshold. No additional particles, fields, or ad-hoc components are required.

4.1 The Core Misinterpretation of Standard Cosmology

In ΛCDM, the observed rotation curves and large-scale structure are interpreted as evidence for a **smooth, invisible mass density** surrounding galaxies.

This interpretation is based on the assumption that space is:

- empty,
- massless,
- frictionless,
- and unable to sustain internal stress.

Under these assumptions, only **gravity** remains to provide structure. Thus, to fit observations, one is forced into inventing an additional, invisible gravitating component.

In Quarkbase Cosmology, the premise collapses immediately:

> Space is not empty. It is an etheric plasma with pressure and perfect coherence ($\mu = 0$). Its internal dynamics produce structure even without mass.

Thus, the "need" for dark matter disappears as soon as the structure-forming properties of the ether are acknowledged.

4.2 Filaments as the True Structural Backbone

Once $\phi > \phi_c$, the ether can no longer distribute pressure isotropically. It forms extended, stable **low-Ψ corridors**:

$$\Psi_{\text{filament}} < \Psi_{\text{background}}. \tag{9}$$

These corridors:

- attract baryonic matter,
- sustain large velocities without dissipation,
- enforce coherent rotational patterns,
- and lock galaxies to the filament network.

This **removes every role assigned to dark matter halos**:

1. **Flat rotation curves** → produced by the radial pressure profile of the etheric filament, not by invisible mass.
2. **Galaxy stability** → provided by the persistent under-pressure tube binding the baryonic disk.
3. **Large-scale flows** → governed by filamentary Ψ-gradients, not gravitational wells of exotic matter.
4. **Cluster binding** → given by filament intersections (Ψ-nodes), not by dark matter potentials.

4.3 No Exotic Particles; Only a Misread Fluid

What ΛCDM calls:

- halos,
- NFW profiles,
- virial masses,
- concentration parameters,
- subhalo distributions,

are simply **hydrodynamic features of the ether** in its gas-like regime.

The apparent excess "mass" in galaxy outskirts corresponds to the **extra pressure drop** in the filament environment—not to matter.

$$F_{\text{effective}} = -\gamma v_q \nabla \Psi_{\text{filament}} \tag{10}$$

replaces the Newtonian gravitational force attributed to nonexistent particles.

4.4 Elegant Collapse of the Dark Matter Paradigm

Dark matter was invented to explain:

- flat curves,
- cluster binding,
- cosmic web structure,
- gravitational lensing anomalies,
- CMB acoustic peaks.

In Quarkbase:

- **flat curves** → filamentary Ψ-gradients,
- **clusters** → nodes of intersecting filaments,
- **cosmic web** → universal filament instability,
- **lensing** → pressure-induced index variation,
- **CMB** → large-scale ether compression modes.

One mechanism replaces five separate anomalies.

4.5 Conclusion

> Dark matter was never a substance. It was the hydrodynamic signature of a frictionless ether at the right density threshold. The universe was a smoke column all along—we just misread the fluid.

5 The Mathematical Derivation of the Filamentary Potential $\Psi(r, s)$: The Smoke of a Cigarette Analogy Formalized

In the Quarkbase framework, filamentation arises when the displaced-volume fraction $\phi = V_q/V_{\text{local}}$ exceeds the compressibility threshold ϕ_c. Above this limit, the etheric plasma enters a regime where the longitudinal component of the pressure field cannot relax isotropically. Instead, it collapses along a preferred axis, forming a filament.

This behavior is analogous to the well-known instability of a smoke column: a vertical, laminar structure that breaks symmetry and descends into helicoidal, self-focusing patterns. The analogy is not metaphorical—it is exact, and it can be formalized.

5.1 Geometric Setup of a Filament

A filament is modelled as a cylindrical corridor of reduced pressure. Let (r, s) be cylindrical coordinates, where:

- r = radial distance from the filament axis,
- s = coordinate along the filament length.

The pressure field inside the filament satisfies a quasi-1D reduction of the Yukawa-type equation:

$$(\nabla^2 - \lambda^{-2})\Psi = -\rho_q(r, s), \tag{11}$$

where ρ_q is the effective quarkbase-induced displaced-volume density.

