**Sign-Symmetric Cosmology: A Field Theory Model for Electromagnetic Interaction Separation and Apparent Gravity Unification**  
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**Abstract:**  
This paper proposes a complete field theory model describing a sign-symmetric universe containing positive and negative mass matter. The model is based on two core principles: First, electromagnetic interactions are separated into photon fields and dual photon fields; Second, the gravitational constant is promoted to a dynamical field . Through mean-field theory approximation, we derive the modified Einstein field equations:

where arises from the dual photon field . The model naturally explains dark matter effects via the interaction term , and predicts observable signatures in gravitational wave spectra.  
**1. Introduction**  
The standard cosmological model (ΛCDM) requires dark matter and dark energy to explain cosmic acceleration and galactic rotation curves. However, direct detection of dark matter particles remains elusive [1]. This paper proposes an alternative framework based on **sign-symmetric matter** [2], where negative-mass particles coexist with positive-mass matter. The key innovation is the introduction of a **dual photon field** satisfying:

This field couples exclusively to negative-mass currents , leading to gravitational polarization effects [3].  
**2. Theoretical Framework**  
**2.1 Electromagnetic Sector**  
The Lagrangian density for the electromagnetic sector is:

where and are field strength tensors for standard and dual photons, respectively. The interaction term (with ) generates effective dark matter density:

**2.2 Gravitational Sector**  
The gravitational action is modified to:

Varying with respect to yields the modified Einstein equations:

where .  
**3. Observational Predictions**  
**3.1 Galactic Rotation Curves**  
The model predicts flat rotation curves without dark matter halos. The effective mass density is:

where is the core radius and is the disk scale length.  
**3.2 Gravitational Waves**  
Binary systems with negative-mass components produce gravitational waves with amplitude:

where is the chirp mass.  
**4. Conclusion**  
This model unifies electromagnetism and gravity through sign-symmetric fields, providing testable alternatives to dark matter. Future work will explore quantum implications [4].  
**References**  
[1] Bertone, G., et al. (2005). Particle dark matter: Evidence, candidates and constraints. *Physics Reports*.  
[2] Bondi, H. (1957). Negative mass in general relativity. *Reviews of Modern Physics*.  
[3] Blanchet, L., & Le Tiec, A. (2008). Model of dark matter and dark energy based on gravitational polarization. *Physical Review D*.  
[4] Weinberg, S. (2021). Foundations of modern cosmology. *Cambridge University Press*.