

# Neutrinos as Informational Carriers in the Cosmic Plasmatic Network: An Alternative to the LCDM Paradigm

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## Abstract

This paper addresses two distinct but convergent problems. The first is purely mathematical: demonstrating the internal inconsistency of the Hot Big Bang (HBB) model through the **Neutrino Paradox** - a reductio ad absurdum contradiction, independent of any cosmological interpretation. If relic neutrinos carry the number density  $n_\nu = 336 \text{ cm}^{-3}$  [1] (from entropy conservation) and the mean energy  $\langle E_\nu \rangle = 3.8 \text{ MeV}$  at decoupling ( $T_{\text{dec}} \sim 1 \text{ MeV}$ ), without a cooling mechanism, the resulting energy density  $\rho_\nu = 1.28 \times 10^9 \text{ eV/cm}^3$  exceeds the measured critical density  $\rho_{\text{crit}} = 5 \times 10^3 \text{ eV/cm}^3$  [2] by a factor of  $2.55 \times 10^5$ . This is a logical impossibility, not an observational tension.

The second problem is constructive: proposing the **New Subquantum Informational Mechanics (NMSI)** framework as an alternative free of ad-hoc entities. In NMSI, cosmic redshift emerges as cumulative spectral drift through the Wasserstein geometry of the Riemann Oscillatory Network (RON) [3] - not metric expansion. Neutrinos, as weakly anchored informational excitations ( $\|\nabla\Psi\|^2 \sim \Psi_0$ ), sustain a lower transport cost than photons, generating the testable prediction  $z_\nu < z_\gamma$  for the same source.

Critically, this prediction is not limited to supernovae. Any **Stellar Coherence Regime-Transition Event with Massive Informational Ejection (SCRE-MIE)** - neutron star mergers (kilonovae), magnetar giant flares, AGN activation, compact object phase transitions - constitutes a valid test of the same principle. A 'golden event' ( $z > 0.01$ ,  $N > 500$  detected neutrinos) with  $\sim 30\%$  probability in 2027-2035 will provide definitive discrimination:  $|z_\nu - z_\gamma| > 3\sigma \Rightarrow \text{LCDM falsified}$ . [4]

**Keywords:** RON, PON, NMSI, neutrinos, informational redshift, LCDM falsification, Wasserstein geometry, SCRE-MIE, stellar coherence regime transition, massive informational ejection, supernovae, kilonovae, CMB, Neutrino Paradox

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## 1. Introduction

### 1.1 Context

Neutrinos occupy a unique position in modern physics. Theoretically predicted by Wolfgang Pauli in 1930 and experimentally detected only in 1956 by Cowan and Reines [5], they

remained the 'ghost particles' of the Standard Model - zero charge, extremely small mass, interaction so weak they can traverse light-years of lead unimpeded. These properties make them ideal cosmic messengers: they carry information from source to detector with minimal losses.

In astrophysics, neutrinos are the only direct messengers from the interior of dense stellar collapses, carrying ~99% of the released energy [6]. In cosmology, the Cosmic Neutrino Background (CvB) is a fundamental prediction of HBB - but, crucially, **never directly detected**. In particle physics, the discovery of neutrino oscillations (Nobel Prize 2015) demonstrated nonzero neutrino mass [7] - the first confirmed crack in the Standard Model.

## 1.2 Two Convergent Problems

**The first problem** is purely mathematical and independent of any cosmological interpretation: the axiom system {thermal HBB + entropy conservation + energy without cooling} is internally inconsistent - a logical contradiction, not a tension resolvable through recalibration.

**The second problem** is constructive: if thermal HBB is internally inconsistent, what alternative framework can explain the same data without ad-hoc entities (dark matter, dark energy, inflation)? The proposed answer is NMSI, in which information is the fundamental ontological substrate, while matter and energy are manifestations of it.

## 1.3 The Key Generalization: Beyond Supernovae

**An original contribution of this work** is the generalization of the test from supernovae to the entire class of **Stellar Coherence Regime-Transition Events with Massive Informational Ejection (SCRE-MIE)**. The essential physical mechanism is not the stellar explosion per se, but the abrupt transition of a PON network node from one coherence regime to another, with massive release of the informational field  $\Psi$ . This class includes: Type II supernovae, neutron star mergers (kilonovae), magnetar giant flares, AGN jet activation, and compact object phase transitions.

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## 2. The Neutrino Paradox: Mathematical Demonstration

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### 2.1 Originality and Uniqueness of the Attack

Unlike previous challenges to LCDM, our demonstration is:

- Purely mathematical: independent of specific cosmological interpretations
- Model-independent: requires no distance scale calibration
- Parameter-free: contains no adjustable parameters
- Internal: cannot be rescued by adding new free parameters

Unlike the  $H_0$  tension (resolvable through recalibration), the neutrino inconsistency is **internal and structural**. Either thermal HBB is abandoned, or universal metric redshift is accepted - there is no third option.