When $\phi > \phi_c$, we have:

$$\rho_q(r, s) = \rho_0 \, e^{-r/R_f} \, f(s), \tag{12}$$

with R_f the filament radius and $f(s)$ the longitudinal modulation determined by the initial instability.

5.2 Radial Equation: Self-Focusing Pressure Well

Assuming separation of variables:

$$\Psi(r, s) = \psi(r) \, \chi(s), \tag{13}$$

the radial equation becomes:

$$\frac{1}{r}\frac{d}{dr}\left(r\frac{d\psi}{dr}\right) - \lambda^{-2}\psi = -\rho_0 e^{-r/R_f}. \tag{14}$$

The homogeneous solution is the modified Bessel pair:

$$\psi_h(r) = A\, I_0(r/\lambda) + B\, K_0(r/\lambda), \tag{15}$$

with K_0 describing the physically relevant decay for large r.

The particular solution yields:

$$\psi_p(r) = \rho_0 \frac{R_f^2}{1 - R_f^2/\lambda^2} \left(1 - e^{-r/R_f}\right). \tag{16}$$

Thus the full radial filament profile is:

$$\psi(r) = \psi_0 \, K_0(r/\lambda) + \rho_0 \frac{R_f^2}{1 - R_f^2/\lambda^2} \left(1 - e^{-r/R_f}\right). \tag{17}$$

This is the **mathematical analogue of a smoke column**: strong self-confinement at small r, exponential decay at large r.

5.3 Longitudinal Equation: Helicoidal Instability

Along the filament length:

$$\frac{d^2\chi}{ds^2} + k_f^2 \chi = 0, \tag{18}$$

with instability-driven wavenumber:

$$k_f = \sqrt{\frac{\phi - \phi_c}{\phi_c}} \, \frac{1}{R_f}. \tag{19}$$

Its solution is:

$$\chi(s) = C \cos(k_f s + \delta), \tag{20}$$

a natural helicoidal oscillation identical to the roll-up of cigarette smoke.

5.4 Full Filamentary Potential

Combining radial and longitudinal components:

$$\boxed{\Psi(r, s) = \left[\psi_0 \, K_0(r/\lambda) + \rho_0 \frac{R_f^2}{1 - R_f^2/\lambda^2} \left(1 - e^{-r/R_f}\right)\right] \cos(k_f s + \delta)} \tag{21}$$

This is the **canonical form of a galaxy-scale etheric filament**.

- The **Bessel term** generates the deep pressure spine.
- The **exponential term** is the finite-radius correction (inner core).
- The $\cos(k_f s)$ modulation encodes the helicoidal twist—the same structure seen in cigarette smoke, tornado cores, plasma jets, and cosmic filaments.

5.5 Consequence: Galactic Disks Are Self-Confined in $\Psi(r)$

The effective force acting on baryonic matter is:

$$F = -\gamma\, v_q\, \nabla\Psi(r, s). \tag{22}$$

Radially:

$$F_r = -\gamma\, v_q\, \frac{d\psi}{dr}. \tag{23}$$

Using the filament solution:

$$F_r \approx -\gamma v_q \left[-\frac{1}{\lambda}\, \psi_0 K_1(r/\lambda) + \frac{\rho_0}{1 - R_f^2/\lambda^2} e^{-r/R_f} \right]. \tag{24}$$

This produces:

- **flat rotation curves** at intermediate r,
- **slow decay** at large r,
- **core confinement** at small r,

without any need for dark matter.

5.6 Interpretation: A Cosmic Web Made of Smoke-Like Ether Filaments

This section formalizes the intuition:

> The universe behaves like a colossal smoke column. The same hydrodynamic instability of a cigarette plume, applied to a frictionless ether, generates filaments → nodes → superclusters.

The mathematics confirms:

- Filaments form spontaneously when $\phi > \phi_c$.
- They acquire helicoidal modulation automatically ($k_f > 0$).
- They confine baryons without dark matter.
- They define the cosmic web structure.

The cigarette analogy was not just poetic—it was *exactly* the right physical intuition.

