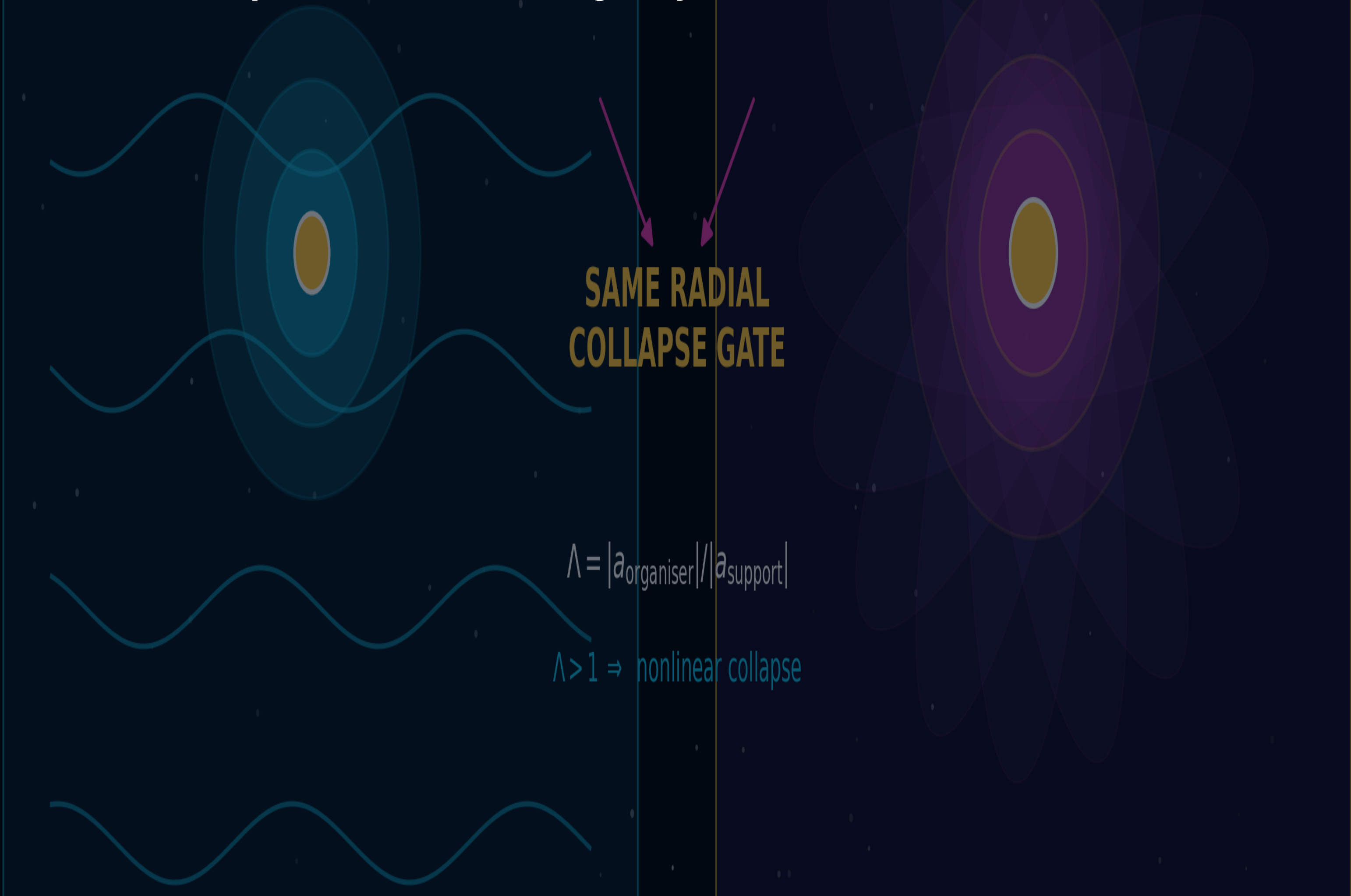
THE BUOYANT NODE BRIDGE

SAME COLLAPSE MATHEMATICS
DIFFERENT PHYSICAL FIELDS

A direct mathematical correspondence between mechanical sonoluminescent collapse and mass-sourced gravity-first stellar node formation



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Status: Speculative cross-scale mechanism paper. It does not claim gravity is acoustic, that sound propagates through vacuum, or that sonoluminescence proves RBFL. It derives a falsifiable correspondence in which different physical fields occupy the same radial-collapse role.

Scientific boundary

The conceptual firewall

Same collapse mathematics does not mean the same physical wave.

The sonoluminescent bubble is driven by a **mechanical longitudinal pressure wave** that requires a liquid medium. Remove the liquid and there is no acoustic propagation, no Bjerknes trapping, and no Rayleigh–Plesset bubble collapse.
A forming star is driven by a **mass-sourced gravitational field**. In the RBFL hypothesis, that ordinary baryonic field is supplemented by a proposed baryon-anchored coherence response. Neither ordinary gravity nor the proposed RBFL response is identified here with sound.
The paper's direct link is therefore dynamical, not ontological: the two different organisers enter the same acceleration slot, cross the same inward-drive-versus-support instability gate, and produce the same finite-volume compression scaling. The carrier, constitutive physics, medium requirement, and final attractor remain different.

Executive result in one page

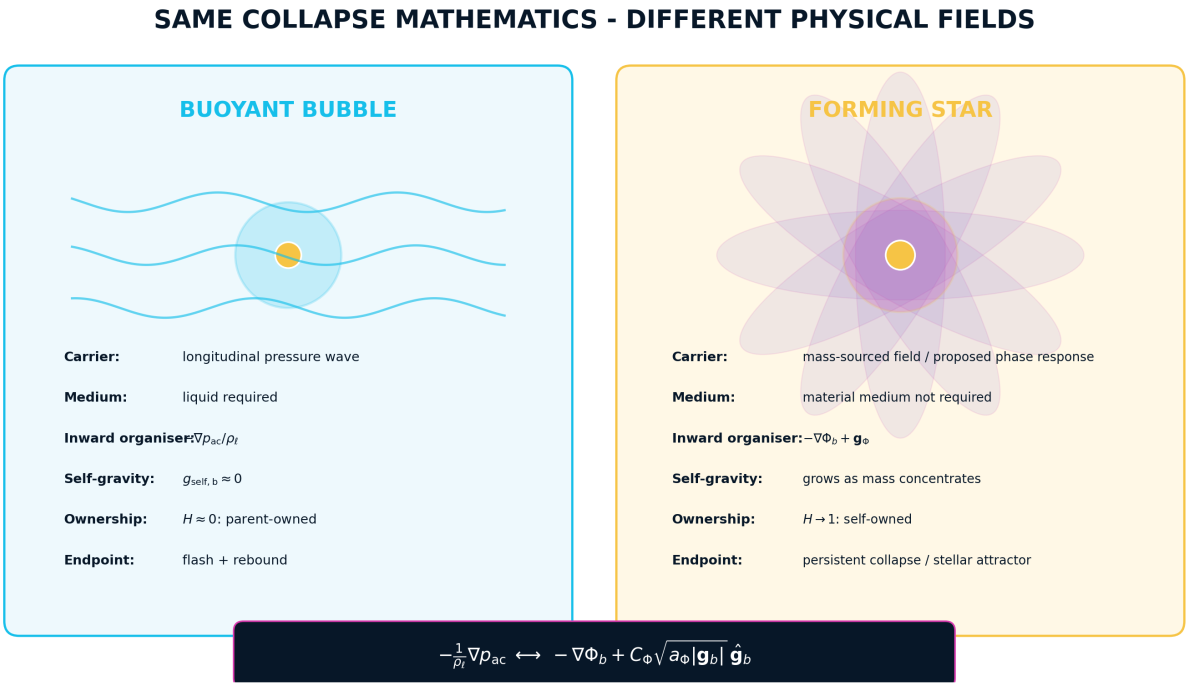

Figure 1: The reframe in one image. Acoustic and gravitational organisation are physically different, but both can occupy the inward-organiser position in a radial instability equation.

