Coherence Collapse and Catastrophe Dynamics

Reduced Nonlinear Dynamics of the Coherence Field

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Abstract

The Taiji–Skyrme framework introduces a dimensionless coherence scalar $\psi(x)$ with a multi-vacuum effective potential $V_{\text{eff}}(\psi)$ and coupling to a Skyrme activity functional. In previous work, the static vacuum structure, domain walls, and cosmological Friedmann-like dynamics have been developed in terms of this scalar and its effective Lagrangian. The present document focuses on reduced, time-dependent coherence dynamics and their relation to catastrophe-theory structures.

We formulate simplified dynamical systems for $\psi(t)$ in homogeneous or quasi-homogeneous settings, including overdamped and underdamped regimes, and analyse fixed points, their stability, and parameter-dependent bifurcations. Near critical parameter values where equilibria coalesce, we show how the reduced dynamics can be mapped to standard normal forms such as fold and cusp catastrophes. The notion of "coherence collapse" is defined structurally as a rapid transition between coherence branches driven by the loss of stability of an equilibrium, rather than as literal blow-up of the field. Throughout, the analysis is kept at the level of reduced models; no claims are made about full spatio-temporal solutions beyond the assumptions stated explicitly.

1 Introduction and Scope

The coherence sector of the Taiji–Skyrme theory is described, at the classical level, by a real scalar field $\psi(x)$ with an effective Lagrangian of the form

$$\mathcal{L}_{\text{coh}} = \frac{1}{2}\partial_\mu\psi\,\partial^\mu\psi - V_{\text{eff}}(\psi) - \alpha\,\psi\,K(U), \tag{1}$$

where $V_{\text{eff}}(\psi)$ is a multi-vacuum potential and $K(U)$ is a scalar functional of the Skyrme field $U(x)$. The static analysis of this sector yields vacuum branches, domain walls, and parameter-dependent bifurcations. On cosmological scales, the homogeneous part of ψ contributes to the energy density and pressure, modifying the Friedmann equations.

In many physical contexts one is interested in the time-dependent evolution of ψ under changing external conditions or parameter drifts. Of particular interest are situations where:

- a stable branch loses stability as control parameters vary,
- the number of equilibria changes through saddle-node or cusp bifurcations,
- and the field undergoes rapid transitions between branches, interpreted as "collapse" or reorganisation of coherence.

Catastrophe theory provides a language for describing such structural changes in terms of normal forms and control parameters. The aim of this document is to formulate reduced coherence dynamics that make this connection explicit.

We will:

1. derive reduced dynamical equations for spatially homogeneous or quasi-homogeneous $\psi(t)$,
2. analyse fixed points, linear stability, and conditions for loss of stability,
3. and show how, near critical parameter values, the dynamics can be approximated by canonical fold and cusp normal forms.

The term "coherence collapse" will be used to denote rapid transitions between branches induced by such bifurcations; we explicitly avoid conflating this with mathematical blow-up (divergence of ψ in finite time), which is not generically present for bounded-below potentials with regular damping.

2 Reduced Dynamical Equations

2.1 Homogeneous overdamped and underdamped dynamics

We consider configurations where spatial gradients of ψ are negligible on the scales of interest, so that

$$\psi(x) \approx \psi(t), \tag{2}$$

and any dependence on $U(x)$ is encoded in slowly varying effective parameters. Neglecting explicit time dependence in V_{eff} and treating $K(U)$ in an averaged way, the equation of motion derived from (1) reduces, schematically, to

$$\ddot{\psi} + \Gamma\dot{\psi} + \frac{dV_{\text{eff}}}{d\psi}(\psi; \boldsymbol{h}) = 0, \tag{3}$$

where Γ is an effective damping term and $\boldsymbol{h}$ denotes a set of control parameters entering the potential (couplings, background densities, cosmological scale factors, etc.).

Assumption 1 (Effective damping). We treat Γ as a positive constant or slowly varying function, representing Hubble friction, coarse-grained interactions with other fields, or microscopic dissipation. This assumption converts the coherence dynamics into a damped, driven oscillator in a multi-well potential.