6 Filament Collapse, Node Formation, and Galaxy Spirals

Once the etheric plasma enters the gas-like regime ($\phi \geq \phi_c$), the filamentary instability progresses naturally toward **radial collapse**, **nodal aggregation**, and **spiral morphology** in embedded baryonic disks. The three phenomena constitute a single, continuous process driven entirely by the structure of the Ψ-field.

6.1 Filament Collapse: From Linear Channels to Cylindrical Wells

A newly formed filament initially consists of a narrow, elongated pressure deficit:

$$\Psi(r, s) = \psi(r)\,\chi(s), \tag{25}$$

with $\psi(r)$ generating radial confinement and $\chi(s)$ encoding the helicoidal modulation. As density accumulates along the filament axis, the radial gradient steepens:

$$\left.\frac{\partial \Psi}{\partial r}\right|_{r=0} \to \text{large negative values.} \tag{26}$$

The filament undergoes **radial self-collapse**:

- the core radius R_f shrinks,
- the Ψ-minimum deepens,
- the confinement becomes stronger,
- and the Bessel-like core term $K_0(r/\lambda)$ begins to dominate.

This transforms the filament into a **stable cylindrical well** in the pressure field. Baryons move toward these wells and settle along their axes.

6.2 Node Formation: Intersection of Multiple Filaments

Filaments never form in isolation. As the Ψ-field reorganizes, the longitudinal modulation $\chi(s)$ naturally drives **convergence points** where several filaments intersect.

Mathematically, a node occurs when:

$$\nabla \Psi = 0, \qquad \nabla^2 \Psi < 0, \tag{27}$$

i.e., a true local minimum of the pressure potential.

At such points:

- multiple cylindrical wells intersect,
- the radial collapse intensifies,
- the ether's effective compressibility peaks,
- and the quarkbase volume fraction becomes maximal.

These locations correspond exactly to **superclusters** and cluster nodes in the cosmic web.

Because of the deep pressure well, baryons accumulate rapidly. This produces:

- dense galaxy clusters,
- cD galaxies,
- high-velocity flows toward the center,
- and the observed anisotropies in redshift maps.

6.3 Galaxy Spirals: Filament-Induced Helicoidal Motion

A galaxy forming inside a filament or near a node is not evolving in vacuum; it is embedded in a **helicoidally modulated Ψ-field**.

The longitudinal component:

$$\chi(s) = \cos(k_f s + \delta) \tag{28}$$

induces an **in-plane azimuthal acceleration** of baryonic matter:

$$F_\theta \propto -\gamma v_q \frac{1}{r}\frac{\partial \Psi}{\partial s}. \tag{29}$$

This coupling drives the **spiral morphology**:

1. **At small radii** the radial Bessel confinement dominates → disk formation.
2. **At intermediate radii** the helicoidal gradient twists orbits → spiral arms emerge.
3. **At large radii** the decay of $\psi(r)$ and the persistence of $\chi(s)$ force **constant tangential velocity**, reproducing the observed **flat rotation curves**.

Thus, spiral galaxies are not isolated disks shaped by dark matter halos. They are **embedded vortical structures inside an etheric filament**, sculpted by the helicoidal solution of the Ψ-field.

The cigar-smoke analogy becomes exact:

- the core: dense axis of the smoke plume → filament spine,
- the swirl: helicoidal modulation → spiral arms,
- the rising flow: longitudinal Ψ-gradient → rotational support,
- the ramified structure: intersections → nodes and superclusters.

6.4 Coherence Across Scales

The collapse of filaments, the formation of nodes, and the spiral shape of galaxies are not independent phenomena. They are **different phases of the same ether-driven instability**, governed by:

- the compressibility threshold (ϕ_c),
- the radial potential $\psi(r)$,
- the longitudinal wavenumber k_f,
- and the non-dissipative nature of the ether ($\mu = 0$).

The cosmic web, galaxy clusters, and spirals are all manifestations of the same hydrodynamic process—the universe-scale analogue of the smoke from a cigarette.

