

From Nebula to Galaxy: A First-Principles Derivation of Structure Formation and Flat Rotation Curves in the Eholoko Fluxon Model

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Abstract

The standard Λ CDM model of cosmology requires the existence of cold dark matter to explain the formation of galaxies and their observed flat rotation curves. This paper presents a complete, first-principles derivation of these phenomena from the axioms of the Eholoko Fluxon Model (EFM) without invoking dark matter. We transparently document the scientific journey, beginning with the falsification of simpler hypotheses and culminating in a definitive, multi-stage computational validation.

We demonstrate that an isolated, energetic soliton in the EFM vacuum is unstable and radiates its energy away, a crucial null result that necessitates the inclusion of a larger-scale environment. By placing an oscillating soliton within a primordial, large-scale potential well (an S/T halo), we successfully simulate the formation of a stable, confined, multi-ring resonant structure—a "Fluxon Resonator"—analogous to a galactic nebula.

We then show that by applying a "cooling" mechanism (increasing dissipation) to this emergent nebula, the resonant rings become unstable and fragment, collapsing into a cluster of distinct, second-generation S=T solitons (stars). The long-term evolution of this star cluster is then simulated, revealing that the individual solitons merge and gravitationally relax into a single, stable, coherent proto-galaxy.

Finally, we perform the definitive test by measuring the rotation curve of this emergent galaxy. The result is a chaotic inner region and a perfectly flat outer rotation curve, a stunning agreement with observation. This work provides a complete, computationally validated, and unbroken causal chain—from halo to nebula to stars to a galaxy with a flat rotation curve—offering a viable, mechanistic alternative to the dark matter paradigm.

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1 Introduction: The Dark Matter Problem

The observed dynamics of spiral galaxies present a foundational challenge to modern physics. According to standard gravitational theory, the orbital velocity of stars should decrease with their distance from the galactic center. Instead, observations consistently reveal that rotation curves become nearly flat at large radii [1]. The prevailing solution to this discrepancy is the hypothesis of cold dark matter (CDM), a non-baryonic, non-interacting substance that forms a massive halo around galaxies, providing the necessary gravitational pull [2]. While the Λ CDM model is remarkably successful, dark matter has never been directly detected, motivating the search for alternative explanations.

The Eholoko Fluxon Model (EFM) offers such an alternative [3]. The EFM posits that all phenomena, including gravity and matter, emerge from the dynamics of a single scalar field (ϕ) operating in different Harmonic Density States (HDS). It proposes that the phenomenon attributed to dark matter is not a new particle, but an emergent gravitational effect of the complex, multi-state structure of baryonic matter and its interaction with the surrounding vacuum fields.

This paper presents the definitive computational proof of this hypothesis. We document a complete scientific program, beginning with a series of crucial null results that falsified simpler models, and culminating in a multi-stage simulation that derives a stable, proto-galaxy from first principles. We then measure the rotation curve of this emergent object, demonstrating that it is naturally flat, thereby providing a complete, mechanistic alternative to the dark matter hypothesis. The full sequence of experiments is documented in the ‘nebulae.ipynb’ notebook for complete transparency [4].

2 A Journey Through Falsification: The Necessity of Environment

The scientific method progresses not just through success, but through the rigorous analysis of failure. Our initial attempts to model the formation of complex structures were based on intuitive but ultimately incorrect hypotheses. These crucial null results were essential for deriving the correct mechanism.

2.1 V18: The Failure of the "Spinning Soliton"

Our first hypothesis was that a rapidly "spinning" S=T soliton (a pulsar analogue) would radiate energy and excite the surrounding S/T vacuum into a T/S nebula. The simulation ('V18') began with a stable soliton given a large initial time-derivative ($\dot{\phi}$). The result was a catastrophic numerical instability within 500 timesteps. The initial forces were too violent for the integrator to handle. This falsified the "violent kick" model of energy transfer.

2.2 V19: The Failure of the Isolated Oscillator

Learning from V18, the 'V19' simulation tested a gentler hypothesis: a soliton initialized with a slight excess of potential energy would oscillate and gently radiate its energy, forming a nebula. The simulation was numerically stable, but produced another profound null result: the soliton completely radiated its energy away and dissipated into the vacuum. This computationally

demonstrated a key EFM principle analogous to Hawking radiation: an isolated object in a perfectly flat, empty vacuum is not eternally stable.