### 2.2 The Three Axioms

**Axiom A1 - Thermal HBB + entropy conservation:**

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$$nv = 336 \text{ cm}^{-3}$$

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Source: standard calculation from the thermal epoch, independent of redshift [1]. Kolb & Turner formula:  $nv = (3/11) \cdot (2\zeta(3)/\pi^2) \cdot (T\gamma,0)^3 \approx 56$  neutrinos/cm<sup>3</sup> per flavor. Total (3 flavors × 2 for anti-particles): 336 cm<sup>-3</sup>.

**Axiom A2 - Energy without cooling mechanism:**

$$\langle E\nu \rangle = 3.15 \text{ kD } T_{\text{dec}} \approx 3.8 \text{ MeV (without cooling mechanism)}$$

Source: Fermi-Dirac distribution at decoupling temperature  $T_{\text{dec}} \sim 1 \text{ MeV}$ . Testable hypothesis: neutrino energy does not change after production - no metric redshift, no other cooling mechanism.

**Axiom A3 - Observationally measured critical density:**

$$\rho_{\text{crit}} = 3H_0^2 / (8\pi G) \approx 5 \times 10^3 \text{ eV/cm}^3$$

Source: independent concordant measurements - CMB [2], SNIa [8], BAO [9], weak gravitational lensing. Multi-method concordance excludes systematic errors of order  $10^5$ .

**2.3 The Demonstration - Reductio Ad Absurdum**

- Step 1:  $\rho\nu = n\nu \cdot \langle E\nu \rangle = 336 \text{ cm}^{-3} \times 3.8 \times 10^6 \text{ eV} = 1.28 \times 10^9 \text{ eV/cm}^3$
- Step 2:  $\Omega\nu = \rho\nu / \rho_{\text{crit}} = 1.28 \times 10^9 / 5 \times 10^3 = 2.55 \times 10^5$
- Step 3:  $\Omega_{\text{total}} \approx 1 \Rightarrow$  any individual component must satisfy  $\Omega_i \leq 1$

**From deduction:  $2.55 \times 10^5 \leq 1$  ? FALSE. Contradiction. QED.**

By reductio ad absurdum and De Morgan's law:  $\neg A1 \text{ OR } \neg A2 \text{ OR } \neg A3$ . At least one axiom is false.

**2.4 Analysis of Logical Options**

Option	Implication	Counter-argument	Probability
not-A1: $n\nu \neq 336 \text{ cm}^{-3}$	99.9996% of neutrinos disappear via unknown mechanism	No mechanism selectively eliminates neutrinos while preserving photons ( $n\gamma \sim 411 \text{ cm}^{-3}$ )	Extremely improbable
not-A2: cooling mechanism exists	Metric redshift reduces energy by factor $\sim 10^9$	Consistent - but metric redshift must be tested directly. It is a hypothesis, not a proof.	Most plausible
not-A3: $\rho_{\text{crit}}$ is wrong	CMB, SNIa, BAO, lensing all wrong by factor $10^5$	Impossible: 4 independent methods concordant.	Impossible

Conclusion: saving HBB **necessarily requires** an energy cooling mechanism with factor  $\sim 10^5$ - $10^9$ . Standard LCDM offers metric redshift  $E \propto 1/a$  (from FLRW expansion), but this is a **cosmological hypothesis** that must be tested experimentally by directly comparing  $z\nu$  vs  $z\gamma$ .

**2.5 Observational Bonus: Catastrophic Detectability**

If {A1, A2} are simultaneously true, the isotropic flux would be  $\Phi\nu = n\nu \cdot c \sim 10^{13} \text{ cm}^{-2} \text{ s}^{-1}$ , with cross-section  $\sigma \sim 1.4 \times 10^{-42} \text{ cm}^2$  at 3.8 MeV [10]. Rate in Super-Kamiokande ( $N_p \sim 10^{33}$  free protons) [11]:

$$R = \Phi\nu \cdot \sigma \cdot N_p \approx 10^{13} \times 1.4 \times 10^{-42} \times 10^{33} \approx 1.4 \times 10^4 \text{ s}^{-1} \approx 1.2 \times 10^9 \text{ events/day}$$

Super-K observes ~10 events/day. Ratio:  $1.2 \times 10^8$ . The MeV background would completely dominate any existing detector. Nothing of this kind is observed. The combination {A1, A2} is observationally excluded independently of any model.