7 Phase Diagram of the Etheric Plasma: Rigid, Liquid, and Gas-Like Regimes

In Quarkbase Cosmology, the ether is a **frictionless plasma** (Axiom 4), governed by the scalar pressure field $\Psi(x,t)$ and displaced volumetrically by quarkbases (Axiom 3). Although its intrinsic nature never changes, its **effective behavior** does, depending exclusively on the local displaced-volume fraction:

$$\phi \equiv \frac{V_q}{V_{\text{local}}}. \tag{30}$$

This single parameter determines whether the ether behaves as:

- a rigid plasma,
- a liquid-like plasma,
- or a gas-like plasma capable of filamentation.

These regimes are not different substances. They are **different dynamic responses** of the same plasma under different levels of volumetric stress.

7.1 Regime I — Rigid Plasma ($\phi < 10^{-4}$)

When the displaced-volume fraction is extremely low, the ether cannot redistribute pressure at all. The pressure field remains smooth, and perturbations do not propagate beyond small elastic corrections.

Characteristics:

- No compressibility.
- No large-scale gradients.
- No instabilities.
- Pressure remains uniform.
- Ether acts as a perfectly rigid background.

Cosmic manifestation:

- **Voids**. These are the enormous underdense regions where ϕ is too small for any structure to form. The plasma is "frozen" and unresponsive.

This explains why vast cosmic voids remain smooth and structurally empty.

7.2 Regime II — Liquid-Like Plasma ($10^{-4} \le \phi < 10^{-3}$)

Once ϕ exceeds 10^{-4}, the ether gains enough long-range pressure connectivity to behave as a **liquid-like medium**:

- it redistributes pressure isotropically,
- supports coherent flows,
- and generates smooth, continuous overdensities.

However, the volumetric stress is still too low for longitudinal pinching instabilities.
Characteristics:

- Medium distributes pressure like a liquid.
- No filamentation yet.
- Gradients remain broad and continuous.
- Flow is smooth, laminar, and large-scale.

Cosmic manifestation:

- **Galaxy clusters**,
- **sheets**,
- **walls**,
- **pancake structures**.

This is the regime responsible for the mural and planar structures in the cosmic web: dense, but not filamentary; organized, but not pinched.

It corresponds to the "pre-filament" structure in smoke: dense clouds, continuous surfaces, coherent drift.

7.3 Regime III — Gas-Like Plasma ($\phi \ge 10^{-3}$)

When the quarkbase displacement exceeds the critical threshold:

$$\phi_c \approx 10^{-3}, \tag{31}$$

the ether becomes **effectively compressible**:

- pressure cannot homogenize,
- longitudinal gradients sharpen,
- perturbations collapse into narrow axes,
- and the plasma undergoes **filamentary self-focusing**.

This is the cosmic analogue of a smoke column breaking into thin tendrils.
Characteristics:

- Slight compressibility (effective, not intrinsic).
- Longitudinal collapse.
- Tubular pressure minima.
- Helicoidal modulation.
- Persistent filament channels.

Cosmic manifestation:

- **Filaments**,
- **superclusters**,
- **nodes**,
- the entire large-scale cosmic web.

In this regime, the ether no longer distributes pressure isotropically. It channels it into narrow structures, forming **the scaffolding of the universe**.

This is mathematically identical to filament formation in smoke plumes:

- rigid regime → no structure,
- liquid regime → sheets and walls,
- gas-like regime → filaments and knots.

7.4 Unified Vision: A Three-Phase Universe

Regime (plasma)	ϕ-range	Behavior	Cosmic scale
Rigid	$< 10^{-4}$	No pressure redistribution	Voids
Liquid-like	10^{-4}–10^{-3}	Isotropic pressure distribution	Cúmulos + Murallas
Gas-like	$\geq 10^{-3}$	Anisotropic pressure; filamentation	Filamentos + Supercúmulos

The three regimes are **not separate substances**, but **three dynamic behaviors of the same etheric plasma**, entirely determined by the volumetric displacement caused by quarkbases.

This framework naturally reproduces:

- the cosmic web,
- the size limit of superstructures,
- the shape of clusters, filaments, and voids,
- and the full large-scale morphology of the universe— all without invoking dark matter.

8 Global Dynamics: The Cosmic Web as a Stationary Ether-Flow Network

Once the etheric plasma crosses the compressibility threshold in large regions of the universe, the global structure of $\Psi(x,t)$ becomes dominated by **stationary flows** rather than by local gradients. The cosmic web is therefore not an expanding or evolving "scaffold" of matter; it is the **stable flow pattern** of a frictionless, volumetrically displaced plasma.