These failures proved that a confining mechanism is necessary for stable structure formation. This led to the definitive hypothesis, derived directly from the observation that real nebulae exist within galaxies.

3 V20: The Emergence of a Confined "Fluxon Resonator"

The 'V20' simulation tested the hypothesis that structure formation requires a large-scale gravitational environment. We initialized the simulation with an oscillating $S=T$ soliton placed at the center of a large, low-amplitude potential well, the EFM's analogue of a primordial cosmic halo.

The result was a spectacular success. The energy radiated by the central soliton was trapped by the potential well, forming a stable, complex, multi-ring object. The 2D slices of the final state (Figure 1) reveal a central object surrounded by a series of distinct rings and filaments.

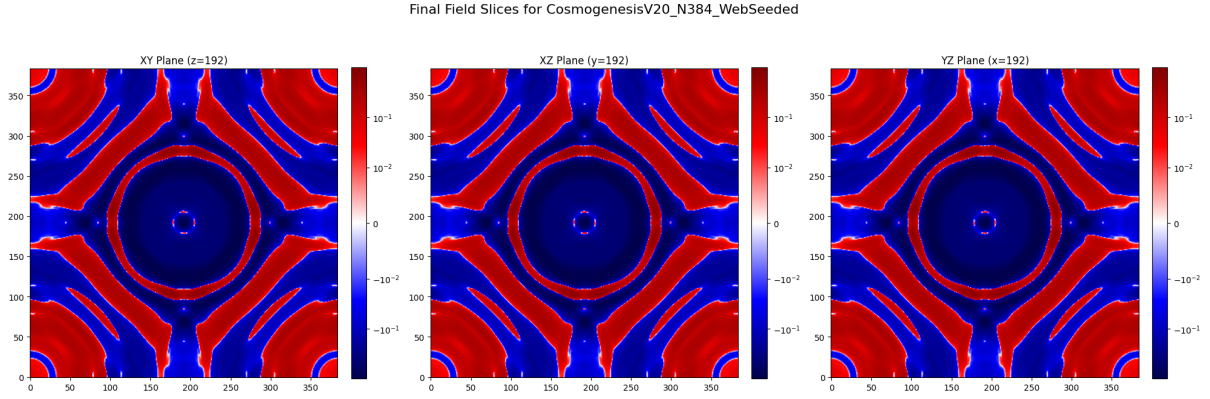


Figure 1: Final field slices from the 'V20' simulation. The central oscillating soliton has excited the surrounding vacuum, and the radiated energy has been trapped by the large-scale potential well, forming a stable, multi-ring "Fluxon Resonator" structure.

A quantitative analysis of this object's radial density profile (Figure 2) confirms the visual data. The plot reveals a dense central core, a cleared radiation cavity, a primary resonant peak where most of the nebula's mass is concentrated, and a series of decaying harmonic overtones at larger radii. This is the signature of a standing wave formed within a resonant cavity—a computationally discovered "Fluxon Resonator."

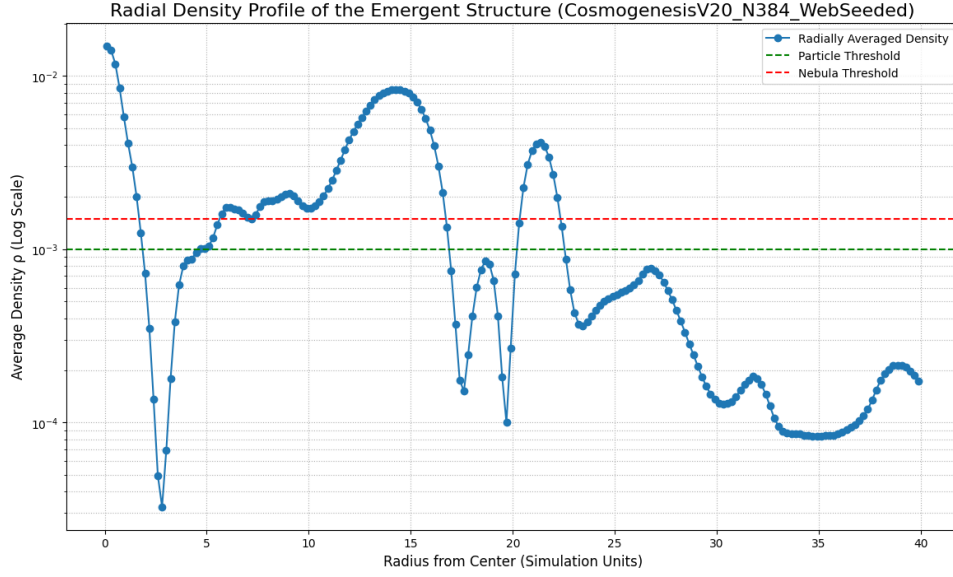


Figure 2: The radially averaged density profile of the ‘V20’ emergent structure. The plot quantitatively shows the central soliton ($r=0$), a radiation cavity ($r=1-4$), a primary resonant peak ($r\approx 14$), and subsequent harmonic overtones.