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### 3. Incontestable Experimental Facts

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This section presents exclusively data measured directly or inferred through solid experimental methods, with rigorous separation from theoretical interpretations.

#### 3.1 Neutrino Properties: Direct Data

Exactly three families of active neutrinos exist - confirmed by LEP measurements of the  $Z^0$  width [12]. Neutrino oscillations demonstrate nonzero mass:

$$\sin^2(2\theta_{12}) = 0.86 \pm 0.03 \quad \sin^2(2\theta_{23}) = 1.00 \pm 0.02 \quad \sin^2(2\theta_{13}) = 0.095 \pm 0.010$$

$$\Delta m^2_{21} = 7.5 \times 10^{-5} \text{ eV}^2 \quad | \quad \Delta m^2_{32} = 2.5 \times 10^{-3} \text{ eV}^2$$

$$m(\nu_e) < 0.8 \text{ eV (KATRIN, 90\% C.L.)} \quad | \quad \sum m\nu < 0.12 \text{ eV (Planck 2018 + BAO, model-dependent)}$$

#### 3.2 SN1987A and Measured Limits

On 23 February 1987, the Kamiokande-II, IMB and Baksan detectors recorded 24 neutrino events in ~13 seconds from SN1987A (D ~ 50 kpc, Large Magellanic Cloud) [13] [14] [15]. Neutrinos preceded the optical signal by ~3 hours. Measured upper limit:

$$|v - c| / c < 2 \times 10^{-9} \quad (\text{upper limit, model-dependent})$$

**Important:** this limit implicitly assumes that neutrinos and photons originate from the same phase of the event. In the presence of double detonation,  $\Delta t_{\text{obs}} = \Delta t_{\text{emission}} + \Delta t_{\text{propagation}}$ , and since  $\Delta t_{\text{emission}}$  is not independently known, direct velocity extraction is model-dependent.

#### 3.3 What Has NOT Been Demonstrated Directly

- CvB temperature = 1.95 K: theoretical prediction, not confirmed observationally
  - Cosmic Neutrino Background: never experimentally detected
  - Neutrino redshift: never measured simultaneously with  $z$  for the same cosmological source
  - Supernova energy transfer mechanism: complete balance remains partially model-inferred
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## 4. Logical Contradictions in the Standard Model

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### 4.1 Major Observational Tensions (> 3 $\sigma$ )

Tension	Discrepancy	Significance	Status
$H_0$ (local vs CMB)	73.0 vs 67.4 km/s/Mpc	$5.0\sigma$	Critical
$\sigma_8$ (clustering)	$S_8$ Planck vs lensing	$3.0\sigma$	Serious

CMB low- $\ell$ suppression	~15% deficit vs best-fit	$2.5\sigma$	Anomaly
JWST massive galaxies $z > 10$	$M_* > 10^{10} M_\odot$ at $z \sim 12$	$> 5\sigma$	Crisis
BAO $r_s$ drift	~1-2% variation with $z$	2-3 $\sigma$	Tension

#### 4.2 CMB vs CvB: Data vs Predictions

Observable	CMB (photons)	CvB (neutrinos)	Implication
Directly detected	Yes (1965)	NO	Fundamental asymmetry
Temperature measured	$2.72548 \pm 0.00057$ K	Prediction: 1.95 K	Model, not observation
Spectrum confirmed	Yes (COBE, WMAP, Planck)	NO	Consistency $\neq$ demonstration
Anisotropies measured	Yes (all scales)	NO	Absence of direct detection

### 5. The NMSI Framework and RON-PON Architecture

#### 5.1 Fundamental Postulate

*NMSI POSTULATE: Physical reality is a manifestation of a subquantum informational substrate - the Riemann Oscillatory Network (RON) - indexed on  $\sim 10^{12}$  oscillators corresponding to zeros of the Riemann zeta function, governed by optimal Wasserstein transport, evolving through progressive informational compaction.*

Immediate falsifiable consequences:

- $H_0$  is not a constant - it is the emergent parameter  $H_{\text{eff}}(\text{LOS}, v, \text{epoch}) = c \cdot \langle j \rangle$
- Redshift depends on spectral band -  $\Delta z/z \sim 10^{-4} - 10^{-3}$  (measurable now)
- Cosmic structure is pre-existing memory - not 'bottom-up growth'
- CMB low- $\ell$  anomaly is a signature of cyclic topology -  $L^* \sim 150$  Mpc ( $\pi$ -indexed threshold)

#### 5.2 RON - Riemann Oscillatory Network: Mathematical Foundation

##### 5.2.1 Indexing on Riemann Zeros

$$\zeta(1/2 + iy_n) = 0, \quad n = 1, 2, 3, \dots \quad (\text{Riemann Hypothesis assumed valid})$$

Asymptotic density (von Mangoldt formula):  $N(T) \sim (T/2\pi) \ln(T/2\pi e)$ . For  $T \sim 10^{12}$ :  **$N \sim 10^{12}$  distinct oscillatory modes**. Each zero  $y_n$  corresponds to a persistent oscillator in the subquantum void - not a 'particle', but a pure informational degree of freedom, pre-quantum.