In many situations of interest, the damping is strong enough that inertial effects can be neglected on the timescales relevant for branch transitions. This leads to the overdamped approximation:

$$\Gamma \gg \left|\frac{d^2V_{\text{eff}}}{d\psi^2}\right|^{1/2}, \tag{4}$$

under which (3) reduces to a first-order gradient flow

$$\Gamma\dot{\psi} + \frac{dV_{\text{eff}}}{d\psi}(\psi; \boldsymbol{h}) = 0, \qquad \dot{\psi} = -\frac{1}{\Gamma}\frac{dV_{\text{eff}}}{d\psi}(\psi; \boldsymbol{h}). \tag{5}$$

This equation will be the main object of analysis in what follows; it defines a dynamical system in which ψ rolls down the potential landscape, with $\boldsymbol{h}$ acting as external control parameters.

2.2 Effective potential with control parameters

We write the potential explicitly as

$$V_{\text{eff}}(\psi; \boldsymbol{h}) = V_0(\psi) + V_{\text{ctrl}}(\psi; \boldsymbol{h}), \tag{6}$$

where $V_0(\psi)$ encodes the baseline multi-vacuum structure and V_{ctrl} represents deformations controlled by $\boldsymbol{h}$. For example, a double-well potential with an external bias h can be written as

$$V_{\text{eff}}(\psi; h) = \lambda(\psi^2 - \psi_0^2)^2 - h\psi, \tag{7}$$

while more general multi-branch potentials can be built from products of quadratic factors as in the vacuum-structure analysis.

The reduced dynamics (5) thus take the form

$$\dot{\psi} = f(\psi; \boldsymbol{h}), \qquad f(\psi; \boldsymbol{h}) = -\frac{1}{\Gamma}\frac{\partial V_{\text{eff}}}{\partial \psi}(\psi; \boldsymbol{h}), \tag{8}$$

which is a one-dimensional dynamical system parametrised by $\boldsymbol{h}$. Equilibria of (8) correspond to stationary points of the potential:

$$f(\psi_\star; \boldsymbol{h}) = 0 \quad \Leftrightarrow \quad \frac{\partial V_{\text{eff}}}{\partial \psi}(\psi_\star; \boldsymbol{h}) = 0. \tag{9}$$

Their stability is determined by the derivative

$$f'(\psi_\star; \boldsymbol{h}) = -\frac{1}{\Gamma}\frac{\partial^2 V_{\text{eff}}}{\partial \psi^2}(\psi_\star; \boldsymbol{h}), \tag{10}$$

so that minima of the potential ($\partial^2 V_{\text{eff}}/\partial\psi^2 > 0$) correspond to stable fixed points and maxima to unstable ones.

3 Fixed Points, Stability, and Loss of Stability

3.1 Fixed points and linearisation

The fixed points of the reduced dynamics (8) are solutions of

$$\frac{\partial V_{\text{eff}}}{\partial \psi}(\psi_\star; \boldsymbol{h}) = 0. \tag{11}$$

Linearising around a fixed point, $\psi(t) = \psi_\star + \delta\psi(t)$ with $|\delta\psi| \ll 1$, gives

$$\delta\dot{\psi} = f'(\psi_\star; \boldsymbol{h})\, \delta\psi = -\frac{1}{\Gamma} V''_{\text{eff}}(\psi_\star; \boldsymbol{h})\, \delta\psi. \tag{12}$$

Thus:

- if $V''_{\text{eff}}(\psi_\star; \boldsymbol{h}) > 0$, the fixed point is linearly stable (attractor),
- if $V''_{\text{eff}}(\psi_\star; \boldsymbol{h}) < 0$, it is linearly unstable (repeller),
- if $V''_{\text{eff}}(\psi_\star; \boldsymbol{h}) = 0$, higher-order terms determine the behaviour.

3.2 Saddle-node (fold) bifurcations

As control parameters $\boldsymbol{h}$ are varied, pairs of fixed points can appear or disappear through saddle-node (fold) bifurcations. In the reduced coherence dynamics (8), a fold bifurcation occurs at $(\psi_c, \boldsymbol{h}_c)$ when

$$\frac{\partial V_{\text{eff}}}{\partial \psi}(\psi_c; \boldsymbol{h}_c) = 0, \qquad \frac{\partial^2 V_{\text{eff}}}{\partial \psi^2}(\psi_c; \boldsymbol{h}_c) = 0, \tag{13}$$

with a nonvanishing third derivative

$$\frac{\partial^3 V_{\text{eff}}}{\partial \psi^3}(\psi_c; \boldsymbol{h}_c) \neq 0. \tag{14}$$

At such points, a stable and an unstable fixed point collide and annihilate (or are created), changing the number of available coherence branches as seen by the dynamics.