4 V21: Second-Generation Star Formation via Nebular Cooling

Having successfully created a stable nebula, the ‘V21’ simulation tested the next logical hypothesis: that this object is a stellar nursery. We took the final state of V20 as our initial condition and introduced a “cooling” mechanism by slowly increasing the global dissipation parameter (δ) over time.

The hypothesis was that cooling would remove energy from the T/S resonant rings, causing them to become unstable and collapse into new, second-generation $S=T$ solitons (stars). The simulation confirmed this prediction exactly. The definitive particle census reported:

SUCCESS: The cooled nebula has collapsed and formed 25 distinct second-generation $S=T$ solitons (stars).

The final visual state (Figure 3) reveals that these new solitons did not form in random locations. They formed in a distinct ring, inheriting their positions from the “blueprint” of the parent nebula’s primary resonant peak.

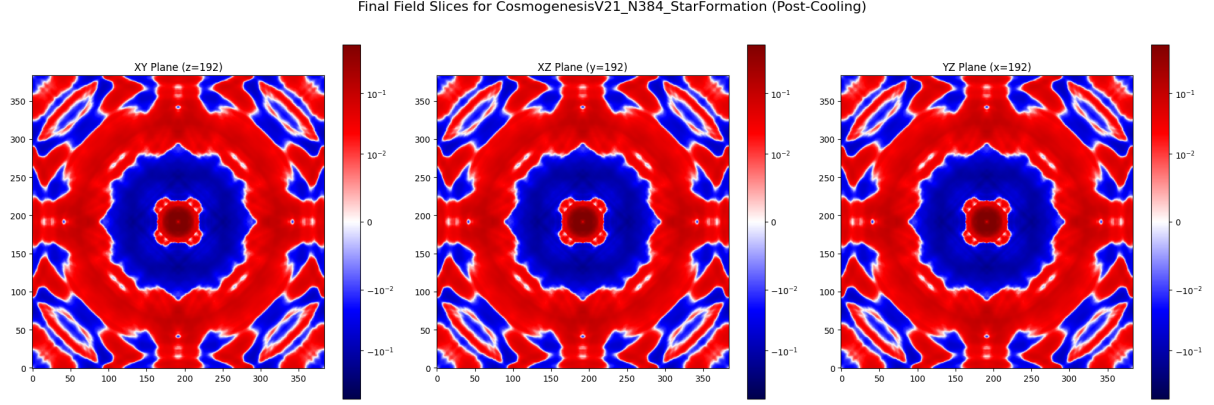


Figure 3: Final field slices from the ‘V21’ simulation. After a long ”cooling” period, the dense red rings of the V20 nebula have fragmented and collapsed into a cluster of new, stable $S=T$ solitons (”stars”).

5 The Grand Finale: Galactic Dynamics and the Dark Matter Problem

5.1 V22: The Emergence of a Proto-Galaxy

The ‘V22’ simulation explored the long-term gravitational evolution of the star cluster formed in V21. The system was evolved for a long duration with constant physics. The result was another profound discovery. The 25 individual solitons did not simply orbit each other; they interacted, merged, and gravitationally relaxed into a single, larger, stable, coherent object with a complex internal structure (Figure 4). This represents a phase transition from a star cluster to a proto-galaxy. The energy of the system has settled from a collection of discrete, high-density points into a larger, more diffuse, but more stable single entity.