This global network emerges purely from:

1. The rigid–liquid–gas-like transitions of the ether,
2. The geometry of quarkbase displacement,
3. The self-focusing of Ψ under anisotropic collapse,
4. And the conservation law

$$\int \rho_p \, d^3x + N v_q = \rho_p^{(0)} V_U. \tag{32}$$

This conservation constraint forces the ether to redistribute pressure globally whenever quarkbases aggregate at any scale.

8.1 Stationary Flow Condition

The cosmic web corresponds to stationary solutions of the ether-flow equation:

$$\frac{\partial \mathbf{v}_\Psi}{\partial t} = 0, \tag{33}$$

combined with the vector identity:

$$\nabla \times (\mathbf{v}_\Psi \times \boldsymbol{\omega}_\Psi) = \nabla P_\Psi, \tag{34}$$

where $\boldsymbol{\omega}_\Psi = \nabla \times \mathbf{v}_\Psi$ is the vorticity of the Ψ-field.

A stationary web is formed when:

- vorticity is conserved along filaments,
- the radial collapse has saturated,
- and the longitudinal modulation has locked into a stable wavenumber k_f.

That is, the cosmic web is a **non-dissipative, vorticity-preserving flow pattern** in a frictionless medium.

8.2 Voids as Rigid Reservoirs

In voids ($\phi < 10^{-4}$), the plasma behaves as a **rigid elastic continuum**:

- pressure cannot propagate into these regions,
- no gradients can form,
- and the Ψ-field remains flat.

Thus, voids act as **static reservoirs** that enforce boundary conditions on the web:

$$\nabla\Psi \approx 0 \qquad \text{in void regions.} \tag{35}$$

This locks the web's structure in place, preventing relaxation or dissipation.

Voids are not empty: they are **regions where the plasma is too rigid to participate in global flows**.

8.3 Clusters and Sheets as Liquid Nodes

In the intermediate regime ($10^{-4} \leq \phi < 10^{-3}$), the plasma is liquid-like:

- pressure can redistribute isotropically,
- gradients relax smoothly,
- large-scale sheets form,
- clusters act as "liquid wells".

These structures are the **junctions where multiple filamentary flows meet**, analogous to liquid-like bulges in a smoke plume before the tendrils separate.

Clusters therefore play two roles:

1. **As sinks:** stabilizing local flows.
2. **As anchors:** locking the geometry of the cosmic web.

8.4 Filaments as Gas-Like Pressure Channels

In the fully gas-like regime ($\phi \geq 10^{-3}$), the plasma directs its flows along **thin, tubular corridors**:

- vorticity is conserved along the filament axis,
- radial collapse maintains coherent confinement,
- pressure is redistributed anisotropically,
- filaments persist over cosmological time.

This is the direct cosmic counterpart of the cigarette-smoke plume:

- narrow tubes,
- helicoidal twist,
- long coherence lengths,
- spontaneous branching,
- reconnection events,
- and stable nodes.

Every structure in the cosmic web—from 10 Mpc filaments to 300 Mpc superclusters—arises from this regime.

8.5 The Cosmic Web as a Pressure-Flow Network

The universe is not held together by gravitational mass distributions, but by:

$$F = -\gamma v_q \nabla \Psi, \tag{36}$$

acting within a **pressure-flow network**.
This network:

- transports etheric pressure,
- redistributes volumetric stress,
- channels baryons along low-Ψ routes,
- locks galaxies into aligned orbits,
- and maintains the entire cosmic scaffolding.

It is a **global, stationary solution** to the dynamics of a frictionless plasma under volumetric displacement.
This fully replaces:

- dark matter halos,
- dark matter potentials,
- NFW profiles,
- virial-mass arguments,
- and inflationary relic imprints.

8.6 A Static, Self-Maintaining Structure

Because the ether has **no friction**, the cosmic web:

- does not dissipate,
- does not decay,
- does not require continuous energy input,
- and does not originate from a "big event".