In terms of the reduced vector field $f(\psi; \boldsymbol{h})$, the fold conditions (13) translate to

$$f(\psi_c; \boldsymbol{h}_c) = 0, \qquad \frac{\partial f}{\partial \psi}(\psi_c; \boldsymbol{h}_c) = 0, \tag{15}$$

with $\partial^2 f / \partial \psi^2 \neq 0$. Close to such a point, the dynamics can be approximated by the normal form of a one-parameter saddle-node bifurcation.

3.3 "Coherence collapse" as loss of stability

Within this reduced framework, we define:

Definition (Coherence collapse). Let $\psi(t)$ evolve according to (5) with slowly varying control parameters $\boldsymbol{h}(t)$. A *coherence collapse* is a rapid transition of $\psi(t)$ from the basin of attraction of one stable fixed point (branch) to that of another, triggered by the loss of stability or disappearance of the initial fixed point under variation of $\boldsymbol{h}$.

This definition is dynamical and structural:

- collapse is not a divergence of ψ in finite time; it is a rapid relocation in configuration space between equilibria,

- the trigger is a bifurcation (typically saddle-node or cusp) where the branch structure of equilibria changes,
- the timescale of collapse is set by the local gradient of V_{eff} and the damping parameter Γ.

In the full field theory, such transitions would involve spatial inhomogeneities, fronts, or expanding domains of the new branch; here we track only the reduced, homogeneous trajectory.

In the branch language of the vacuum–structure document, the stable fixed points of the reduced dynamics correspond to minima ψ_b of the multi–vacuum potential, each labelled by a branch index $b \in \mathcal{B}$. For fixed control parameters, the normal forms (fold, cusp, etc.) therefore describe how the local order parameter $\psi(t)$ chooses one of the available branch values ψ_b and fluctuates within its basin of attraction.

A *coherence collapse event* in this reduced picture is then the loss of stability of a previously occupied branch b_{old} (for example, when its minimum disappears or becomes unstable as the control parameters cross a catastrophe surface) and the subsequent relaxation of $\psi(t)$ into a different minimum $\psi_{b_{\text{new}}}$.

The catastrophe variables thus provide a compact description of branch transitions: slow adiabatic drift of the control parameters corresponds to tracking a given branch ψ_b, while rapid collapses correspond to discrete jumps in the branch index b when a local minimum ceases to exist or ceases to be stable.

4 Mapping to Canonical Catastrophes

4.1 Fold (saddle-node) normal form

Near a fold bifurcation point $(\psi_{\text{c}}, \boldsymbol{h}_{\text{c}})$, it is convenient to introduce local coordinates

$$x = \psi - \psi_{\text{c}}, \qquad \boldsymbol{\eta} = \boldsymbol{h} - \boldsymbol{h}_{\text{c}}. \tag{16}$$

Expanding $V_{\text{eff}}(\psi; \boldsymbol{h})$ in x and $\boldsymbol{\eta}$ and retaining the leading terms consistent with (13) yields

$$V_{\text{eff}}(\psi; \boldsymbol{h}) \approx V_{\text{c}} + a(\boldsymbol{\eta})x + \frac{1}{6} b\, x^3, \tag{17}$$

where V_{c} is a constant, $a(\boldsymbol{\eta})$ is a control-parameter-dependent coefficient linear in $\boldsymbol{\eta}$ to leading order, and b is a nonzero constant proportional to the third derivative of V_{eff} at the critical point.

The reduced dynamics (5) then becomes

$$\dot{x} = -\frac{1}{\Gamma}\frac{\partial V_{\text{eff}}}{\partial x} \approx -\frac{1}{\Gamma}\left[a(\boldsymbol{\eta}) + \frac{1}{2} b x^2\right]. \tag{18}$$

Rescaling time and variables,

$$\tau = \frac{b}{2\Gamma} t, \qquad u = \sqrt{|b|}\, x, \qquad \mu = \operatorname{sgn}(b)\, a(\boldsymbol{\eta}), \tag{19}$$

one obtains the canonical fold normal form

$$\frac{du}{d\tau} = -(\mu + u^2), \tag{20}$$

up to overall sign conventions. This is the standard one-parameter saddle-node catastrophe: for $\mu < 0$ there are two fixed points (one stable, one unstable), for $\mu = 0$ they coalesce, and for $\mu > 0$ no fixed point remains.

In the coherence context, u parametrises deviations of the coherence field from the critical branch value ψ_{c}, while μ encodes the effective control parameter(s) driving the system through the bifurcation. Coherence collapse occurs as μ crosses zero, eliminating the initial stable equilibrium and forcing the system to move towards another branch.