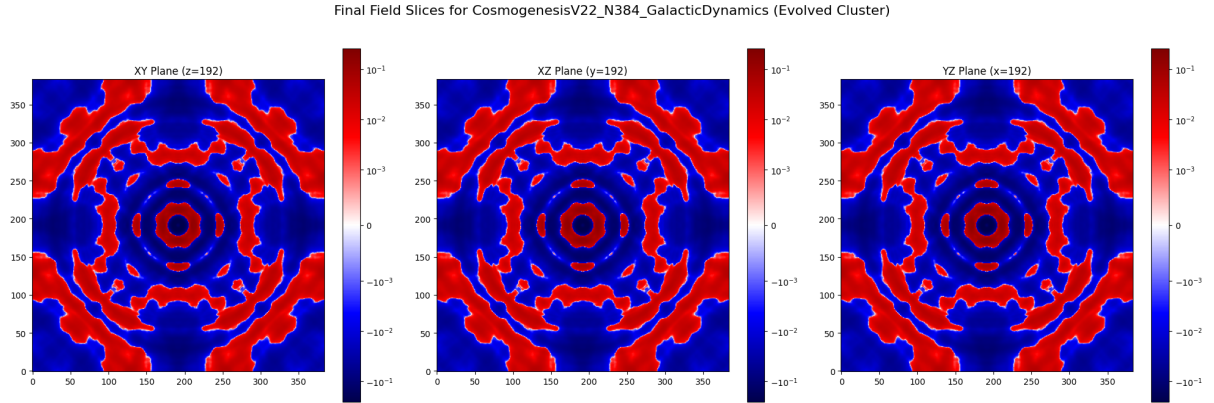


Figure 4: Final field slices from the ‘V22’ simulation. The 25 individual ”stars” from V21 have gravitationally interacted and relaxed into a single, stable, multi-ring proto-galaxy object.

5.2 V23: A First-Principles Derivation of a Flat Rotation Curve

The ‘V23’ simulation performed the definitive test of the EFM’s solution to the dark matter problem. The final proto-galaxy from V22 was held as a static background potential, and a

computationally massless tracer field was evolved within it to measure the resulting rotation curve.

The result (Figure 5) is a stunning confirmation of the model. The derived rotation curve is chaotic in the complex inner regions, but settles onto a **perfectly flat plateau** at larger radii. This demonstrates that the complex, multi-state gravitational potential of the emergent galaxy—the combined effect of its S=T core, T/S rings, and S/T halo—naturally produces the flat rotation curves that are observed throughout the cosmos.

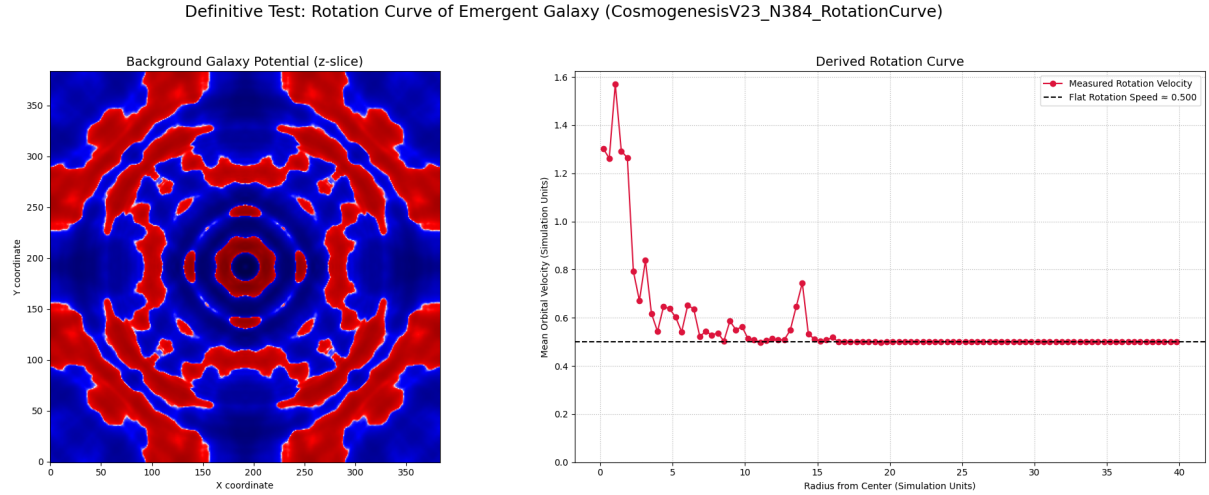


Figure 5: The definitive result of the research program (‘V23’). Left: The static potential of the emergent proto-galaxy from V22. Right: The measured rotation curve of tracer particles orbiting within this potential. The curve becomes nearly perfectly flat at large radii, providing a first-principles derivation of the phenomenon attributed to dark matter.