The bubble is the clean parent-driven limit

The bubble is subject to Earth's gravity through buoyancy, but it is not bound by its own gravity. Its self-gravitational acceleration is negligible compared with the acoustic wall acceleration. That leaves the liquid-borne pressure field free to determine the bubble's translational node, radial breathing, and collapse phase with very little competition from internal gravity.

For the bubble,

$$\mathbf{a}_{\mathrm{ac}} = -\frac{1}{\rho_\ell}\nabla p_{\mathrm{ac}}, \qquad \rho_\ell > 0 \text{ and a material medium is required.} \tag{1}$$

For the forming star,

$$\mathbf{a}_\star = -\nabla\Phi_b + C_\Phi\sqrt{a_\Phi|\mathbf{g}_b|}\,\hat{\mathbf{g}}_b, \qquad \nabla^2\Phi_b = 4\pi G\rho_b. \tag{2}$$

The two organisers are not physically interchangeable. They are mathematically corresponding inputs to the same reduced radial equation:

Direct acceleration-slot correspondence

$$\boxed{-\frac{1}{\rho_\ell}\nabla p_{\mathrm{ac}} \quad\longleftrightarrow\quad -\nabla\Phi_b + C_\Phi\sqrt{a_\Phi|\mathbf{g}_b|}\,\hat{\mathbf{g}}_b} \tag{3}$$

At characteristic radius R, this becomes

$$\boxed{\frac{\Delta p_{\mathrm{ac}}}{\rho_\ell R} \quad\longleftrightarrow\quad \frac{GM}{R^2} + C_\Phi\sqrt{a_\Phi\frac{GM}{R^2}}} \tag{4}$$

with the shared gate

$$\boxed{\Lambda = \frac{|a_{\mathrm{organiser}}|}{|a_{\mathrm{support}}|}\begin{cases} < 1, & \text{supported or breathing,} \\ = 1, & \text{instability boundary,} \\ > 1, & \text{nonlinear inward collapse.}\end{cases}} \tag{5}$$

After the crossing, both geometries amplify density and temperature:

$$\rho \propto R^{-3}, \qquad T \propto R^{-3(\gamma-1)} \quad \text{for approximately adiabatic compression.} \tag{6}$$

Their outcomes diverge through field ownership. The bubble remains parent-owned by the acoustic resonator and therefore flashes and rebounds when the cycle reverses. The stellar core's self-gravity grows as M increases and R contracts, allowing a handoff toward a self-owned collapse and a long-lived stellar attractor.

The paper's central claim

Sonoluminescence is not evidence that gravity is made of sound. It is a controlled Earth laboratory in which a mechanically driven, negligible-self-gravity node realises the same radial-collapse mathematics proposed for a gravity-driven stellar node. That makes the bubble a laboratory proxy for the *collapse architecture*, not for the physical identity of the field.

Contents

1 The conceptual firewall: same mathematics, different physics

1.1 What is being linked

The direct link is a correspondence between two **finite-volume radial instabilities**. Both systems contain:

$$\boxed{\begin{aligned}&\text{field-organised node} \rightarrow \text{bounded breathing} \rightarrow \text{support-loss boundary}\\ &\quad \rightarrow \text{nonlinear compression} \rightarrow \text{heating and radiation}\end{aligned}} \tag{7}$$

The organiser on the left is mechanical acoustic pressure. The organiser on the right is mass-sourced gravity, supplemented in the RBFL hypothesis by a baryon-anchored coherence term.

1.2 What is not being linked

This paper does not claim:

- gravity is an acoustic pressure wave;
- space is a liquid carrying ordinary sound;
- a static gravitational field is itself a gravitational wave;
- the bubble and the protostar share the same microscopic carrier;
- the existence of sonoluminescence proves the RBFL acceleration law.

The comparison is between dynamical roles, stability structure, and compression geometry.

1.3 Physical comparison

Feature	Buoyant sonoluminescent bubble	Forming star under RBFL hypothesis
Physical organiser	Mechanical longitudinal pressure wave	Mass-sourced gravitational field plus proposed baryonic coherence response
Medium requirement	Requires a liquid or other material acoustic medium	Does not require a material propagation medium
Radial acceleration	$-(1/\rho_\ell)\nabla p_{\mathrm{ac}}$	$-\nabla\Phi_b + C_\Phi\sqrt{a_\Phi\lvert\mathbf{g}_b\rvert}\,\hat{\mathbf{g}}_b$
Self-gravity	Negligible, $g_{\mathrm{self,b}} \approx 0$	Increases as mass concentrates and radius contracts
Node ownership	Parent-owned, $H \approx 0$	Can hand off toward self-owned, $H \rightarrow 1$
Collapse endpoint	Flash followed by rebound or another cycle	Persistent contraction, hydrostatic core, accretion, eventual stellar ignition

Table 1: The physical firewall. The systems share an instability architecture, not a common ordinary wave type.

2 Why buoyancy makes the bubble a clean laboratory node

2.1 Buoyancy includes Earth gravity, but the bubble is not self-gravitationally bound

A gas bubble in water experiences Earth's gravitational field because the displaced liquid is heavier than the gas. Its buoyant force is approximately

$$\mathbf{F}_{\mathrm{buoy}} = (\rho_\ell - \rho_g)V g\,\hat{\mathbf{z}}. \tag{8}$$