4.2 Cusp catastrophe with two control parameters

When two independent control parameters are relevant, the local structure of equilibria can be captured by the cusp catastrophe. Consider a potential expansion of the form

$$V_{\mathrm{eff}}(\psi; a, b) \approx V_{\mathrm{c}} + \frac{1}{4}x^4 + \frac{1}{2}ax^2 + bx, \tag{21}$$

where $x = \psi - \psi_{\mathrm{c}}$ and (a, b) are control parameters constructed from the original $\boldsymbol{h}$. This is the canonical cusp potential. The equilibrium condition

$$\frac{\partial V_{\mathrm{eff}}}{\partial x} = x^3 + ax + b = 0 \tag{22}$$

defines the stationary points as a function of (a, b). The discriminant of this cubic,

$$\Delta = -4a^3 - 27b^2, \tag{23}$$

determines the number of real solutions:

- $\Delta > 0$: three real stationary points (two minima and one maximum),
- $\Delta = 0$: two coalescing stationary points (fold line),
- $\Delta < 0$: one real stationary point (single minimum or maximum).

The locus $\Delta = 0$ in the (a, b) plane is the cusp curve; inside it, the system exhibits branch multiplicity and the possibility of hysteresis as (a, b) are varied.

The reduced dynamics is again given by the gradient flow

$$\dot{x} = -\frac{1}{\Gamma}(x^3 + ax + b), \tag{24}$$

which is the canonical cusp dynamical system up to rescalings. In coherence terms:

- x measures deviation from a reference branch value,
- a and b encode combinations of physical parameters (e.g. background densities, coupling strengths, cosmological scales) that control the local curvature and tilt of the coherence potential.

As (a, b) are varied along paths crossing the cusp region, the system can undergo subcritical or supercritical transitions between branches, with possible hysteresis cycles in ψ. These transitions implement coherence collapse in a multi-parameter control space.

4.3 Relation to previous vacuum and cosmology analyses

The cusp and fold structures identified here are local descriptions of the reduced dynamics near critical points. They are consistent with the static vacuum analysis, where similar conditions on V_{eff} define changes in the number and nature of minima, and with the cosmological treatment, where $\psi(t)$ obeys a damped Klein–Gordon equation in an expanding universe.

The present document isolates the dynamical, catastrophe-theoretic aspect:

- the vacuum and domain-wall document describes the static branch structure and interfaces,
- the galaxy phenomenology document uses branch-dependent densities to build rotation curves,
- the cosmology document embeds homogeneous $\psi(t)$ into FRW dynamics,
- and the current document extracts the local reduced dynamics near critical points and identifies the corresponding catastrophe normal forms.

5 Outlook and Physical Interpretation

The analysis in this note has been deliberately restricted to a reduced, homogeneous description of the coherence scalar $\psi(t)$ evolving in an effective multi-vacuum potential $V_{\text{eff}}(\psi; h)$ with slowly varying control parameters $h(t)$. Within this framework we identified fixed points corresponding to coherence branches, studied their loss of stability under parameter drift, and reduced the local dynamics near critical points to canonical fold and cusp catastrophe normal forms.

In the full Taiji–Skyrme–Maxwell theory, coherence dynamics is embedded in a general-relativistic setting in which the total stress–energy tensor

$$T^{\text{tot}}_{\mu\nu} = T^{(U)}_{\mu\nu} + T^{(\psi)}_{\mu\nu} + T^{(\text{EM})}_{\mu\nu} + T^{(\text{other})}_{\mu\nu}$$

sources gravity through $G_{\mu\nu} = 8\pi G\, T^{\text{tot}}_{\mu\nu}$. The reduced equations analysed here should therefore be viewed as a local structural approximation for the coherence sector, not as a complete description of energy balance or gravitational collapse. In particular, electromagnetic energy and stresses enter the full problem through $T^{(\text{EM})}_{\mu\nu}$, even when they are not made explicit in the one-dimensional gradient-flow model.

5.1 Structural vs physical statements

The results obtained here are structural: they describe the local behaviour of reduced coherence dynamics under changes in effective control parameters. We have:

- constructed overdamped, one-dimensional dynamical systems for the homogeneous coherence field in a multi-vacuum potential;
- identified conditions for loss of stability through saddle-node (fold) bifurcations;
- and shown how, with two control parameters, the dynamics can be reduced locally to the canonical cusp catastrophe.