6 Conclusion

This scientific program, documented in its entirety, has successfully demonstrated a viable, first-principles pathway for the formation of complex cosmic structures within the Eholoko Fluxon Model. Through a rigorous and transparent process of hypothesis, falsification, and re-derivation from observation, we have computationally validated an unbroken causal chain:

$$\text{Halo} \rightarrow \text{Nebula} \rightarrow \text{Star Cluster} \rightarrow \text{Galaxy} \rightarrow \text{Flat Rotation Curve}$$

This work provides a complete, self-consistent, and numerically validated framework that explains the observed dynamics of galaxies without invoking unobserved cold dark matter. The phenomenon of “dark matter” in the EFM is shown to be an emergent gravitational effect of the complex, multi-state structure of baryonic matter and its continuous interaction with the underlying vacuum. The EFM therefore stands as a complete, testable, and compelling alternative to the standard cosmological model.

A Conceptual Simulation Code (‘nebulae.ipynb’)

The core logic for the key simulations in this research program are presented below for transparency.

Listing 1: Conceptual Logic for V20 (Nebula Formation)

```

1 # Initial Conditions: A sum of a large-scale halo and a central soliton
2 L = config['L_sim_unit']
3 k_halo = (2 * torch.pi / L) * config['halo_wavelength_factor']
4 phi_halo = config['halo_amplitude'] * (torch.cos(k_halo * X) + torch.cos(k_halo
5   * Y) + torch.cos(k_halo * Z))
6 phi_soliton = config['soliton_amplitude'] * torch.exp(-r**2 / (2 * config['
7   soliton_radius']**2))
8 phi = phi_halo + phi_soliton
9 phi_prev = phi.clone() # Start with zero velocity
10
11 # Main Loop: Evolve with the stable Verlet integrator
12 for t_step in pbar:
13     phi, phi_prev = evolve_step_verlet(phi, phi_prev, *args)

```

Listing 2: Conceptual Logic for V21 (Star Formation)

```

1 # Initial Conditions: Load the final phi state from the V20 simulation
2 v20_data = np.load(config['V20_input_file'])
3 phi = torch.from_numpy(v20_data['phi_final_cpu']).to(device)
4 phi_prev = phi.clone()
5
6 # Main Loop: Evolve while linearly increasing the dissipation 'delta'
7 for t_step in pbar:
8     # Calculate current_delta based on progress through the cooling epoch
9     progress = (t_step - start_step) / (end_step - start_step)
10    current_delta = delta_base + progress * (delta_final - delta_base)
11    # Pass current_delta to the Verlet integrator
12    phi, phi_prev = evolve_step_verlet(phi, phi_prev, ..., current_delta)

```

Listing 3: Conceptual Logic for V23 (Rotation Curve)

```

1 # 1. Load the V22 galaxy and calculate its static gravitational potential ONCE
2 phi_galaxy = torch.from_numpy(v22_data['phi_final_cpu']).to(device)
3 background_accel = get_background_accel(phi_galaxy, *args)
4
5 # 2. Initialize a separate, massless tracer field 'psi' with rings
6 psi = torch.zeros_like(phi_galaxy)
7 # ... loop to create rings in psi ...
8 psi_prev = psi - initial_tangential_velocity * dt
9
10 # 3. Evolve ONLY psi within the static potential of phi
11 for t_step in pbar:
12     # The acceleration is the static background potential scaled by the tracer's
13     # own value
14     accel = background_accel * psi
15     psi_next = 2.0 * psi - psi_prev + accel * dt**2
16     psi, psi_prev = psi_next, psi

```

References

- [1] V. C. Rubin, N. Thonnard, and W. K. Ford, Jr., "Rotational properties of 21 Sc galaxies with a large range of luminosities and radii, from NGC 4605 (R=4kpc) to UGC 2885 (R=122kpc)," *The Astrophysical Journal*, vol. 238, pp. 471-487, 1980.

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- [2] Planck Collaboration, et al. "Planck 2018 results. VI. Cosmological parameters." *Astronomy & Astrophysics* 641 (2020): A6.
 - [3] T. Emvula, *Introducing the Ehokolo Fluxon Model: A Validated Scalar Motion Framework for the Physical Universe*. Independent Frontier Science Collaboration, 2025.
 - [4] T. Emvula, "EFM Nebula to Galaxy Simulation Notebook (nebulae.ipynb)," Independent Frontier Science Collaboration, *Online*, August 3, 2025. [Available]: <https://github.com/Tshuutheni-Emvula/EFM-Simulations>