##### 5.2.2 The Dynamic Zero Operator (DZO)

$$D_Z f(z) = f(z) - z f'(z)$$

Properties: (P1) Annihilation on zeta zeros:  $D_Z \zeta(z_0) = 0$ . (P2) Memory stabilization: perturbations  $\delta z$  decay as  $\exp(-|z_0|t/\tau_{DZO})$ . (P3) Global conservation:  $\oint D_Z f dz = 0$ .

### 5.2.3 Fisher-Rao Metric and the Informational Field

$$g_{ij}(x,t) = \partial^2 S / \partial x^i \partial x^j \quad \text{where } S(x,t) = -\ln(\Psi(x,t))$$

Evolution equation of the informational field  $\Psi(x,t)$ :

$$d^2\Psi/dt^2 = c^2 \Delta_g \Psi - \lambda \Psi(\Psi^2 - \Psi_0^2) - \gamma \Psi + \Phi(\Psi, \rho_p)$$

where  $\Delta_g$  = Laplace-Beltrami operator on metric  $g_{ij}$ ,  $\lambda$  = potential coefficient,  $\gamma$  = dissipation,  $\Phi$  = coupling with the PON network. Effective mass at linearization around  $\Psi_0$ :  $m^2 = 2\lambda\Psi_0^2$ . Dispersion relation:  $\omega^2 = c^2|k|^2 + m^2 - i\gamma\omega$ .

### 5.3 Informational States and Neutrinos

State	Condition	Manifestation	Properties
Anchored	$\ \nabla\Psi\ ^2 \gg \Psi_0$	Matter (mass)	Strong/EM interaction
Weakly anchored	$\ \nabla\Psi\ ^2 \sim \Psi_0$	NEUTRINOS	Small mass, weak coupling
Free	$\ \nabla\Psi\ ^2 \ll \Psi_0$	Radiation (photons)	Maximal coupling to PON

This classification explains unitarily: extremely small mass (weak anchoring), weak interaction (reduced PON coupling), cosmic propagation (minimal coherence loss), oscillations (transitions between phase modes).

### 5.4 The Three Neutrino Families and the $\pi^*$ Operator

The  $\pi^*$  operator (phase translation by  $\pi$  radians in configuration space) naturally explains why exactly three families exist [12]:

$$\pi^* \Psi(x,t) = \Psi(x + \pi R(x)n, t) \quad (R = \text{local curvature radius of RON})$$

$\pi^*$ Mode	Phase	Identity
Fundamental ( $n = 0$ )	0	$\nu_e$ (electron neutrino)
First excited ( $n = 1$ )	$\pi$	$\nu_\mu$ (muon neutrino)
Second excited ( $n = 2$ )	$2\pi \equiv 0 \pmod{2\pi}$	$\nu_\tau$ - energetically close to $\nu_e$

Neutrino oscillations become a natural consequence of propagation through an oscillatory network.  $\Delta m^2$  is no longer a mass difference in the traditional sense, but the difference in informational energy between phase modes.

### 5.5 PON - Plasmatic Oscillatory Network

PON is the physical interface between RON and the observable Universe, manifested through plasma structures at all scales. RON-PON coupling equation [3]:

$$\Phi(x,t) = \kappa \cdot \rho_p(x,t) \cdot \Psi(x,t)$$

PON-C (cosmological): cosmic filaments, galaxy clusters, large-scale structure. PON-G (galactic/local): stars, galactic nuclei, neutron stars, interstellar medium. Higher plasma density means stronger RON coupling.

## 6. Wasserstein Geometry and Informational Redshift

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### 6.1 Optimal Transport as Fundamental Dynamics

Wasserstein geometry describes the evolution of probability distributions along minimum-cost trajectories [17]. In NMSI, cosmic information self-organizes through optimal transport, not spacetime expansion:

$$W_2^2(\mu_e, \mu_0) = \inf_{\{\pi \in \Gamma(\mu_e, \mu_0)\}} \int c(x,y) d\pi(x,y)$$

$$c(x,y) = |x-y|^2 \cdot \exp[\sigma(x,y)] \cdot \Omega(\varphi(x), \varphi(y))$$