The bubble's own self-gravity, however, is

$$g_{\mathrm{self,b}} = \frac{GM_b}{R^2} = \frac{4\pi}{3}G\rho_g R. \tag{9}$$

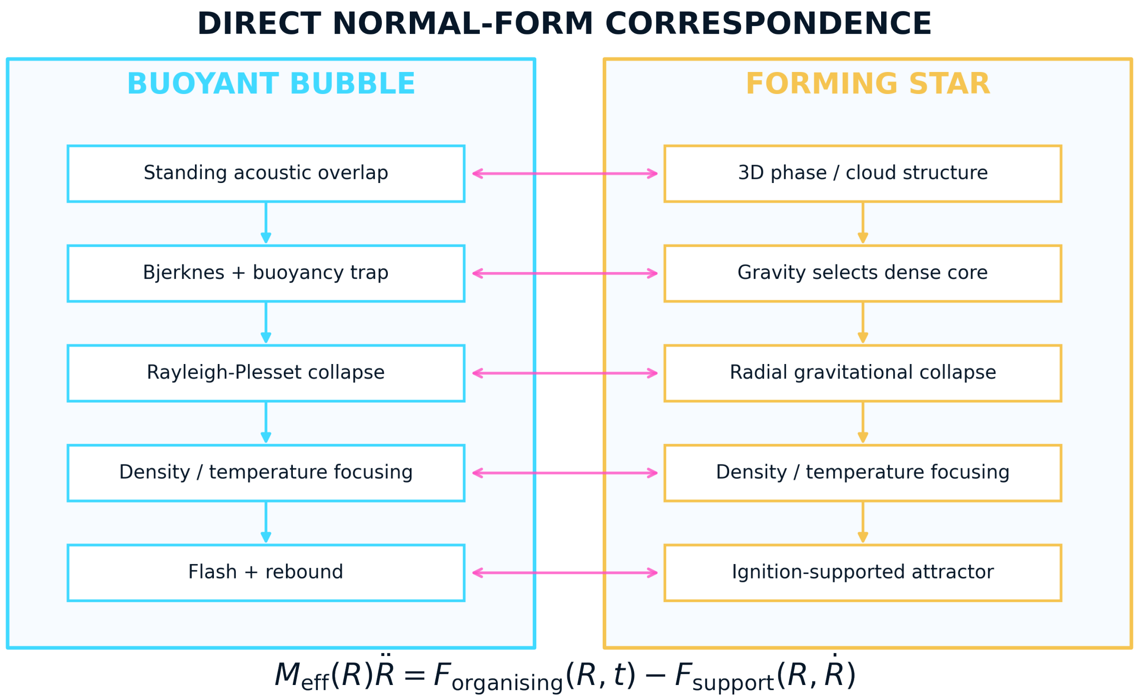

Figure 2: Direct normal-form correspondence. Horizontal arrows identify equal positions in the collapse sequence; they do not equate the underlying physical fields.

For representative single-bubble sonoluminescence values $R \sim 5\,\mu\mathrm{m}$, $\rho_g \sim 1.2\,\mathrm{kg\,m^{-3}}$, $\rho_\ell \sim 1000\,\mathrm{kg\,m^{-3}}$, and $\Delta p \sim 150\,\mathrm{kPa}$ [1], the characteristic acoustic wall acceleration is

$$a_{\rm ac} \sim \frac{\Delta p}{\rho_\ell R} \sim 3\times 10^{7}\,\mathrm{m\,s^{-2}}, \tag{10}$$

while

$$g_{\rm self,b} \sim 1.7\times 10^{-15}\,\mathrm{m\,s^{-2}}. \tag{11}$$

The ratio is

The buoyant-node limit

$$\boxed{\epsilon_b \equiv \frac{g_{\rm self,b}}{a_{\rm ac}} = \frac{4\pi G\rho_g\rho_\ell R^2}{3\Delta p} \sim 6\times 10^{-23}} \tag{12}$$

This is the clean mathematical meaning of the user's insight: the sound field is not competing with bubble self-gravity. The acoustic resonator can organise the node almost entirely through pressure geometry, surface tension, viscosity, gas pressure, diffusion, and shape stability.

The medium requirement is absolute for this acoustic mechanism. In the limit that the host liquid is removed, the mechanical pressure field and its Bjerknes force cease to exist. This is the clearest physical separation from the stellar side: the bubble's organiser is a disturbance *of matter*, while gravity is a mass-sourced field that remains defined in vacuum.

2.2 Translational node: Bjerknes force balanced by buoyancy

The time-averaged primary Bjerknes force on a pulsating bubble in a spatially varying pressure field is

$$\langle \mathbf{F}_B \rangle = -\langle V(t)\nabla p(\mathbf{x},t)\rangle\,. \tag{13}$$

A levitated equilibrium satisfies

$$\boxed{\langle \mathbf{F}_B \rangle + \mathbf{F}_{\text{buoy}} + \langle \mathbf{F}_{\text{drag}} \rangle \approx 0,} \tag{14}$$

with a restoring derivative around the equilibrium point. Detailed treatments under sonoluminescence conditions find that a Bjerknes–buoyancy balance captures the equilibrium well, with added-mass and drag corrections refining the motion [2].

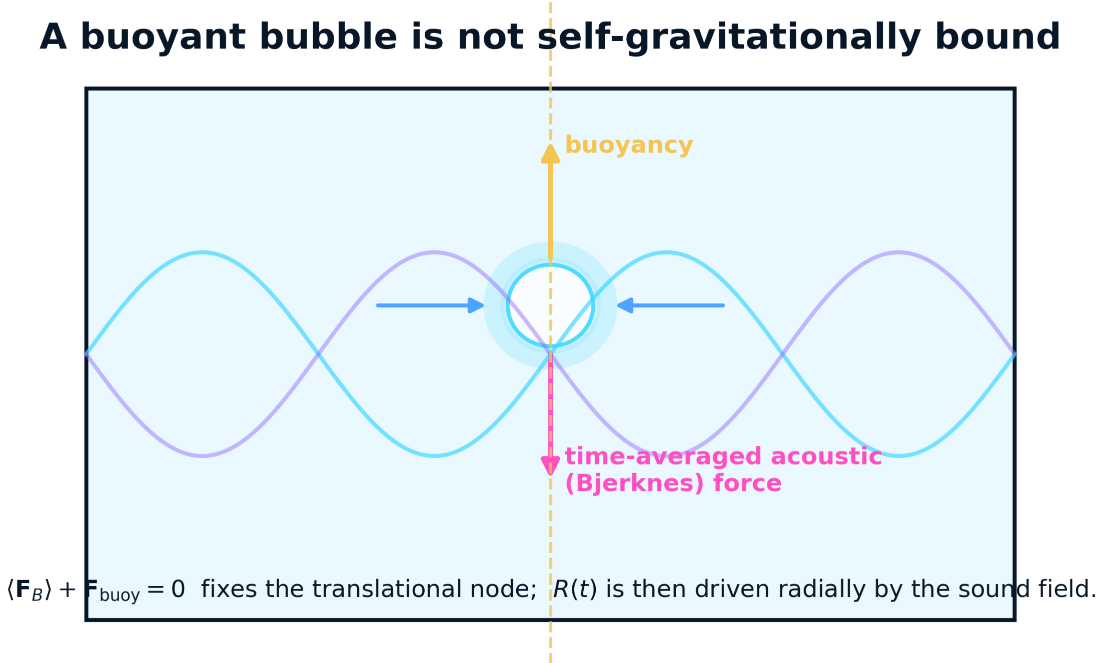

Figure 3: The bubble is translationally organised by the standing acoustic field and buoyancy. Its radial breathing $R(t)$ is a separate degree of freedom driven by the local pressure history.

2.3 Clean overlap means a stable mode, not zero disturbance

The resonator pressure can be represented as a phasor sum

$$\mathcal{P}(\mathbf{x}) = \sum_{j=1}^{N} P_j(\mathbf{x}) e^{i\psi_j(\mathbf{x})}, \qquad p(\mathbf{x}, t) = p_0 + \text{Re}\left[\mathcal{P}(\mathbf{x}) e^{-i\omega t}\right]. \tag{15}$$

Define a normalised acoustic overlap index

$$I_{\text{ac}}(\mathbf{x}) = \frac{\left|\sum_j P_j e^{i\psi_j}\right|^2}{\sum_j P_j^2 + \varepsilon}. \tag{16}$$

Then constructive mode organisation gives large I_{ac} and a reproducible local pressure amplitude

$$P_{\text{eff}}(\mathbf{x}) = |\mathcal{P}(\mathbf{x})|. \tag{17}$$

Even a nominally single-frequency standing wave is already an interference solution of incident and reflected waves. Additional frequencies or modes introduce controlled relative phases and can reshape the collapse history.

