Two Anchors for the Attractor Framework: Hydrogen and the Jeans Instability Application Paper – June 2026 [A] (Application)

Abstract

The attractor framework has been extended beyond the original variables of basin depth (B) and corrective permeability (κ) to include **energy barrier (B_E)** , **threshold depth (B_T)** , and **channel accessibility (C)** . This paper provides empirical anchoring for these extensions using two well-understood physical systems: the hydrogen atom and the Jeans instability of a gas cloud. Hydrogen's 2p and 2s transitions have identical B_E (10.2 eV) yet differ in κ by eight orders of magnitude. This demonstrates that B_E alone is insufficient; a second parameter (C) is required. The ratio of their Einstein A-coefficients is independently predicted by quantum electrodynamics (dipole vs. two-photon processes), providing a non-circular check of the factorised form. The Jeans instability provides a contrasting case: a deterministic bifurcation where the collapse threshold is a **threshold depth B_T = M/M_J − 1** (for M > M_J). The linear growth rate of the instability scales as Γ∝BTΓ∝*BT*□□, a power law, in contrast to the exponential Arrhenius form of hydrogen. Together, these two test cases validate the extended attractor framework across both noise-driven escape and deterministic bifurcation regimes, using a shared vocabulary (B_E, B_T, C, κ) while acknowledging that each regime draws on the appropriate subset.

1. Introduction

The attractor framework originally described persistence using basin depth B and corrective permeability $\kappa = 1/\tau$. However, the hydrogen atom revealed a critical limitation: two states with identical B (the 2p and 2s levels) have vastly different κ. This forced the introduction of **channel accessibility (C)** , leading to the extended expression for noise-driven escape: $\kappa_{i\to j} = \nu_0\, C_{ij}\, e^{-B_{E,ij}/\sigma}$

where B_E is the energy barrier, σ is noise (e.g., kT), and ν_0 an attempt frequency. For deterministic bifurcations (e.g., gravitational collapse of a gas cloud), a different descriptor is needed: **threshold depth (B_T)** , with κ (or the growth rate of the instability) following a power law rather than an exponential. This paper demonstrates that both extensions are empirically grounded, using hydrogen to illustrate the need for C and the Jeans instability to illustrate the need for B_T.

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2. Hydrogen: The Need for Channel Accessibility C

2.1 Data

Transition	**B_E (eV)**	**κ (s^{-1})**	**Measured A-coefficient**	**Process**
2p → 1s	10.2	6.26×10^{8}	6.26×10^{8} s^{-1}	Electric dipole (E1)
2s → 1s	10.2	8.22	8.22 s^{-1}	Two-photon (E1E1)

2.2 Why B_E Alone Fails

Both states have the same energy barrier to the ground state (10.2 eV), yet their decay rates differ by eight orders of magnitude. This shows that the basin depth B (here represented by B_E) is insufficient to determine κ; a second parameter must be introduced.

The framework defines **C** as a dimensionless channel accessibility. For a given transition mechanism (e.g., electric-dipole), C is the ratio of the actual transition probability to the theoretical maximum for that mechanism. For the 2p → 1s E1 transition, we set C = 1. The 2s → 1s decay is not an E1 transition at all; it proceeds via a different physical process (two-photon emission). Its rate is independently calculated from quantum electrodynamics without reference to the framework. The ratio of the two measured rates ($\approx 10^8$) is predicted by QED and is not a free parameter. Therefore, the factorised form κ ∝ C e^{-B_E/σ} with B_E identical implies that C must account for the entire rate difference. This is consistent with the independent QED prediction, providing a non-circular validation that an additional channel-dependent parameter is needed.

Note: The 2s→1s process is not a suppressed version of the same channel; it is a different channel (two-photon vs. single-photon). For the purpose of validating the need for a channel-specific parameter, this is sufficient. The framework's C parameter is better illustrated by comparing allowed E1 transitions with different matrix elements (e.g., 2p→1s and 3p→1s), where the same mechanism applies and the ratio of C values is independently known. In any case, hydrogen irrefutably demonstrates that B_E alone does not determine κ.

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3. Gas Cloud (Jeans Instability): Threshold Depth and Power-Law Scaling

3.1 The Bifurcation Regime

A uniform, isothermal, self-gravitating gas cloud of mass M has a critical **Jeans mass** M_J. For $M > M_J$, the cloud is unstable to gravitational collapse; for $M < M_J$, it is stable. The transition is a **saddle-node bifurcation** in the dynamical landscape.

3.2 Attractor Variables for a Deterministic Bifurcation

- **Threshold depth**: $B_T = M/M_J - 1$ (for $M > M_J$). At $B_T = 0$ the bifurcation occurs.
- **Energy barrier**: For a deterministic bifurcation, there is no thermal barrier; B_E is not defined. The transition is controlled solely by the distance to threshold.
- **Growth rate**: For $M > M_J$, the linear growth rate Γ of the instability is the inverse of the collapse time. This serves as the analogue of κ in this regime.

3.3 Scaling Law from Linear Stability Analysis

The standard Jeans dispersion relation for a self-gravitating, isothermal medium gives:

$$\omega^2 = k^2 c_s^2 - 4\pi G \rho_0,$$

where $c_s = \sqrt{kT/(\mu m_H)}$ is the sound speed and ρ_0 the background density. For a cloud of mass M, the critical wavenumber is $k_J = \sqrt{4\pi G \rho_0}/c_s$. For $M > M_J$, the longest wavelength (smallest k) is unstable, and the growth rate is

$$\Gamma = \sqrt{4\pi G \rho_0 - k^2 c_s^2}.$$

Near the threshold, the deviation can be expressed in terms of B_T. Using the relation between cloud size and density, one finds $\Gamma \propto \sqrt{B_T}$. Hence the collapse time $\tau \sim 1/\Gamma \sim B_T^{-1/2}$. This is a power law with exponent 1/2, in contrast to the exponential Arrhenius form of hydrogen.

On the stable side (M < M_J), the frequency ω is real, giving oscillatory sound waves. Without a dissipative mechanism, there is no exponential recovery; thus the concept of a "recovery rate" κ is not directly applicable. The framework's threshold depth B_T is best understood as a control parameter on the unstable side.

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4. Synthesis: Shared Vocabulary, Distinct Descriptors

Feature	**Hydrogen**	**Jeans Instability**
Regime	Noise-driven quantum escape	Deterministic bifurcation
Primary descriptor	B_E (energy barrier)	B_T (threshold depth)
Second descriptor	C (channel accessibility)	Not required (power-law exponent fixed)
Scaling	Exponential: $\kappa \propto C e^{-B_E/\sigma}$	Power law: $\Gamma \propto B_T$

Both systems are described by the same conceptual **vocabulary** (basin depth, corrective permeability, threshold, accessibility), but each regime draws on the appropriate subset. Hydrogen validates the need for a channel-specific factor C, while the Jeans instability validates the concept of a threshold depth B_T and the associated power-law scaling.

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5. Conclusion

The hydrogen atom and the Jeans instability provide empirical support for the extended attractor framework. Hydrogen shows that identical energy barriers can yield vastly different transition rates, necessitating a channel accessibility parameter C. The Jeans instability shows that deterministic bifurcations are governed by a threshold depth B_T and follow power-law scaling, distinct from the exponential Arrhenius law. Together, these two test cases anchor the framework across two fundamental classes of attractor transitions. The next step is to extend the approach to dissipative systems and to social/cognitive attractors, where C may become state-dependent and network-derived.

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