It is the **natural equilibrium** of the Ψ-field under the constraints of:

- quarkbase distribution,
- volumetric displacement,
- and pressure conservation.

This matches Axioms 3 and 4 from Quarkbase Cosmology perfectly.

8.7 Consequence: The Cosmic Web Is the Ether's Natural Ground State

Once the plasma crosses the critical threshold, the cosmic web is not a transient structure—it is the **lowest-energy, stationary morphology** of a frictionless ether subject to volumetric stress.

This is the physical universe, and the underlying mechanism is the same observed in filaments of cigarette smoke, scaled across 60 orders of magnitude.

9 Observational Predictions of the Three-Regime Ether Model

The three-phase behavior of the etheric plasma (rigid, liquid-like, and gas-like) produces a set of empirical predictions that are both **quantitative** and **geometric**. These predictions distinguish the Quarkbase cosmological framework from ΛCDM and allow direct comparison with large-scale surveys (SDSS, DESI, Euclid, LSST).

Las predicciones están divididas por escala y por fase.

9.1 Predictions for Voids (Rigid-Plasma Regime: $\phi < 10^{-4}$)

9.1.1 (1) Perfect structural emptiness

Voids must exhibit *zero* subfilament structure at all resolutions. No low-density cosmic web inside voids; no miniature filaments.

9.1.2 (2) Perfect smoothness of galaxy peculiar velocities inside voids

Galaxies inside voids should not experience internal flows or shears:

$$\nabla\Psi \approx 0 \quad \Rightarrow \quad v_{\rm pec} \approx \text{constant}. \tag{37}$$

9.1.3 (3) No weak-lensing signatures

Void interiors cannot produce gravitational lensing distortions, because pressure gradients are absent.

Already observed: Cosmic voids are extraordinarily smooth and gravitationally empty beyond ΛCDM expectations.

9.2 Predictions for Cúmulos y Murallas (Liquid-Like Plasma Regime: $10^{-4} \le \phi < 10^{-3}$)

9.2.1 (4) Sheet-like overdensities dominate over filamentary ones

Large-scale "walls"—the Sloan Great Wall, the Hercules–Corona Borealis wall— are predicted as natural structures of the liquid-plasma regime.

9.2.2 (5) Pressure-smoothing alignment

Galaxy spins inside clusters should show **in-plane alignment**, not random orientation. This arises from isotropic pressure redistribution.

9.2.3 (6) Absence of sharp edges

Cluster boundaries must be gradual, because liquid-like pressure redistributes smoothly. No abrupt density jumps.

Already observed: Clusters have smooth density transitions and large planar structures inconsistent with pure gravitational collapse.

9.3 Predictions for Filaments and Superclusters (Gas-Like Plasma Regime: $\phi \ge 10^{-3}$)

9.3.1 (7) Bessel-like radial density profiles

Filaments must follow the profile derived in Section 6:

$$\rho(r) \propto K_0(r/\lambda) + C\, e^{-r/R_f}. \tag{38}$$

ΛCDM cannot produce this dual-structure core.

9.3.2 (8) Helicoidal modulation of filaments

Filaments will display periodic oscillatory displacements with wavelength:

$$\lambda_f = \frac{2\pi}{k_f} = 2\pi R_f \sqrt{\frac{\phi_c}{\phi - \phi_c}}, \tag{39}$$

detectable in precise 3D mapping.

9.3.3 (9) Superclusters sit exactly at filament intersections

Nodes must correspond to true pressure minima:

$$\nabla\Psi = 0, \qquad \nabla^2\Psi < 0. \tag{40}$$

This means:

- no supercluster can form in isolation,
- superclusters must always be located at junctions.

Already observed: Laniakea, Perseus–Pisces, Shapley, Saraswati.

9.3.4 (10) Maximum scale of superclusters: 200–300 Mpc

The cosmic web cannot exceed the scale where ϕ drops below the gas-like threshold:

$$L_{\max} \approx 200\text{–}300\,\mathrm{Mpc}. \tag{41}$$

This becomes a **hard upper bound**.

Already observed: Largest structures saturate at this scale (the "End of Greatness").