3 The mechanical system: acoustic trapping and bubble collapse

3.1 Rayleigh–Plesset dynamics

For a spherical bubble of radius $R(t)$ in a liquid of density ρ_ℓ, viscosity μ, and surface tension σ, the classical incompressible radial equation is

$$\rho_\ell\left(R\ddot{R}+\frac{3}{2}\dot{R}^2\right)=p_B(R,t)-p_\infty(t)-\frac{2\sigma}{R}-\frac{4\mu\dot{R}}{R}. \tag{18}$$

This is the Rayleigh–Plesset form used as the backbone of much single-bubble sonoluminescence modelling [3, 4]. Compressibility corrections such as Keller–Miksis become important during the most violent stages, but the structural argument below does not depend on one particular compressible closure.

Write the external pressure as

$$p_\infty(t)=p_0-P_{\text{eff}}\sin(\omega t+\phi). \tag{19}$$

The acoustic overlap therefore enters the radial equation through P_{eff}:

$$I_{\text{ac}}\to P_{\text{eff}}\to p_\infty(t)\to R(t). \tag{20}$$

3.2 Drive and support written as accelerations

Divide Eq. (18) by $\rho_\ell R$:

$$\ddot{R}+\frac{3}{2}\frac{\dot{R}^2}{R}=-\frac{p_\infty-p_B}{\rho_\ell R}-\frac{2\sigma}{\rho_\ell R^2}-\frac{4\mu\dot{R}}{\rho_\ell R^2}. \tag{21}$$

During the compressive half-cycle, define the inward pressure drive

$$\mathcal{A}_{\text{in}}^{(b)}\equiv\frac{\max[p_\infty-p_B,0]}{\rho_\ell R}, \tag{22}$$

and a positive support scale

$$\mathcal{A}_{\text{sup}}^{(b)}\equiv\frac{\max[p_B-p_\infty,0]}{\rho_\ell R}+\frac{2\sigma}{\rho_\ell R^2}+\frac{4\mu\left|\dot{R}\right|}{\rho_\ell R^2}+\mathcal{A}_{\text{shape}}+\mathcal{A}_{\text{diff}}, \tag{23}$$

where the last two terms remind us that nonspherical instabilities and mass diffusion constrain stable sonoluminescence [5, 6].

The bubble collapse number is

$$\boxed{\Lambda_b(R,t)=\frac{\mathcal{A}_{\text{in}}^{(b)}}{\mathcal{A}_{\text{sup}}^{(b)}}.} \tag{24}$$

The boundary $\Lambda_b\approx 1$ marks the local transition from support-dominated breathing toward net inward acceleration. This ratio is a reduced diagnostic, not a replacement for integrating the full bubble equation.

3.3 The luminous event

The bubble expands over much of the acoustic cycle, then contracts violently. Experiments show stable, repeatable flashes synchronised to the drive [1, 7]. During the rapid compression, the interior density rises and thermal, chemical, ionisation, and radiation processes become important [4].

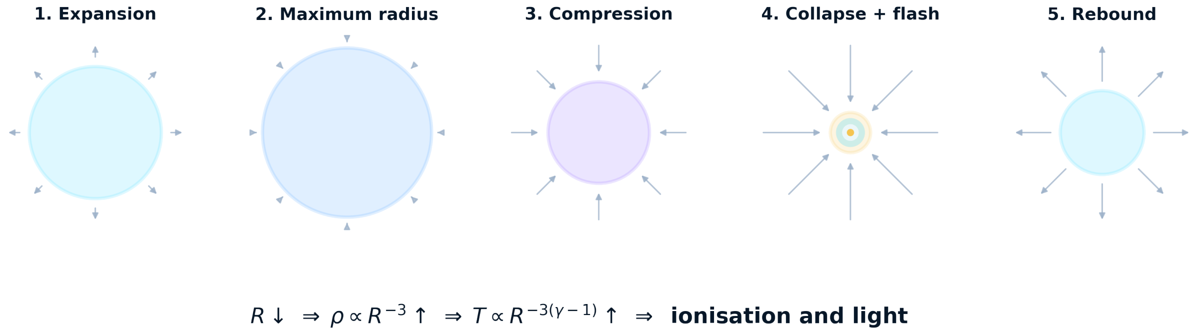

Figure 4: Schematic sonoluminescence cycle. The exact microscopic emission mechanism depends on gas composition and thermochemical conditions; the geometric fact required here is the extreme radial compression before the flash.

4 The mass-sourced system: gravity-first stellar collapse

4.1 The continuum equations

A self-gravitating gas obeys, schematically,

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0, \tag{25}$$

$$\frac{D\mathbf{u}}{Dt} = -\frac{1}{\rho}\nabla p - \nabla\Phi_g + \mathbf{a}_{\text{mag}} + \mathbf{a}_{\text{turb}}, \tag{26}$$

$$\nabla^2 \Phi_g = 4\pi G\rho. \tag{27}$$

The same momentum equation already displays the bridge: $-(1/\rho)\nabla p$ and $-\nabla\Phi_g$ are additive accelerations generated by scalar potentials per unit mass.

4.2 One-zone radial reduction

For a spherical Lagrangian shell or one-zone core of radius $R_\star(t)$ and enclosed mass M, a transparent reduced equation is

$$\ddot{R}_\star = -\frac{GM}{R_\star^2} + \alpha\frac{c_s^2}{R_\star} + \frac{j^2}{R_\star^3} + a_{\text{mag}} + a_{\text{turb}} + a_{\text{rad}}, \tag{28}$$

where c_s is a thermal/signal speed, j is specific angular momentum, and the remaining terms summarise magnetic, turbulent, and radiative support. The detailed collapse is non-homologous and develops hydrostatic cores, accretion flows, discs, and outflows [8–11]; Eq. (28) is the radial normal-form reduction, not a full stellar-formation simulation.

Define

$$\mathcal{A}_{\text{in}}^{(\star)} \equiv \frac{GM}{R_\star^2}, \tag{29}$$

$$\mathcal{A}_{\text{sup}}^{(\star)} \equiv \alpha\frac{c_s^2}{R_\star} + \frac{j^2}{R_\star^3} + a_{\text{mag}} + a_{\text{turb}} + a_{\text{rad}}. \tag{30}$$

Then

$$\boxed{\Lambda_\star(R,t) = \frac{\mathcal{A}_{\text{in}}^{(\star)}}{\mathcal{A}_{\text{sup}}^{(\star)}}.} \tag{31}$$

For a simple thermal sphere with support dominated by c_s^2/R, this becomes

$$\Lambda_\star \sim \frac{GM}{\alpha R c_s^2}, \tag{32}$$

which is the same virial/Jeans competition expressed as an inward-to-support ratio.

Figure 5: Schematic gravitational sequence. A dense core forms and collapses before a long-lived luminous star exists. Starlight is downstream of node selection, mass concentration, and heating.