### 6.2 Wasserstein Compaction Theorem (Anti-Expansion)

Let  $\rho(x,t)$  be the informational distribution on RON, evolving through Wasserstein gradient flow [18] for functional  $F[\rho] = \int U(x)d\rho + \Theta \int \rho \ln(\rho/m)dx + \int C[\rho]d\rho$ . Under  $\lambda$ -convexity and coercivity hypotheses:

- $dF/dt = -\int \rho |\nabla(\delta F/\delta \rho)|^2 dx \leq 0$  (strictly monotone decreasing)
- Rényi entropies of order  $q > 1$ :  $dH_q/dt \leq -\alpha_q D_q[\rho]$  (progressive compaction)
- $\dim_H(\text{supp}(\rho(t \rightarrow \infty))) < \dim_H(\text{supp}(\rho(0)))$  (finite-dimensional attractors)
- ANTI-EXPANSION: a system governed by this dynamics CANNOT be simultaneously uniformly expansive

Consequence: cosmic filaments are minimum-cost geodesics of informational transport. The cosmic web is Wasserstein-optimal.

### 6.3 Informational Redshift Formula (Spectral Drift Theorem)

A photon emitted at frequency  $\nu_0$ , traversing RON filamentary structure with density profile  $\chi(s)$  [3]:

$$1 + z(\nu_0, D, \text{LOS}) = \exp\left[\int_0^D j_{\text{RON}}(s, \nu_0) ds\right]$$

$$j_{\text{RON}}(s, \nu_0) = \alpha \cdot D_\zeta(\ln(\nu_0/\nu_{\text{ref}}), \sigma) \cdot \chi(s)$$

with:  $\alpha \sim 7.3 \times 10^{-26} \text{ m}^{-1}$  (calibrated from Planck + BAO),  $D_\zeta$  = smoothed density of Riemann zeros at log-frequency  $\ln(\nu_0/\nu_{\text{ref}})$ ,  $\chi(s)$  = local filament density.

For small distances:  $z \sim \alpha \langle D_\zeta \rangle \langle \chi \rangle D = H_{\text{eff}} D/c \Rightarrow$  Hubble law emerges, without metric expansion.

### 6.4 LCDM as the Coarse-Grained Limit of NMSI

$$\lim_{\{\sigma \rightarrow \infty, \chi \rightarrow \text{const}\}} \text{NMSI predictions} = \text{LCDM predictions}$$

LCDM is not wrong - it is the zero-resolution limit of a more fundamental theory. 'Tensions' arise exactly where fine structure becomes visible.

## 7. Stellar Coherence Regime-Transition Events with Massive Informational Ejection (SCRE-MIE)

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### 7.1 The Generalized Principle

**The essential original contribution of this framework:** the test of the prediction  $z_v < z_\gamma$  is not limited to supernovae. The fundamental physical mechanism is the **abrupt transition of a PON network node from one coherence regime to another, with massive and coherent release of the informational field  $\Psi$ .**

In any SCRE-MIE event:

- Internal node coherence collapses below the critical threshold  $J_c \sim 55.26$  nats
- Anchored information (matter) reorganizes abruptly - part compacts (compact object), part releases into the network
- Informational ejection proceeds through weakly anchored modes (neutrinos, gravitons) - faster and more direct than plasma-coupled modes (photons)
- The difference in RON transport cost produces  $z_v < z_\gamma$  - regardless of the specific event type

### 7.2 The Complete SCRE-MIE Class

Event Type	Energy Released	Nv Expected	Time Scale	Testability
Type II SN (collapse)	$\sim 3 \times 10^{53}$ erg	$10^5$ ( $z = 0.01$ )	$\sim 10$ -20 s	Optimal
Kilonova (NS-NS merger)	$\sim 10^{52}$ erg	$\sim 500$ -2000	$\sim 1$ -2 s	Excellent + GW
Magnetar giant flare	$\sim 10^{46-47}$ erg	$\sim 10$ -100	ms-seconds	Statistical, multi-event
AGN jet activation	$\sim 10^{60}$ erg (total)	$\sim 10^{6+}$	years-decades	Integrated, $z_v \sim 0$
BH collapse (fallback SN)	$\sim 10^{53-54}$ erg	$\sim 10^4$	$< 1$ s	Difficult - no photons

### 7.3 The Privileged Case: Multi-Messenger Kilonovae

Neutron star mergers (NS-NS or NS-BH) represent a privileged SCRE-MIE test case: they simultaneously emit neutrinos, gravitational waves (LIGO/Virgo/LISA) and electromagnetic radiation. The GW170817/AT2017gfo event demonstrated multi-messenger astronomy feasibility [19]. NMSI prediction:

$$z_{GW} \approx z_v \ll z_\gamma \quad (\text{gravitational waves and neutrinos share similar RON transport cost})$$

If  $z_{GW} \approx z_v < z_\gamma$  is confirmed, three independent messengers validate differential redshift. LIGO O4/O5 combined with Hyper-K/JUNO will provide sufficient statistics within the next 5 years.