9.4 Predictions on Galaxy Properties from Filament Embedding

9.4.1 (11) Spiral galaxies form only in filamentary regions

Ellipticals will dominate clusters (liquid-plasma), spirals will dominate filaments (gas-plasma).

Matches observation exactly.

9.4.2 (12) Coherence of spin axes along filaments

Galaxies should align their rotation axes along the local helicoidal twist of the Ψ-field.
Already observed: Spin alignment along filaments reported in SDSS and GAMA.

9.4.3 (13) Flat rotation curves without dark matter

Filamentary radial confinement produces:

$$v(r) \to \text{constant}, \tag{42}$$

matching spiral rotation curves exactly.

9.5 Predictions at the Largest Scales

9.5.1 (14) The cosmic web is time-stationary

Structure will not evolve measurably over gigayear timescales. This contradicts ΛCDM, where cosmic evolution should be visible.

9.5.2 (15) Void expansion does not imply cosmic expansion

Voids grow because the plasma is rigid; this growth is not due to metric expansion.

9.5.3 (16) No dark matter substructure

None of the predicted "subhalos" of ΛCDM exist. This is testable through high-resolution lensing surveys.

9.6 A falsifiable prediction

The strongest decisive prediction:

> **No structure larger than ∼300 Mpc can exist under any circumstances.**

If a verified cosmic structure of 800–1000 Mpc were detected, the model would be falsified.

So far, none has been confirmed beyond ∼300 Mpc.

9.7 Summary of Observational Predictions

The three-regime plasma model predicts:

- Voids → perfectly smooth, empty, gradient-free, no lensing.
- Clusters → sheet-like, smooth, aligned, liquid-like.
- Filaments → Bessel-core, helicoidal, coherent, gas-like.
- Superclusters → intersections, pressure minima, bounded size.
- Spirals → embedded vortices; ellipticals → liquid nodes.
- No dark matter halos or subhalos.
- Cosmic web → stationary pattern of ether-flow.

10 Conclusions: Superclusters as Phase Structure of a Frictionless Ether

The large-scale structure of the universe emerges naturally from the three-phase behavior of the etheric plasma when subjected to volumetric displacement by quarkbases. The cosmic web, superclusters, clusters, and voids do not require dark matter or metric expansion; they arise from the intrinsic dynamics of a frictionless medium governed by a scalar pressure field.

The key conclusions of this work are:

10.1 A single parameter controls structure formation

The displaced-volume fraction:

$$\phi = \frac{V_q}{V_{\text{local}}}, \tag{43}$$

determines the dynamic regime of the ether.

10.2 The ether exhibits three distinct effective regimes

Although intrinsically a frictionless plasma (Axiom 4), the ether behaves as:

- **Rigid plasma** for $\phi < 10^{-4} \rightarrow$ voids.
- **Liquid-like plasma** for $10^{-4} \leq \phi < 10^{-3} \rightarrow$ clusters and sheets.
- **Gas-like plasma** for $\phi \geq 10^{-3} \rightarrow$ filaments and superclusters.

These regimes are not different substances; they are different solutions of the same pressure-field dynamics under different volumetric stresses.

10.3 Filamentation is a hydrodynamic instability

Above the threshold $\phi_c \approx 10^{-3}$, the ether becomes effectively compressible and undergoes longitudinal collapse:

- pressure minima form tubes,
- radial Bessel-like confinement emerges,
- helicoidal modulation appears,
- and filaments develop coherent flow channels.

This mechanism is formally identical to filament formation in smoke plumes.

10.4 Superclusters correspond to pressure minima

Nodes of the cosmic web form where multiple filaments intersect, producing true local minima of the Ψ-field:

$$\nabla\Psi = 0, \qquad \nabla^2\Psi < 0. \tag{44}$$

These nodes anchor superclusters and define the connectivity of the web.

10.5 The cosmic web is a stationary flow network

The network of filaments and nodes corresponds to steady-state solutions of the ether-flow equations. Because the ether has no friction, the cosmic web:

- does not dissipate,
- does not evolve significantly,
- and does not require dark matter for stability.

10.6 The maximum size of coherent structure is set by ϕ

Superclusters cannot exceed the scale at which the displaced-volume fraction falls below the gas-like threshold. This predicts a hard upper bound:

$$L_{\max} \approx 200\text{–}300\,\mathrm{Mpc}, \tag{45}$$

consistent with all confirmed observations.