5 The direct mathematical link

5.1 Pressure potential and gravitational potential

The cleanest link is dimensional and dynamical:

$$\Phi_{\mathrm{ac}} \equiv \frac{p_{\mathrm{ac}}}{\rho_\ell}, \qquad \Phi_g \equiv -\frac{GM}{R}. \tag{33}$$

Both have units of specific energy. Their gradients are accelerations:

$$-\nabla\Phi_{\mathrm{ac}} = -\frac{1}{\rho_\ell}\nabla p_{\mathrm{ac}}, \qquad -\nabla\Phi_g = -\frac{GM}{R^2}\hat{\mathbf{r}}. \tag{34}$$

At the radial scale R,

$$\boxed{\mathcal{T}: \quad \frac{\Delta p_{\mathrm{ac}}}{\rho_\ell R} \mapsto \frac{GM}{R^2}.} \tag{35}$$

Equation (35) is the direct mathematical substitution. It says the acoustic pressure drop per unit density and length occupies the same radial-acceleration slot as self-gravity. The arrow is a mapping between reduced equations, not a conversion of sound into gravity. The physical carrier on each side remains unchanged.

5.2 Universal radial normal form

Let R_0 and t_0 be characteristic scales and define $r = R/R_0$, $\tau = t/t_0$. Any radial node model with inward drive and outward support can be written

$$\frac{d^2r}{d\tau^2} + \beta(r)\left(\frac{dr}{d\tau}\right)^2 + \zeta(r)\frac{dr}{d\tau} = \mathcal{S}(r,\tau)\,[1 - \Lambda(r,\tau)], \tag{36}$$

where $\mathcal{S} > 0$ sets the support scale. For the Rayleigh–Plesset reduction, $\beta(r)$ contains the familiar geometric inertial term. For a stellar shell, β may be zero in the simplest Lagrangian reduction and the complexity moves into $\mathcal{S}$ and Λ. The bifurcation statement is nevertheless identical:

$$\Lambda < 1: \quad \text{support-dominated or bounded breathing,} \tag{37}$$
$$\Lambda = 1: \quad \text{instantaneous support-loss boundary,} \tag{38}$$
$$\Lambda > 1: \quad \text{net inward collapse branch.} \tag{39}$$

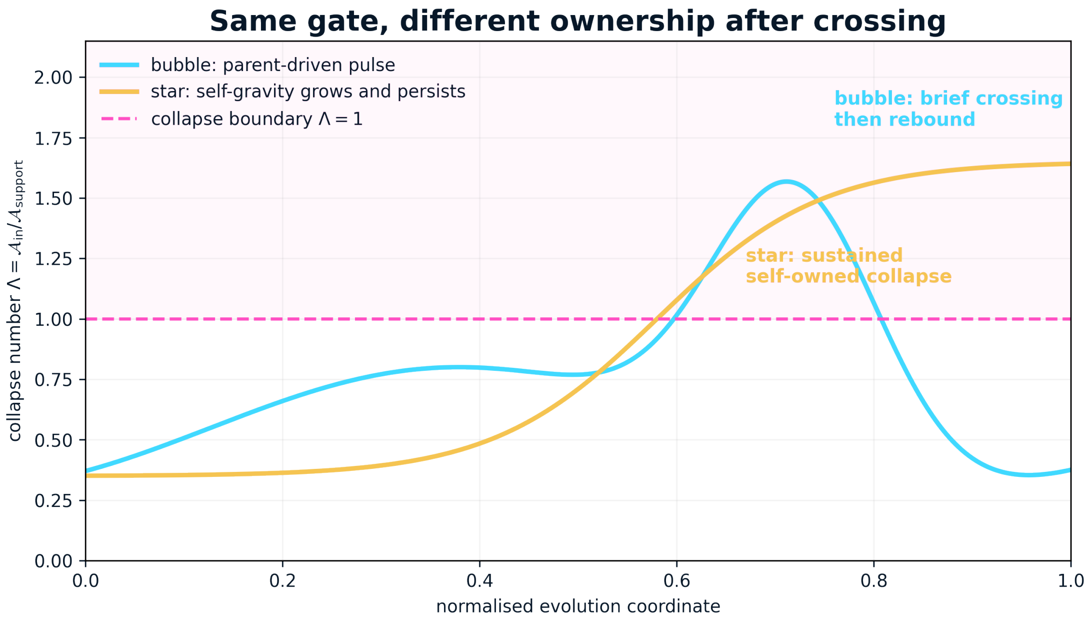

Figure 6: Schematic collapse number. A sonoluminescent bubble crosses the boundary briefly under periodic parent drive and rebounds. A gravitational core can remain above the boundary because self-gravity grows and persists. Curves are explanatory, not fitted data.

5.3 Equivalent effective-potential statement

Both systems can also be represented as radial motion in a time-dependent effective potential:

$$M_{\text{eff}}(R)\ddot{R} + \Gamma(R)\dot{R} = -\frac{\partial U_{\text{eff}}(R,t)}{\partial R}. \tag{40}$$

A breathing node corresponds to a stable minimum

$$\partial_R U_{\text{eff}} = 0, \qquad \partial_R^2 U_{\text{eff}} > 0. \tag{41}$$

The critical collapse event occurs when the minimum becomes marginal and disappears:

$$\partial_R U_{\text{eff}} = 0, \qquad \partial_R^2 U_{\text{eff}} = 0. \tag{42}$$

This is the normal-form meaning of “support failure.”

6 Shared collapse geometry, different luminous endpoints

For a finite mass compressed approximately spherically,

$$\rho(R) = \frac{3M}{4\pi R^3} \quad \Longrightarrow \quad \rho \propto R^{-3}. \tag{43}$$

For an approximately adiabatic gas,

$$PV^\gamma = \text{constant}, \qquad T \propto \rho^{\gamma-1} \quad \Longrightarrow \quad T \propto R^{-3(\gamma-1)}. \tag{44}$$

These relations provide the common geometric amplifier. A radius change is cubed in density and multiplied by the equation of state in temperature.

The endpoints differ:

Sonoluminescent bubble.
The acoustic phase reverses; the parent field still owns the cycle. The bubble emits a brief flash and rebounds or repeats.

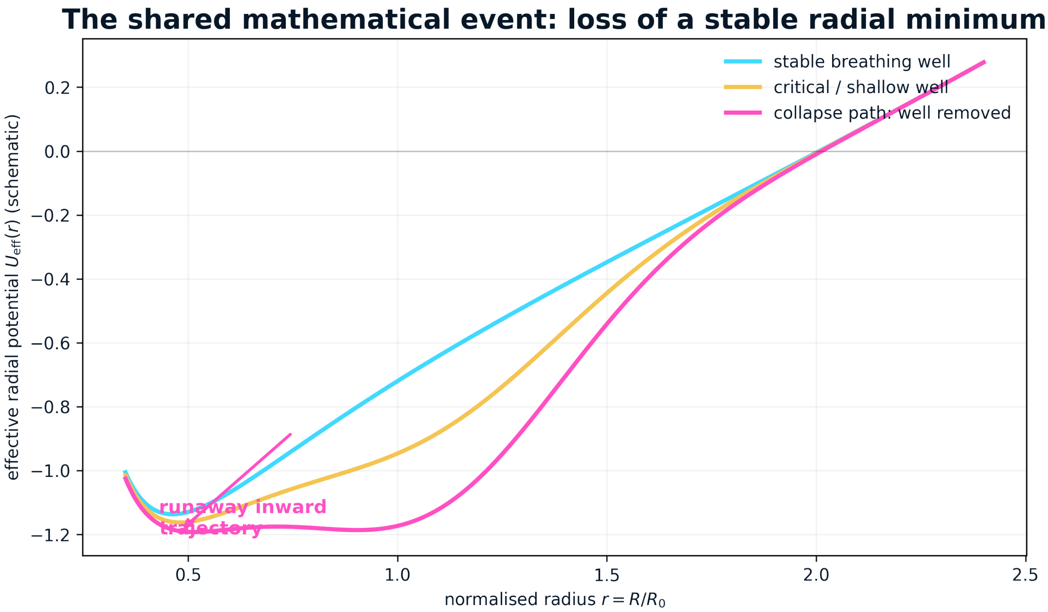

Figure 7: The shared mathematical event is loss of a stable radial minimum. The physical terms inside U_{eff} differ; the bifurcation structure does not. Schematic only.

