**Electromagnetic Segregation of Positive and Negative Mass Universes: A Complete Theory Based on Propagator Sign Symmetry Breaking**  
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**Abstract:**  
This paper constructs a complete mathematical theory describing the segregation of electromagnetic interactions between positive and negative mass universes. Based on experimental evidence of photon mass ∼ 10⁻⁴⁸ kg) and the negative mass property of dark matter in ABC theory, we propose that the propagators of electromagnetic interactions possess a “sign-symmetric” dual structure. The positive mass universe transmits repulsive or attractive electromagnetic forces via positive mass photons (γ⁺); the negative mass universe transmits its internal electromagnetic forces via corresponding negative mass photons (γ⁻). However, due to spontaneous breaking of mass sign symmetry, a massive potential barrier exists between the γ⁺ and γ⁻ fields, preventing their mutual conversion or coupling. This intrinsic segregation of propagators strictly confines electromagnetic interactions within their respective mass-sign domains, unable to cross the “± mass barrier,” thereby perfectly explaining why no electromagnetic interactions are observed between matter and dark matter. This paper provides a mathematically self-consistent proof for this segregation phenomenon through generalized Proca field theory and spontaneous symmetry breaking mechanisms.  
**Keywords:** Photon duality; Sign symmetry breaking; Mass barrier; Proca field; ABC mechanism; Cosmic segregation  
 1. Introduction: Paradigm Shift from Prohibition to Segregation  
Previous research, from the perspectives of energy conservation and propagator mass thresholds, demonstrated that negative mass particles cannot excite positive mass photons, thus being prohibited from participating in known electromagnetic interactions. However, a deeper and more symmetric question arises: Does an independent electromagnetic interaction system exist within the negative mass universe?  
The core thesis of this paper is affirmative. Electromagnetic interaction is not an “exclusive patent” of the positive mass universe but exists universally. Its propagators merely differentiate into two distinct “versions” due to mass sign differences, with fundamental segregation existing between these versions.  
 2. Theoretical Framework: Sign-Symmetric Electromagnetic Field Theory  
 2.1 Generalized Proca Action: Introducing Sign Symmetry  
We start from a generalized Proca action incorporating dual photon fields with sign symmetry:

where:  
- is the positive mass photon field, with field strength .  
- is the negative mass photon field, with field strength .  
- is the common parameter for photon mass terms.  
- contains couplings to matter fields.  
This Lagrangian exhibits formal symmetry under the global transformation . The mass terms and indicate that excitations are positive mass particles, while excitations are negative mass particles.  
 2.2 Equations of Motion and Mass Signs  
Varying the action yields two independent equations of motion:

where and are electromagnetic currents in the positive and negative mass sectors, respectively.  
These equations are fundamentally distinct. Their Green’s functions (propagators) in momentum space are:

These propagators exhibit completely different pole structures—one at (timelike), the other at (spacelike)—mathematically indicating they describe two fundamentally distinct physical entities.  
 3. Interaction Segregation Mechanism: Mass Barrier  
 3.1 Selective Coupling  
The electromagnetic coupling term for matter fields is:

where:  
- is the electromagnetic current composed of positive mass matter fields.  
- is the electromagnetic current composed of negative mass (dark matter) fields.  
**Core hypothesis:** The mass sign of a field determines its exclusive coupling to the electromagnetic field of the same sign:  
- Positive mass particles couple only to , i.e., , with containing no .  
- Negative mass particles couple only to , i.e., , with containing no .  
 3.2 Mass Barrier and Propagator Segregation  
Consider the scattering process between a positive mass electron () and a negative mass dark matter particle (). Even if both carry charge, only two interaction channels are possible:  
3.2.1. Exchange a photon: But does not couple to , so this vertex vanishes.  
3.2.2. Exchange a photon: But does not couple to , so this vertex also vanishes.  
Thus, the Feynman diagram for this scattering process cannot be constructed, and its scattering amplitude is strictly zero in perturbation theory:

No direct mixing terms (e.g., ) exist between and fields, as they belong to distinct vacuum sectors after mass sign symmetry breaking. A massive effective potential barrier exists between them, suppressing mutual conversion or coupling at energy scales far below the Planck scale.  
 4. Cosmological Implications and Observable Effects  
 4.1 Two Parallel Electromagnetic Universes  
This theory depicts a scenario where our positive mass universe and the negative mass dark matter universe coexist and interpenetrate spacetime, yet each maintains its internal structure through independent electromagnetic interactions:  
- **Our universe:** Composed of , , atoms, and molecules, interacting via exchange.  
- **Dark matter universe:** Composed of negative mass particles and their composites, interacting via exchange.  
 4.2 Testable Predictions  
 4.2.1 Photon Oscillation  
Despite strong suppression of - mixing, extremely weak “photon sign oscillation” effects—akin to neutrino oscillations—may occur in extreme high-energy or strong gravitational field environments. This could leave traces in future observations of ultra-high-energy cosmic rays.  
 4.2.2 Vacuum Birefringence  
The dual photon fields may induce subtle effects on vacuum electromagnetic properties, leading to a novel “sign birefringence” effect in strong fields (e.g., pulsar magnetospheres).  
 4.2.3 Cosmological Constant  
The negative mass photon field () may contribute to vacuum energy with opposite sign to the positive mass photon field (), offering a novel approach to resolving the cosmological constant problem.  
 5. Conclusion  
This paper perfectly explains the electromagnetic invisibility between matter and dark matter by introducing a dual photon field theory with sign symmetry:  
**5.1 Symmetry Framework:** Electromagnetic interaction is intrinsically sign-symmetric, with two sets of propagators: positive mass photons () and negative mass photons ().  
**5.2 Segregation Mechanism:** Matter fields selectively couple to photon fields of matching mass sign. and fields are naturally segregated by a mass barrier, precluding communication.  
**5.3 Physical Picture:** Positive and negative mass universes resemble parallel worlds sharing the same spacetime, governed by two perpetually non-intersecting sets of electromagnetic laws.  
This study elevates the dark matter problem from mere “absence” to the profound level of “segregation under symmetry breaking,” providing a new theoretical paradigm and testable predictions for exploring the holographic structure of the universe.  
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