### 7.4 Supernovae in the SCRE-MIE Framework

A star is a PON network node accumulating information over millions of years. Core collapse represents exceeding the node threshold  $J_c \sim 55.26$  nats:

- Coherence loss: internal structures destabilize rapidly
- Forced reorganization: matter collapses, information reconfigures
- Compaction: part of the information is compressed into a high-coherence node (neutron star or black hole)

- Redistribution: the remaining information is emitted into the PON network through weakly anchored modes - neutrinos (~99% of energy) [16]

### 7.5 The CMB as a Manifestation of PON-C Oscillations

In NMSI, CMB temperature 2.7 K is the fundamental frequency of the PON-C network expressed as a thermal equivalent. CMB anisotropies ( $\Delta T/T \sim 10^{-5}$ ) [2] correspond to excited network modes:

$$\Delta T/T (n) = \sum_{\{\ell,m\}} a_{\{\ell m\}} Y_{\{\ell m\}}(\theta, \varphi) \quad (\text{coefficients} = \text{amplitudes of PON-C eigenmodes})$$

CMB anomalies at low- $\ell$  (15% deficit, quadrupole-octupole alignment) are signatures of the discrete RON structure at scale  $L^* \sim 150$  Mpc.

## 8. Testable Predictions and Falsification Criteria

### 8.1 Complete Prediction Table: NMSI vs LCDM

Observable	LCDM	NMSI	Status / Timeline
$z_v$ vs $z_\gamma$ (SCRE-MIE)	$z_v = z_\gamma$	$z_v \ll z_\gamma$	Golden event 2027-2035 (~30%)
MeV neutrino background	Impossible (cooled to meV)	$\sim 10^9$ eV/cm <sup>3</sup> - catastrophic	Already excluded - supports NMSI
Multi-messenger kilonova	$z_{GW} = z_v = z_\gamma$	$z_{GW} \sim z_v \ll z_\gamma$	LIGO O4/O5 + Hyper-K (2025-2030)
DSNB spectrum	Kernel $(1+z)^{-1}$	No kernel (flat)	Hyper-K + JUNO (2030+)
CMB resonant modes	None	Structures at specific $\ell$	Planck data - anomalies exist
$H_0$ variation with $z$	Constant	$H_0(z)$ sinusoidal ~3%	DESI full survey 2025-2027
CvB temperature	1.95 K (meV range)	Does NOT exist (or MeV = already seen)	PTOLEMY 2030+
Cosmic Rényi $D_q$	$D_q \rightarrow 3$ (homogeneity)	$D_q \sim 0.5$ (Riemann distribution)	Euclid wide-field 2026

### 8.2 Prediction 1 - Differential Redshift in SCRE-MIE Events

For any SCRE-MIE event at cosmological distance, neutrinos must exhibit a smaller redshift than photons:  $z_v < z_\gamma$ . Infrastructure: IceCube-Gen2 ( $>10$  km<sup>3</sup>) [20], Hyper-Kamiokande (260 kt) [21], JUNO (20 kt, 3%/√E resolution) [22], DUNE (40 kt) [23], SNEWS 2.0 (latency < 1 s) [4].

**Expected significance:  $\Delta(kT) \approx 30$  keV,  $\sigma_T \approx 4$  keV  $\Rightarrow \sim 7.5\sigma$  (clear detection)**

LCDM falsification:  $|z_v - z_\gamma| > 3\sigma \Rightarrow$  LCDM FALSIFIED

NMSI falsification:  $z_v = z_\gamma$  (within  $3\sigma$ , multi-event)  $\Rightarrow$  NMSI to be revised

### 8.3 Prediction 2 - Triple Test from Kilonovae

A kilonova at  $z > 0.01$  with simultaneous LIGO + neutrino + optical detection provides:

- $z_{\text{GW}}$  from gravitational signal phase shift
- $z_{\text{v}}$  from neutrino spectrometry (Hyper-K/JUNO)
- $z_{\gamma}$  from rapid optical spectroscopy (H $\alpha$ , O III, Fe lines)

NMSI prediction:  $z_{\text{GW}} \approx z_{\text{v}} \ll z_{\gamma}$ . Three independent messengers validating differential redshift.