Forming star.
Self-gravity remains present after contraction. The central core becomes opaque, hydrostatic stages form, accretion continues, and sufficiently advanced contraction eventually permits sustained nuclear burning.

The key causal order

In both systems, light is downstream of field organisation and nonlinear compression. The luminous event is evidence that the node concentrated energy; it is not the mechanism that selected the node.

7 RBFL/RBFT: the proposed coherence layer

7.1 The locked acceleration statement

RBFL/RBFT writes its proposed three-dimensional acceleration as [12, 13]

$$\boxed{\mathbf{g}_{\mathrm{RBFL}} = \mathbf{g}_b + C_\Phi(\mathbf{r}, t)\sqrt{a_\Phi |\mathbf{g}_b|}\,\hat{\mathbf{g}}_b.} \tag{45}$$

Here $\mathbf{g}_b = -\nabla\Phi_b$ is the ordinary baryonic field. The square-root term supplies the proposed saturated phase response, and C_Φ is the local coherence/impedance factor. The sine-intersection paper explicitly treats the interference mechanism as an interpretation of C_Φ, not as an additional hidden force term.

7.2 Phase-overlap index

A schematic baryonic phase contribution is

$$\Phi_i(\mathbf{r}, t) = A_i(\mathbf{r}, t)\sin(\mathbf{k}_i \cdot \mathbf{r} - \omega_i t + \theta_i)\,. \tag{46}$$

The normalised phasor intensity is

$$I_\Phi(\mathbf{r}, t) = \frac{\left|\sum_i A_i e^{i\psi_i}\right|^2}{\sum_i A_i^2 + \varepsilon}, \tag{47}$$

with

$$C_\Phi = \mathcal{C}[I_\Phi, \nabla I_\Phi, \partial_t I_\Phi, \rho_b, \mathcal{G}]. \tag{48}$$

A proposed stable amplified node satisfies [12]

$$C_\Phi > 1, \qquad \nabla C_\Phi = 0, \qquad H[C_\Phi] \prec 0, \qquad \partial_t C_\Phi \approx 0. \tag{49}$$

7.3 The acoustic-to-RBFL overlap map

The direct interference correspondence is

$$\boxed{I_{\mathrm{ac}} = \frac{\left|\sum_j P_j e^{i\psi_j}\right|^2}{\sum_j P_j^2 + \varepsilon} \qquad \longleftrightarrow \qquad I_\Phi = \frac{\left|\sum_i A_i e^{i\psi_i}\right|^2}{\sum_i A_i^2 + \varepsilon}.} \tag{50}$$

The mathematical operator is identical: coherent phasor addition followed by normalised intensity. The physical amplitudes are not identical. Acoustic P_j are pressure-mode amplitudes. RBFL A_i are proposed phase-response amplitudes attached to baryonic anchors.

7.4 RBFL stellar-collapse equation

For a spherical baryonic core, Eq. (45) gives the proposed inward acceleration magnitude

$$g_{\mathrm{RBFL}}(R) = \frac{GM}{R^2} + C_\Phi(R,t)\sqrt{a_\Phi \frac{GM}{R^2}}. \tag{51}$$

The RBFL one-zone stellar equation is therefore

Proposed RBFL gravity-first collapse equation

$$\boxed{\ddot{R}_\star = -\left[\frac{GM}{R_\star^2} + C_\Phi\sqrt{a_\Phi \frac{GM}{R_\star^2}}\right] + \mathcal{A}_{\mathrm{sup}}^{(\star)}.} \tag{52}$$

The corresponding RBFL collapse number is

$$\boxed{\Lambda_{\star,\mathrm{RBFL}} = \frac{\dfrac{GM}{R^2} + C_\Phi\sqrt{a_\Phi \dfrac{GM}{R^2}}}{\alpha\dfrac{c_s^2}{R} + \dfrac{j^2}{R^3} + a_{\mathrm{mag}} + a_{\mathrm{turb}} + a_{\mathrm{rad}}}.} \tag{53}$$

This is the exact location where the RBFL hypothesis can be tested: does a baryon-derived, independently predicted C_Φ improve predictions of collapse boundaries or core evolution without being fitted to the same outcome?

8 Parent ownership and field handoff

8.1 A natural ownership parameter

Define the fraction of the inward organisation supplied by the local self-field:

$$H \equiv \frac{\mathcal{A}_{\mathrm{self}}}{\mathcal{A}_{\mathrm{self}} + \mathcal{A}_{\mathrm{parent}} + \varepsilon}. \tag{54}$$

For the bubble,

$$\mathcal{A}_{\mathrm{self}} \approx g_{\mathrm{self,b}} \approx 0, \qquad H_b \approx 0. \tag{55}$$

The bubble remains an acoustic-parent-owned node.

For the star,

$$\mathcal{A}_{\text{self}} = \frac{GM}{R^2} \quad \text{or under RBFL} \quad \frac{GM}{R^2} + C_\Phi \sqrt{a_\Phi \frac{GM}{R^2}}, \tag{56}$$

which grows relative to the parent cloud/environment as M accumulates and R shrinks. Thus $H_\star$ can approach unity.

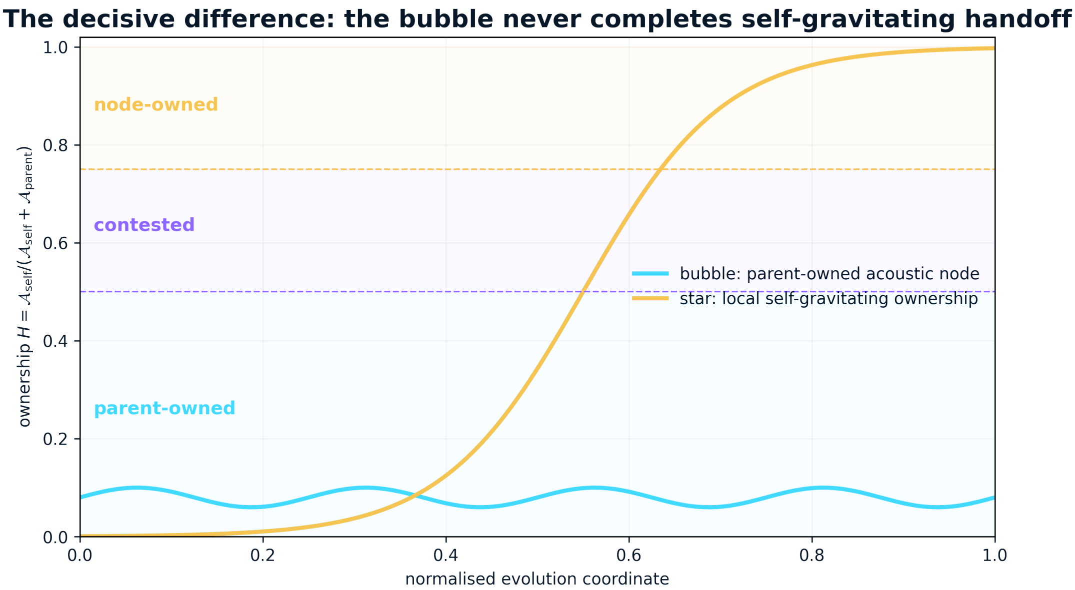

Figure 8: The direct difference between the two limits. The bubble remains parent-driven. The stellar core can complete a local self-gravitating handoff. Curves are schematic.