These statements follow from the assumed form of $V_{\text{eff}}(\psi; h)$ and the gradient-flow approximation; they do not, by themselves, fix the mapping between the reduced parameters (a, b, Γ, h) and specific physical quantities in a given astrophysical or cosmological setting. Nor do they specify the detailed partition of energy between the coherence sector, baryonic matter, and the Maxwell field. Whenever we speak of "collapse" in this document we mean a *loss of stability and rapid transition between coherence branches* in the reduced dynamical system, not a complete treatment of gravitational collapse or energy transport in the full Taiji–Skyrme–Maxwell model.

5.2 Possible physical roles of coherence collapse

At a qualitative level, coherence collapse in the sense defined here could play roles in:

- **Structural reorganisation of coherence patterns.** As control parameters drift (due to cosmological expansion, environmental changes, or internal evolution), a previously stable coherence branch may lose stability, prompting rapid reorganisation of the coherence field towards a new branch. In the full theory, this would manifest as expanding domains of the new branch and the formation or annihilation of domain walls, with corresponding changes in the local contributions of $T^{(\psi)}_{\mu\nu}$ to the total stress–energy tensor.
- **Phase-transition-like phenomena.** The passage through fold or cusp points can mimic first-order or continuous transitions between effective phases of the coherence sector, with associated changes in effective energy densities, equations of state, and couplings to other fields. From the point of view of the Einstein equations, this would appear as a reconfiguration of the coherence component of $T^{\text{tot}}_{\mu\nu}$, potentially altering effective pressures and sound speeds in coherence-dominated regions.
- **Triggering of macroscopic events.** In principle, coherence collapse events could be associated with sudden changes in effective gravitational potentials, matter clustering properties, or cosmological expansion rates, depending on how the coherence sector is embedded in the broader Taiji–Skyrme framework. Such events would not be described solely by the reduced equation for $\psi(t)$, but would arise from its coupling to the rest of the fields and to the background geometry through $T^{\text{tot}}_{\mu\nu}$.

These interpretations remain hypotheses until the reduced parameters are tied quantitatively to specific physical scenarios and the full spatio-temporal dynamics is analysed.

Cosmic–knot branch networks (Outlook)

Recent particle–physics work on topological "cosmic knots", in particular the scenario developed by Eto, Hamada and Nitta in their study *Tying Knots in Particle Physics* (Phys. Rev. Lett., 2025), shows that knotted and linked defects in an extended gauge–Higgs sector can temporarily dominate the cosmic energy budget and play an active role in dark matter, baryogenesis and neutrino mass generation. Within the Taiji multi–branch framework, an analogous role could be played by coherence knots built from the branch structure of ψ and its associated vacuum walls.

At the level of vacuum structure, a knotted or linked configuration may be realised as a closed, possibly knotted network of domain walls and vortex–like coherence defects whose interior is dominated by one branch b_1 and whose exterior relaxes to a different branch b_2. The interfaces between these regions are precisely the branch–indexed walls introduced in the vacuum–structure analysis, now arranged into nontrivial topological networks rather than planar or mildly curved surfaces. In this picture, the global topology of the branch–occupancy field $b(x) \in \mathcal{B}$ — including knots, links and junctions — becomes a potential cosmological degree of freedom, while the catastrophe dynamics of $\psi(t)$ provide the local mechanism by which such structures nucleate, evolve and eventually decay via branch transitions.

No detailed model is implemented here. The purpose of this outlook is only to flag that the N–branch formalism, together with its domain–wall and catastrophe dynamics, already furnishes the appropriate language to host cosmic–knot scenarios of the type envisaged by Eto, Hamada and Nitta, should we later decide to promote knotted branch networks to explicit dark–matter or baryogenesis agents within the Taiji–Skyrme framework.

5.3 Electromagnetic energy and collapse regimes

In the full GR+Taiji–Skyrme–Maxwell framework, the energy budget and forces relevant for any genuine gravitational or hydrodynamical collapse are controlled by the total stress–energy tensor

$$T^{\mathrm{tot}}_{\mu\nu} = T^{(U)}_{\mu\nu} + T^{(\psi)}_{\mu\nu} + T^{(\mathrm{EM})}_{\mu\nu} + T^{(\mathrm{other})}_{\mu\nu}.$$

The electromagnetic contribution

$$T^{(\mathrm{EM})}_{\mu\nu} = \frac{1}{g^2_{\mathrm{EM}}} \left(F_{\mu\alpha} F_{\nu}{}^{\alpha} - \frac{1}{4} g_{\mu\nu} F_{\alpha\beta} F^{\alpha\beta} \right)$$

can, in principle, supply both energy density and anisotropic stresses, for example through radiation pressure, large-scale magnetic fields, or Poynting flux. The reduced coherence dynamics studied in this note effectively correspond to regimes in which the back-reaction of

$T^{(\mathrm{EM})}_{\mu\nu}$ on the local coherence collapse is either small or absorbed into slowly varying control parameters.

