**The “Elementary Particle” Spectrum of Negative Mass Dark Matter: A Theoretical Model Based on Field Combination Classification and Topological Charge Identification**

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**Abstract:**  
Based on Li Zhijun’s ABC theory, this paper systematically proposes, for the first time, a theory that negative mass dark matter (NMDM) possesses its own rich spectrum of “elementary particles”. The core thesis is: Just as positive mass matter particles (quarks, leptons) are defined by their specific coupling patterns to the ABC fields negative mass dark matter particles similarly form their unique particle spectrum through couplings to the sign-reversed branches of the ABC fields. We demonstrate that due to the existence of a Charge-Parity (CP)-type symmetry, a duality exists between the dark matter “particle” spectrum and the matter particle spectrum, but with all mass signs being negative. By constructing a classification model for the dark matter field based on , we predict three fundamental types of dark matter “flavor” particles and their strong interactions mediated by negative mass gluons thereby forming dark matter “hadrons” (e.g., the dark baryon dark meson The model further predicts dark electromagnetic interactions (mediated by the negative mass photon and dark weak interactions, forming a dark matter universe parallel and nearly mirror-like to the visible matter world. This paper provides a rigorous mathematical formulation of the mass matrix, charge operator, and interaction Lagrangian for this dark matter particle spectrum, and discusses its cosmological observational effects.

**Keywords**: ABC theory; Negative mass dark matter; Dark particle spectrum; Duality; Dark strong interaction; Dark electromagnetic interaction; Dark weak interaction; Cosmological probe

1. **Introduction: Particle Physics of the Dark Matter World**

Modern cosmology has determined that dark matter exists and constitutes 26.8% of the universe, but its particle physics nature remains a mystery. Li Zhijun’s ABC theory posits that the fundamental distinction between dark matter and ordinary matter lies in the sign of the Higgs field vacuum to which they couple vs This strongly suggests that dark matter is not a single particle but should possess a complex particle spectrum analogous to the visible matter world, constituted by a set of dark matter version of “elementary particles”.

1. **Theoretical Framework: Field Combination Definition of Dark Matter Particles**

2.1 Duality Principle of Field Combinations

Particles in the matter world are defined by their excitation modes on the positive vacuum branches of the ABC fields According to the duality principle, a corresponding dark matter world exists, whose particles have corresponding excitations on the negative vacuum branches

For a matter particle (e.g., the up quark u):

Its corresponding dark matter partner particle (named the “dark up-quark” has the field combination:

Its mass sign is opposite but its dark charge and dark color charge follow similar group theory rules.

2.2 Dark Interaction Gauge Group

Interactions in the matter world are described by the gauge group . We hypothesize that the dark matter world is governed by a dual gauge group :

where is the dark color charge gauge group, and is the dark hypercharge gauge group.

2.3 Dark Matter “Flavor” Particle Spectrum

We predict the existence of three generations of dark fermions (dark quarks and dark leptons):

| **Particle** | **Dark Charge** | **Dark Color Charge** | **Mass Sign** |
| --- | --- | --- | --- |
| (dark up-quark) | +2/3 | Triplet (red, green, blue) |  |
| (dark down-quark) | -1/3 | Triplet (red, green, blue) |  |
| (dark strange-quark) | -1/3 | Triplet (red, green, blue) |  |
| (dark electron) | -1 | Singlet |  |
| (dark neutrino) | 0 | Singlet |  |

Their general field combination form is:

1. **Dynamics of Dark Interactions**

3.1 Dark Strong Interaction and Dark Confinement

Dark quarks carry dark color charge and undergo dark strong interactions mediated by the exchange of dark gluons Their interaction Lagrangian is:

where is the dark color charge gauge covariant derivative, and are the generators of .

Similar to QCD, dark color charge undergoes confinement. Dark quarks bind to form dark hadrons:  
\* Dark baryons: Composed of three dark quarks, e.g., (the neutral, stable main component of dark matter).  
\* Dark mesons: Composed of a dark quark and a dark anti-quark, e.g.,

3.2 Dark Electromagnetic Interaction

Particles carrying dark charge undergo dark electromagnetic interactions mediated by the exchange of the dark photon The Lagrangian is:

Since all dark particle masses their vacuum polarization is opposite to that of the matter world, potentially leading to a running behavior of the dark electromagnetic coupling constant different from QED.

3.3 Dark Weak Interaction

We further predict the existence of a dark weak interaction, mediated by dark bosons, which could lead to the decay of dark particles, resulting in a complex dark matter cosmological evolution history.

1. **Construction of a Mathematically Self-Consistent Model**

4.1 Mass Generation and the Dark Higgs Mechanism

Dark particles acquire mass through Yukawa interactions with the dark Higgs field (coupled to the vacuum):

After the dark Higgs field acquires a vacuum expectation value it generates negative mass:

The root of the negative mass lies in the dark Higgs field coupling to the vacuum.

4.2 Stability and Symmetry

The stability of the lightest dark hadron (e.g., is guaranteed by dark baryon number conservation . This symmetry is an accidental symmetry of the gauge group.

4.3 Interaction with the Matter World

The only direct interaction between dark matter and the matter world is gravity. Due to the opposite mass sign, this gravity is repulsive.

Furthermore, there might be kinetic mixing between and :

This mixing could lead to a tiny coupling between the dark photon and the photon, offering a possibility for experimental detection.

1. **Cosmological and Observational Implications**

5.1 Structure Formation

The repulsive gravity of negative mass dark matter would suppress the formation of small-scale structures. This aligns with observed issues like the missing dwarf galaxy problem. However, once dark matter forms composite particles (dark hadrons), their effective interactions might change, allowing structure formation on larger scales.

5.2 Annihilation and Indirect Detection

Dark quarks might undergo annihilation, e.g., If kinetic mixing exists, dark hadron annihilation could ultimately produce Standard Model particles (e.g., providing signals for indirect detection.

5.3 Direct Detection

Due to repulsive gravity, negative mass dark matter would not accumulate within Earth-based detectors. Traditional direct detection methods based on nuclear recoil fail. New methods are needed, such as detecting its repulsive gravitational effects or through kinetic mixing effects.

1. **Conclusion and Outlook**

Based on the ABC theory, this paper proposes a complete theoretical model for the “elementary particle” spectrum of negative mass dark matter:

1. Duality: The dark matter world possesses a particle spectrum and interactions (dark QCD, dark QED, dark weak interaction) dual to those of the matter world.
2. Compositeness: The main component of dark matter is composite particles (dark hadrons), whose stability is guaranteed by dark baryon number conservation.
3. Detectability: The model predicts unique cosmological effects and possible indirect detection signals.

**Future work:**  
1. Calculate the mass spectrum and interaction cross-sections of dark hadrons.  
2. Study the specific signals of dark matter annihilation.  
3. Explore the experimental constraints and detection prospects of kinetic mixing.

This model advances dark matter research from a “single particle” paradigm to a “complex dark sector” paradigm, providing rich theoretical guidance for the next generation of cosmological observations and particle experiments.

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