8.2 RBFL engineered handoff language

The prior RBFL ignition report defined a control-layer handoff coefficient and a parent-proximity breathing term [14]. In its own engineering notation,

$$H_{\text{handoff}} = \frac{\chi_{\text{node}}}{\chi_{\text{node}} + \chi_{\text{parent}}}, \tag{57}$$

and temporary breathing was represented by a parent-clamp function $B_{\text{prox}}(t)$. The present paper does not import those engineering controls into the gravity law. It uses the same conceptual lesson: a node can be stable through bounded oscillation and ordered ownership transfer rather than static perfect confinement.

9 Why the correspondence is direct but not an identity claim

The link is direct at five mathematical levels:

1. **Potential level:** p/ρ and Φ_g are specific-energy potentials.
2. **Momentum level:** $-(1/\rho)\nabla p$ and $-\nabla\Phi_g$ enter the same acceleration equation.
3. **Radial level:** $\Delta p/(\rho R)$ and GM/R^2 occupy the same inward-drive slot.
4. **Stability level:** both lose a stable radial equilibrium when inward drive exceeds support.
5. **Compression level:** both amplify density as R^{-3} and temperature through the equation of state.

The differences are equally important:

1. The acoustic field is externally driven and periodic; gravity is sourced by mass-energy and can persist without a periodic driver.

2. The bubble's self-gravity is negligible; the protostar's self-gravity is the central organising interaction.
3. Surface tension and liquid inertia dominate bubble boundaries; gas pressure, radiation, rotation, turbulence, and magnetic stresses dominate stellar support.
4. Sonoluminescence is a transient flash; stellar ignition is a long-lived nuclear attractor after multiple collapse stages.

The direct-link sentence

A sonoluminescent bubble is the mechanically driven, buoyant, negligible-self-gravity limit of a general radial node-collapse equation. A forming star is the mass-sourced, self-gravitating, handoff-completing limit of that same equation. The organiser is different; the instability topology is shared. RBFL proposes that a baryon-anchored coherence functional helps select and strengthen the gravitational node without turning gravity into sound.

10 Falsifiable predictions created by the bridge

A useful bridge must predict more than "both things collapse." The following tests are designed to separate a real cross-scale law from a flexible analogy.

10.1 Prediction 1: phase-controlled acoustic overlap

For two controlled acoustic components,

$$\mathcal{P} = P_1 e^{i\psi_1} + P_2 e^{i\psi_2}, \tag{58}$$

so

$$|\mathcal{P}|^2 = P_1^2 + P_2^2 + 2P_1P_2 \cos \Delta\psi. \tag{59}$$

The bridge predicts that collapse severity, flash timing, and the stable operating region should track a declared overlap functional after ordinary frequency-response and power differences are controlled. A frozen model must predict held-out phase settings.

10.2 Prediction 2: collapse-number data collapse

After normalising radius and time, runs with different acoustic pressures, equilibrium radii, and fluid properties should partially collapse onto families parameterised by Λ_b. The analogous star-core models should organise by $\Lambda_\star$ or $\Lambda_{\star,\mathrm{RBFL}}$. A useful universality claim requires the same transition boundary, not merely separately tuned fits.

10.3 Prediction 3: loss-of-minimum precursor

Before the violent collapse, the reconstructed radial effective potential should show a shallowing minimum and a measurable reduction in local restoring frequency. The same precursor should appear in a reduced stellar-core potential before runaway contraction.

10.4 Prediction 4: ownership distinguishes rebound from persistence

The post-threshold outcome should be classified by H. Systems with $H \approx 0$ remain parent-driven and rebound when the drive reverses. Systems in which H rises toward unity should persist in self-owned contraction or a hydrostatic attractor.

10.5 Prediction 5: RBFL-specific burden

The RBFL-specific claim is not supported merely because the standard acoustic and gravitational equations share a normal form. RBFL must predict C_Φ from declared baryonic geometry before the target collapse outcome is inspected. If fitted residuals are needed to define C_Φ, the bridge does not validate the law.

11 Decisive laboratory programme

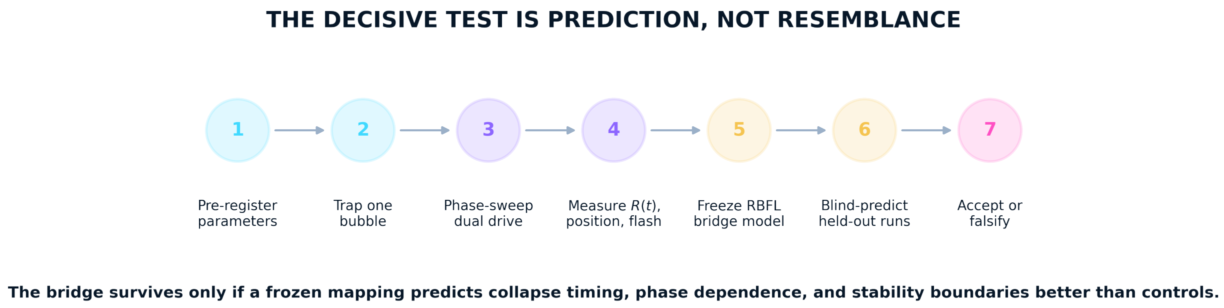

Figure 9: A critic-safe programme. The model is frozen before held-out conditions are measured.

11.1 Apparatus

A decisive sonoluminescence test would record, synchronously:
- acoustic pressure and phase at the bubble location;
- three-dimensional bubble position and translational oscillation;
- high-speed or stroboscopic radius history $R(t)$;
- flash timing and integrated optical intensity;
- liquid temperature, dissolved-gas concentration, gas composition, and static pressure;
- drive harmonics and resonator transfer function.

11.2 Protocol

1. Pre-register the standard bubble model and the additional overlap/RBFL bridge functional.
2. Calibrate the resonator without a bubble, then with a non-luminous bubble.
3. Identify a stable single-bubble operating window without optimising against flash output.
4. Sweep relative phase at energy-matched settings.
5. Split conditions into discovery and untouched holdout sets.
6. Freeze all functional forms and coefficients.
7. Predict holdout $R(t)$, collapse time, flash phase, and stable/unstable classification.
8. Compare against standard Rayleigh–Plesset and Keller–Miksis baselines using held-out likelihood, calibration, and ablation tests.