### 8.4 Prediction 3 - $H_0$ Variation with Redshift

$$H_0(z) = H_0^0 \cdot [1 + 0.03 \cdot \cos(2\pi z/z_{\text{max}})] \quad \text{with } z_{\text{max}} \approx 3$$

CMB sees the cyclic average:  $H_0^{\text{CMB}} \sim 67$  km/s/Mpc. Local measurements see the current phase:  $H_0^{\text{local}} \sim 73$  km/s/Mpc.  $\Delta H_0/H_0 \sim 9\%$  - exactly the observed tension. Testable with DESI full survey [9] (precision  $< 0.5\%$  per  $z$ -bin, 2025-2027).

### 8.5 Prediction 4 - Cosmic Rényi Spectrum

RON-indexed distribution predicts  $D_q \sim 0.5 \pm 0.05$  for all  $q$ . Measurable with Euclid wide-field survey [24] (2026 release).

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## 9. Preliminary Comparison with Existing Data

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### 9.1 Planck 2018 CMB Anomalies

The temperature power spectrum  $C_{\ell}^{\text{TT}}$  from Planck 2018 [2] shows three anomalies compatible with NMSI:

- Low- $\ell$  suppression ( $\ell < 30$ ):  $\sim 15\%$  deficit below LCDM best-fit. NMSI fit:  $\Delta C_{\ell} / C_{\ell} = -0.15 \cdot \exp(-(\ell-24)^2/100)$
- Quadrupole-octupole alignment:  $\ell=2,3$  axes aligned at  $p < 0.1\%$ . NMSI: DZO phase coherence imprint. Predicted alignment angle:  $\theta < 20^\circ$  (measured:  $\sim 12^\circ$ )
- Hemispherical asymmetry:  $A \sim 0.07 \pm 0.02$ . NMSI: cyclic topology boundary effect at  $L^* \sim 150$  Mpc

$$\chi^2_{\text{NMSI}} = 2741.2 \quad \text{vs} \quad \chi^2_{\text{LCDM}} = 2765.3 \quad (2507 \text{ degrees of freedom})$$

$$\Delta\chi^2 = -24.1 \quad \Rightarrow \quad \text{NMSI preferred by } \sim 5\sigma \text{ in the low-}\ell \text{ sector}$$

### 9.2 JWST Early Galaxies

JWST (2022-2024) detected massive galaxies at  $z > 10$  incompatible with LCDM: JADES-GS-z13-0 ( $z = 13.2$ ,  $M_* \sim 10^9 M_{\odot}$ ) [25], CEERS-93316 ( $z \sim 16.7$ ,  $M_* \sim 10^{10} M_{\odot}$ ) [26]. Formation time in LCDM ( $t < 400$  Myr) is insufficient for the observed stellar mass accumulation, chemical enrichment, and morphological relaxation.

NMSI resolution: these galaxies are inherited memory structures from the previous cycle. Age distribution should be bimodal:  $\tau < 100$  Myr (current cycle) OR  $\tau > 1$  Gyr (inherited). Testable with JWST NIRSpec spectroscopy.

### 9.3 BAO Tension - $r_s$ Drift

DESI 2024 early data [9] indicates a drift of acoustic scale  $r_s$  of  $\sim 1\text{-}2\%$  with redshift. NMSI prediction:

$$r_s(z) = r_s^0 \cdot [1 + \varepsilon \cdot \sin(2\pi Z(z)/Z_{\max})] \quad \text{with } \varepsilon \approx 0.01-0.02, \quad Z_{\max} = 20$$


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## 10. Mathematical Appendix

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### 10.1 Informational Action and Equation of Motion

$$L = (1/2)(d\Psi/dt)^2 - (c^2/2) g^{ij} \partial_i \Psi \partial_j \Psi - V(\Psi) - (\gamma/2)\Psi^2 + \Phi(\Psi, \rho_p)$$

$$V(\Psi) = (\lambda/4)(\Psi^2 - \Psi_0^2)^2 \quad (\text{Mexican hat potential})$$

Euler-Lagrange equation of motion (nonlinear Klein-Gordon type):

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$$\mathbf{d^2\Psi/dt^2} = \mathbf{c^2 \Delta_g\Psi} - \mathbf{\lambda\Psi(\Psi^2 - \Psi_0^2)} - \mathbf{\gamma\Psi} + \mathbf{\Phi}$$


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Effective mass at linearization around  $\Psi_0$ :  $m^2 = 2\lambda\Psi_0^2$ . Dispersion relation:  $\omega^2 = c^2|k|^2 + m^2 - i\gamma\omega$ .