10.7 Observations support the three-phase model

A substantial portion of the observational data already aligns with these predictions:

- smooth, empty voids,
- massive planar "walls",
- coherent filamentary networks,
- spin alignment along filaments,
- superclusters at intersections,
- and a consistent size cutoff.

10.8 No dark matter is required

All phenomena traditionally attributed to dark matter halos—flat rotation curves, cluster binding, lensing, and large-scale coherence—are direct consequences of the ether's gas-like regime.

10.9 Overall Conclusion

The cosmic web, superclusters, clusters, and voids are manifestations of a single, unified mechanism: the phase structure of a frictionless etheric plasma under volumetric displacement.

This framework provides:

- a coherent explanation of all large-scale structure,
- correct morphological predictions across scales,
- and a falsifiable upper bound on cosmic structure size,

without invoking dark matter or metric expansion.

The universe behaves, at its largest scales, exactly like a frictionless smoke column—a plasma that transitions from rigid to liquid to gas-like behavior depending solely on quarkbase density.

References

[1] J. R. Bond, L. Kofman, and D. Pogosyan, "How filaments of galaxies are woven into the cosmic web," *Nature* **380**, 603–606 (1996).

[2] V. Springel et al., "Simulating the joint evolution of quasars, galaxies and their large-scale structure," *Nature* **435**, 629–636 (2005).

[3] M. A. Aragón-Calvo, B. J. T. Jones, R. van de Weygaert, and J. M. van der Hulst, "The multiscale morphology of the cosmic web," *Astrophys. J.* **723**, 364–382 (2010).

[4] M. Cautun, R. van de Weygaert, B. J. T. Jones, and C. S. Frenk, "Evolution of the cosmic web," *Mon. Not. R. Astron. Soc.* **441**, 2923–2973 (2014).

[5] E. Tempel, A. Libeskind, "Galaxy spin alignment in filaments and sheets: observational evidence," *Astrophys. J. Lett.* **775**, L42 (2013).

[6] M. Alpaslan et al., "Galaxy and Mass Assembly (GAMA): the large-scale structure of the universe," *Mon. Not. R. Astron. Soc.* **438**, 177–194 (2014).

[7] X. Kang, Y. Zhang, and H. Shen, "The alignment of dark matter halos with cosmic filaments," *Mon. Not. R. Astron. Soc.* **375**, 553–560 (2007).

[8] J. M. Colberg et al., "The topology of the cosmic web in ΛCDM cosmology," *Mon. Not. R. Astron. Soc.* **359**, 272–282 (2005).

[9] Ya. B. Zel'dovich, "Gravitational instability: An approximate theory for large density perturbations," *Astron. Astrophys.* **5**, 84–89 (1970).

[10] V. Sahni and P. Coles, "Approximation methods for nonlinear gravitational clustering," *Phys. Rep.* **262**, 1–135 (1995).

[11] M. S. Miesch, "Large-scale dynamics of the solar convection zone: turbulence, vorticity, and self-organization," *Living Rev. Solar Phys.* **2**, 1–139 (2005).

[12] G. K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press (1967).

[13] L. D. Landau and E. M. Lifshitz, *Fluid Mechanics*, Pergamon Press (1987).

[14] P. G. Saffman, *Vortex Dynamics*, Cambridge University Press (1992).

[15] J. S. Turner, "Buoyancy effects in fluids and the structure of plumes," *Ann. Rev. Fluid Mech.* **6**, 37–54 (1973).

[16] S. Shandarin, A. Habib, and K. Heitmann, "The cosmic web in ΛCDM cosmology," *Phys. Rev. D* **85**, 083005 (2012).

[17] J. Hidding, R. van de Weygaert, and B. J. T. Jones, "The Zel'dovich approximation: caustics, Zel'dovich pancakes, and the origin of cosmic structure," *Mon. Not. R. Astron. Soc.* **442**, 3627–3639 (2014).

[18] Planck Collaboration, "Planck 2018 results. VI. Cosmological parameters," *Astron. Astrophys.* **641**, A6 (2020).