11.3 Required controls

- equal-energy random-phase controls;
- single-frequency controls;
- reversed phase order;
- no-bubble photodetector background;
- non-luminous trapped bubble controls;

- blinded analysis of held-out runs;
- sensitivity analysis for gas diffusion, liquid temperature, shape instability, and resonator drift.

12 What would falsify the direct-link hypothesis?

The proposed bridge is weakened or falsified if any of the following occur:

1. No declared normalisation produces a stable cross-condition collapse boundary; each case needs unrelated tuning.
2. Relative phase has no predictive effect once local pressure amplitude and resonator transfer are controlled.
3. The effective-potential precursor does not appear before collapse.
4. The ownership parameter has no relation to rebound versus persistent contraction in independently simulated systems.
5. The RBFL coherence factor cannot be predicted from baryonic geometry before the outcome is known.
6. A standard model predicts all held-out bubble and stellar observables equally well or better without the additional RBFL layer.

13 What is established, derived, proposed, and still missing

Status	Statement
Established	Single-bubble sonoluminescence consists of an acoustically trapped, periodically driven bubble that undergoes strong collapse and emits short light flashes.
Established	Bubble levitation under relevant conditions can be analysed through a balance of time-averaged acoustic/Bjerknes force, buoyancy, drag, and added-mass effects.
Established	Molecular-cloud cores can undergo self-gravitating collapse, form hydrostatic cores and protostars, and grow through accretion before main-sequence stellar ignition.
Derived here	p/ρ and gravitational potential have identical dimensions; their gradients occupy the same acceleration slot; $\Delta p/(\rho R)$ maps directly to GM/R^2 in a radial reduction.
Derived here	Both systems admit the same drive-versus-support collapse number and loss-of-stable-minimum normal form.
Proposed	The bubble is the parent-driven negligible-self-gravity limit, while star formation is the self-gravitating handoff limit of a broader node-collapse class.
RBFL hypothesis	C_Φ is a baryon-anchored volumetric phase-coherence response that strengthens the gravitational organising term.
Not yet established	Acoustic and gravitational organisation are manifestations of one microscopic field, or that RBFL uniquely explains sonoluminescence or star formation.

Table 2: Evidence boundary. This table should accompany every public presentation of the result.

14 Conclusion

Final synthesis

The sonoluminescent bubble is buoyant and effectively free of self-gravitational binding. This removes internal gravity as a competing organiser and allows a mechanical standing pressure field in the liquid to establish a clean translational trap, coherent radial breathing, and a sharply timed collapse. The bubble crosses an inward-drive-versus-support boundary, compresses as a finite volume, emits light, and rebounds because the parent acoustic cycle remains in control. A forming star crosses the same radial-instability boundary with a mass-sourced gravitational field in the organising slot. Under the RBFL hypothesis, the baryonic field is supplemented by a volumetric coherence response. Unlike the acoustic drive, gravity does not require a liquid and does not reverse simply because a resonator cycle changes sign. As mass accumulates, the local core can take ownership of the collapse, form hydrostatic structures, accrete, and eventually reach sustained nuclear ignition.

The re-framed bridge is therefore

Different fields, same collapse gate

$$\boxed{\underbrace{-\frac{1}{\rho_\ell}\nabla p_{\text{ac}}}_{\substack{\text{mechanical pressure organiser}\\ \text{liquid medium required}}} \quad\longleftrightarrow\quad \underbrace{-\nabla\Phi_b + C_\Phi\sqrt{a_\Phi|\mathbf{g}_b|}\,\hat{\mathbf{g}}_b}_{\substack{\text{mass-sourced gravitational organiser}\\ \text{material medium not required}}}} \tag{60}$$

with

$$\boxed{\Lambda = \frac{|a_{\text{organiser}}|}{|a_{\text{support}}|} > 1 \quad\Longrightarrow\quad \text{nonlinear radial collapse.}} \tag{61}$$

The bubble is therefore an Earth laboratory for the proposed *node-collapse mathematics*, not a claim that gravity is acoustic. Evidence for RBFL requires a frozen coherence model to predict held-out phase, threshold, radius-history, and stability data better than the standard physical baselines. The deeper theory wins only if nature returns those predictions without post-hoc rescue.

A Derivation of the bubble self-gravity suppression ratio

For a spherical gas bubble,

$$M_b = \frac{4\pi}{3}\rho_g R^3, \tag{62}$$

so

$$g_{\text{self,b}} = \frac{GM_b}{R^2} = \frac{4\pi}{3}G\rho_g R. \tag{63}$$

The pressure-driven acceleration scale is

$$a_{\text{ac}} \sim \frac{\Delta p}{\rho_\ell R}. \tag{64}$$

Therefore

$$\epsilon_b = \frac{g_{\text{self,b}}}{a_{\text{ac}}} = \frac{4\pi G\rho_g\rho_\ell R^2}{3\Delta p}. \tag{65}$$

The R^2 dependence makes self-gravity even less relevant as the bubble becomes smaller.

B Virial connection for a uniform stellar core

For a uniform sphere, the gravitational binding energy is

$$W = -\frac{3GM^2}{5R}. \tag{66}$$

If the kinetic plus thermal support is represented by $T \sim (3/2)M\sigma^2$, the virial parameter is

$$\alpha_{\rm vir} = \frac{5\sigma^2 R}{GM}. \tag{67}$$

The reduced collapse number obeys

$$\Lambda_\star \sim \frac{GM}{R\sigma^2} = \frac{5}{\alpha_{\rm vir}}. \tag{68}$$

Thus the drive-versus-support language is a re-expression of familiar virial logic, not an invented instability rule.

C Symbol dictionary

Symbol	Meaning
$R(t)$	Radius of the bubble or reduced stellar core.
ρ_ℓ	Host-liquid density.
ρ_g	Bubble-gas density.
p_B	Bubble interior pressure.
p_∞	Far-field or imposed acoustic pressure.
σ	Surface tension.
μ	Dynamic viscosity.
$\Phi_{\rm ac} = p/\rho_\ell$	Acoustic pressure potential per unit mass.
Φ_g	Gravitational potential.
$\mathcal{A}_{\rm in}$	Inward organising acceleration scale.
$\mathcal{A}_{\rm sup}$	Outward support/damping acceleration scale.
Λ	Collapse number $\mathcal{A}_{\rm in}/\mathcal{A}_{\rm sup}$.
$I_{\rm ac}$	Normalised acoustic phasor-overlap intensity.
I_Φ	Proposed RBFL phase-overlap intensity.
$\mathbf{g}_b$	Ordinary baryonic acceleration field.
C_Φ	RBFL compact coherence/impedance factor.
a_Φ	RBFL phase-saturation acceleration scale.
H	Natural field-ownership fraction.
$H_{\rm handoff}$	Engineering-layer node/parent ownership coefficient in the earlier RBFL ignition sandbox.

D Public communication statement

Recommended wording

Sonoluminescence and stellar birth are driven by physically different fields. The bubble is organised by a mechanical pressure wave travelling through liquid; the forming star is organised by mass-sourced gravity, with RBFL proposing an additional baryon-anchored coherence response. The direct link is mathematical: both organisers enter the inward-acceleration slot of a radial instability equation, both cross the same drive-versus-support gate, and both concentrate density and temperature as radius falls. The bubble is the parent-owned, negligible-self-gravity laboratory limit. The star is the self-gravitating, handoff-completing astronomical limit. Same collapse mathematics; different physical fields.

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