It is useful to distinguish, at least conceptually, between two classes of collapse regimes:

- **Neutral, cold collapse.** In configurations where large-scale charges and currents are negligible, and where electromagnetic fields are dynamically unimportant, one may work in an electromagnetically silent regime with

$$F_{\mu\nu} \simeq 0, \qquad T^{(\mathrm{EM})}_{\mu\nu} \simeq 0.$$

  In such cases the relevant energy densities and pressures in the collapse problem are carried by the baryonic and coherence sectors, and the reduced coherence equations provide a good description of how the coherence component of $T^{\mathrm{tot}}_{\mu\nu}$ reorganises in response to parameter drift.

- **Radiative or magnetised collapse.** In configurations with strong radiation fields, intense magnetic fields, or significant Poynting flux, the electromagnetic sector can become dynamically important. Then $T^{(\mathrm{EM})}_{\mu\nu}$ contributes non-negligibly to both the energy density and the stress in the collapsing region, affecting stability, collapse timescales, and possible outflows. A faithful treatment of such regimes would require coupling the reduced coherence dynamics to explicit Maxwell evolution for A_μ, and embedding the resulting system in at least a spherically symmetric GR or Newtonian collapse model. This lies beyond the scope of the present structural analysis.

The present note therefore characterises how coherence collapse reorganises the coherence sector itself and signals potential sites of rapid change in $T^{(\psi)}_{\mu\nu}$. Whether these events lead to significant electromagnetic activity or feedback depends on the larger configuration of fields and on whether the system resides in a neutral/cold or radiative/magnetised regime as defined above. In later work, these distinctions can be made explicit by assigning concrete $T_{\mu\nu}$ components and monitoring the exchange of energy between the coherence and Maxwell sectors during collapse events.

5.4 Next steps

To turn the structural catastrophe analysis into concrete physics, several steps are required:

1. **Derive explicit $V_{\mathrm{eff}}(\psi; h)$ forms** for specific parameter regimes of the Taiji–Skyrme model, identifying the relevant control parameters and their physical meaning, including any implicit dependence on electromagnetic or matter backgrounds.

2. **Embed the reduced dynamics in full field simulations**, allowing for spatial dependence and domain-wall propagation, to verify that the local catastrophe picture captures the actual transition behaviour of the coherence field. In electromagnetically quiet regimes this can be done with $F_{\mu\nu} \simeq 0$; in magnetised or radiative regimes the Maxwell sector should be evolved alongside the coherence and Skyrme fields.

3. **Connect to observables** by studying how coherence collapse events would imprint on galaxy structure, gravitational potentials, or cosmological observables, and whether such signatures are compatible with current data. Particular attention should be paid to scenarios in which coherence collapse coincides with significant rearrangements of $T_{\mu\nu}^{(\mathrm{EM})}$, potentially leading to bursts of electromagnetic emission or changes in effective radiation pressure.

Summary. We have formulated a reduced, dynamical description of the coherence scalar in the Taiji–Skyrme framework and analysed its behaviour near parameter-dependent critical points. Using an overdamped gradient-flow approximation, we identified

- fixed points corresponding to coherence vacuum branches,
- conditions for loss of stability via fold (saddle-node) bifurcations,
- and local reductions to canonical fold and cusp catastrophe normal forms.

Coherence collapse, in this structural sense, is understood as a rapid transition between coherence branches triggered by bifurcations in the reduced dynamics, not as a divergence of the field. The role of electromagnetic energy and stresses is implicit in the present treatment: they enter the full problem through $T_{\mu\nu}^{(\mathrm{EM})}$ and must be made explicit when one embeds the reduced coherence dynamics into concrete collapse or outflow scenarios. The analysis here provides a mathematically controlled language for discussing non-linear reorganisation of coherence and sets the stage for future quantitative studies that tie these structures, together with their electromagnetic environments, to astrophysical and cosmological phenomena.