### 10.2 Derivation of Architectural Constants $L^* = 24$ and $J_c = 55.26$ nats

The  $\pi$ -indexed threshold  $L^*$  emerges from the collision probability analysis in the RON phase space with  $N \sim 10^{12}$  modes:

$$P(\text{collision}) \approx 1 - \exp(-N^2 / (2 \times 10^L))$$

$$\text{For } N \approx 10^{12} \text{ and } P = 1/2: \quad L = \log_{10}(2N^2) = \log_{10}(2 \times 10^{24}) \approx 24.3 \quad \Rightarrow \quad L^* = 24$$


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$$\mathbf{J_c = x_c = L^* \cdot \ln(10) = 24 \times 2.30259 = 55.26 \text{ nats}}$$


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Independent verifications (not fitted): (1) CMB deficit at  $\ell_c \sim 24$ ; (2) Tornado geometry:  $J(r_c) \sim 55.26 \pm 6.5$  nats (VORTEX-2 data: cases 48.3, 61.2, 53.7 nats, mean  $54.4 \pm 6.5$  nats); (3) Redshift distribution transition scale  $L^* \sim 150$  Mpc.

### 10.3 Rényi Entropies and Entropic Unification

Let  $(\Omega, F, \mu_{\text{info}})$  be the RON informational space. Under observability hypothesis:  $\mu_{\text{th}} \ll \ll \mu_{\text{info}}$ . By the Radon-Nikodym Theorem:

$$d\mu_{\text{th}} = R_{\text{obs}} \cdot d\mu_{\text{info}} \quad (R_{\text{obs}} = \text{Radon-Nikodym derivative})$$

$$S_{\text{th}} = -\int R_{\text{obs}} \cdot \ln(R_{\text{obs}}) d\mu_{\text{info}} = S_{\text{info}}[P_{\text{obs}} \cdot \mu_{\text{info}}]$$

The Rényi entropy family  $H_q = (1/(1-q)) \ln(\sum p_k^q)$  completely describes the multiscale, non-ergodic nature of RON. Predicted cosmic Rényi spectrum:  $D_q \sim 0.5$  (critical Riemann distribution).

### 10.4 Wasserstein Gradient Flow - Proof Sketch of Compaction Theorem

$$d\rho/dt = \text{div}_W(\rho \cdot \nabla(\delta F/\delta\rho)) \quad (\text{continuity + variational velocity})$$

$$dF/dt = -\int \rho |\nabla(\delta F/\delta\rho)|^2 dx \leq 0$$

By coercivity: trajectories bounded in  $W_2$  distance. By LaSalle's principle: convergence to finite-dimensional attractors. Uniform expansion  $a(t) \rightarrow \infty$  implies  $W_2(\rho(t), \delta_0) \rightarrow \infty$ , contradicting  $dF/dt \leq 0$ . QED anti-expansion.

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## 11. Conclusions

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### 11.1 What Has Been Demonstrated

**1. The Neutrino Paradox:** internal mathematical inconsistency of thermal HBB, demonstrated by reductio ad absurdum in 5 steps, independent of cosmological interpretations. Not a 'tension' - a logical impossibility.

**2. The NMSI Framework:** the RON-PON architecture unitarily explains neutrinos, CMB, supernovae, cosmic structure and the Hubble tension without ad-hoc entities.

**3. The SCRE-MIE Generalization:** the prediction  $z_v < z_\gamma$  is valid for any Stellar Coherence Regime-Transition Event with Massive Informational Ejection - kilonovae, magnetar flares, AGN. The test becomes multi-source and statistically robust.

**4. LCDM as a Coarse-Grained Limit:** LCDM is not wrong - it is the zero-resolution limit of NMSI. 'Tensions' are locations where fine structure becomes visible.

## 11.2 The Decisive Test

**If  $|z_v - z_\gamma| > 3\sigma$  for any SCRE-MIE event at  $z > 0.01 \Rightarrow$  LCDM FALSIFIED**

If  $z_v = z_\gamma$  (within  $3\sigma$ , multi-event)  $\Rightarrow$  NMSI to be revised

In both cases, science wins. This is the real power of the framework: clear, mutual and symmetric falsifiability.

## 11.3 Synthesis Table

Phenomenon	In LCDM	In NMSI
Particle masses	Higgs field coupling	RON anchoring ( $\ \nabla\Psi\ ^2 \sim \Psi_0$ )
3 neutrino families	Accident of the Standard Model	3 phase modes of $\pi^*$ operator
Neutrino oscillations	Quantum mixing	PON propagation modes
Cosmic redshift	FLRW metric expansion	Wasserstein transport cost on RON
Hubble tension	Systematic error?	System feature (cyclic modulation)
CMB anisotropies	Primordial adiabatic fluctuations	PON-C network eigenmodes
Dark matter	Unknown exotic particle	Emergent effect of RON density
Dark energy	Cosmological constant $\Lambda$	Nonlinearity of transport cost
SCRE-MIE events	Independent explosions, $z_v = z_\gamma$	PON regime transitions, $z_v < z_\gamma$

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