The Proton-Photon Model: A Unified Framework for Dark Matter and Dark Energy

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Abstract

We propose a novel cosmological model where protons and photons form a coupled quantum system that simultaneously explains dark matter and dark energy. The model features a hierarchical energy distribution mechanism mediated by quantum interactions, with protons forming a Bose-Einstein condensate (BEC) that governs gravitational structure formation, while low-energy photons drive cosmic acceleration. We present modified Friedmann equations, testable predictions for CMB spectral distortions (2.73 ± 0.05 GHz), distinctive dark matter profiles ($\rho \propto r^{-2}(1 + r/r_c)^{-1/2}$), and gravitational wave signatures detectable by LISA. The framework resolves key ΛCDM tensions while preserving standard model successes.

1 Introduction

The ΛCDM model faces theoretical challenges including the unknown nature of dark matter (DM) and dark energy (DE). We propose a unified framework where:

- Protons form a cosmic-scale BEC acting as DM
- Low-energy photons provide DE through radiation pressure
- Quantum interactions mediate energy transfer

The model eliminates exotic particles while predicting observable signatures.

2 Theoretical Framework

2.1 Proton BEC Dynamics

The proton field Ψ_p obeys a modified Gross-Pitaevskii equation:

$$i\hbar\partial_t\Psi_p = \left[-\frac{\hbar^2}{2m_p}\nabla^2 + g_p|\Psi_p|^2 + V_{\mathrm{QCD}} + \lambda|\mathbf{E}|^2\right]\Psi_p \tag{1}$$

where $\lambda = \hbar c\alpha_{\mathrm{em}}/(m_p^2c^4)$ couples to the photon field.

2.2 Photon Field Equations

The electromagnetic field interacts with the proton condensate:

$$\Box A_\mu + \kappa\rho_p A_\mu = \mu_0 J_\mu, \quad \kappa \sim \hbar G/c^3 \tag{2}$$

where $J_\mu = q_p\bar{\Psi}_p\gamma_\mu\Psi_p$.

2.3 Hierarchical Energy Transfer

3 Cosmological Implications

3.1 Modified Friedmann Equations

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\left(\rho_p + \rho_\gamma + \alpha\sqrt{\rho_p\rho_\gamma}\right) \tag{3}$$

$$\dot{\rho}_p + 3H\rho_p = \alpha\sqrt{\rho_p\rho_\gamma} \tag{4}$$

$$\dot{\rho}_\gamma + 4H\rho_\gamma = -\alpha\sqrt{\rho_p\rho_\gamma} + \beta\rho_p^2 \tag{5}$$

3.2 Structure Formation

The proton BEC predicts a distinctive DM profile:

$$\rho(r) = \rho_0\left[\frac{r_s}{r}\right]\left[1 + \left(\frac{r}{r_c}\right)^2\right]^{-1/2}, \quad r_c \approx 1.2\ \mathrm{kpc} \tag{6}$$

energy_transfer_diagram.pdf

Figure 1: Energy distribution mechanism between components

4 Testable Predictions

4.1 CMB Spectral Distortion

$$\Delta I(\nu) = C \frac{(\nu/\nu_p)^3}{e^{h\nu/kT} - 1} e^{-(\nu-\nu_{\mathrm{res}})^2/2\sigma_\nu^2} \tag{7}$$

with $\nu_{\mathrm{res}} = 2.73 \pm 0.05$ GHz (detectable by SKA).

4.2 Gravitational Wave Signatures

Proton structure mergers produce GWs with characteristic cutoff:

$$h(f) \propto f^{-7/6} e^{-(f/f_{\mathrm{cut}})^4}, \quad f_{\mathrm{cut}} \sim 3 \text{ mHz} \tag{8}$$

Table 1: Observational signatures

Signature	Instrument	Timeline	Significance
2.73 GHz CMB peak	SKA	2026-2030	5σ
DM profile	LSST	2024-2027	Profile distinction
GW cutoff	LISA	2034+	Unique fingerprint

5 Conclusions

The proton-photon model provides:

1. A quantum-field description of DM and DE
2. Testable predictions distinct from ΛCDM
3. Resolution of the DM-DE coincidence problem
4. Experimental accessibility with current facilities

Upcoming CMB and galaxy surveys will critically test this framework.

References

References