A Unified Field Theory in 26-Dimensional Combinatorial Space: Strong Interactions, Heavy Fermion Decay, and Cosmological Dynamics  
**Authors:** Li Zhijun, Zhao Guangyao  
**Affiliations:**  
Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049  
Department of Physics, Tsinghua University, Beijing 100084  
**Corresponding Author:** zhaogy@ihep.ac.cn  
 **Abstract**  
This paper proposes a unified field theory framework based on 26-dimensional combinatorial space, systematically constructing a self-consistent theoretical system encompassing strong interactions (quark-gluon coupling), heavy fermion decay (triplet-triplet combination mechanism), and cosmological dynamics (singularity explosion, inflation, and black hole collapse suppression). By introducing the color-charged vortex field , Higgs vortex field , and energy quantum-vortex field coupling , we derive dynamical equations for three types of interactions within a tensor algebra framework:  
1. **Strong Interactions**: The coupling term between the quark color-charged field and gluon vortex field , satisfying gauge invariance.  
2. **Heavy Fermion Decay**: The coupling for triplet-triplet combinations with the Higgs vortex field, predicting a decay width .  
3. **Cosmological Dynamics**: The restorative force of the vortex field drives singularity explosions, particle pressure triggers inflation, and negative-mass dark matter (comprising 26.7% of the universe) induces gravitational suppression of black hole formation.  
The theory is validated through a three-tier verification system: primordial gravitational wave spectra (characteristic frequency ), heavy fermion decay signals (LHC high-energy collisions), and cosmic microwave background polarization (Planck satellite), providing testable predictions for physics beyond the Standard Model.  
**Keywords:** 26-dimensional combinatorial space; color-charged vortex field; triplet-triplet combination; cosmic inflation; heavy fermion decay.  
 **1. Introduction**  
The Standard Model (SM) and General Relativity (GR) exhibit fundamental limitations in describing fundamental interactions and cosmological evolution:  
- **Strong Interactions**: QCD’s asymptotic freedom and confinement mechanisms resist unification with electroweak theory.  
- **Heavy Fermions**: Beyond-SM third-generation fermions (e.g., potential fourth-generation quarks) lack decay path descriptions.  
- **Cosmological Puzzles**: Singularity explosions, inflation mechanisms, and black hole information paradoxes require dynamical explanations.  
Building on Li’s Cosmic Vortex Field Theory (Li, 2023), this work constructs a 26-dimensional combinatorial space (where is spacetime and is an intrinsic symmetry space), unifying three physical processes via tensor coupling.  
 **2. Theoretical Framework: Tensor Structure of 26-Dimensional Combinatorial Space**  
 **2.1 Fundamental Field Definitions**  
- **Color-Charged Vortex Field :**

where are generators satisfying .  
- **Higgs Vortex Field :**

where is the Higgs quadruplet field and is the vacuum expectation value.  
- **Energy Quantum-Vortex Field Coupling :**

where is the 26-dimensional curvature scalar, driving the vortex field restorative force .  
 **2.2 Unified Construction of Interaction Terms**  
All interactions are generated via tensor contraction , where are fundamental field combinations:  
| Interaction Type | Field Combination | Tensor Structure | Coupling Coefficient |  
|————————|—————————-|———————————–|———————-|  
| Quark-Gluon | | | |  
| Heavy Fermion Decay | | | |  
| Cosmic Inflation | | | |  
 **3. Strong Interactions: QCD-like Quark-Gluon Coupling**  
 **3.1 Lagrangian and Equations of Motion**  
The coupling Lagrangian for the quark field (color triplet) and gluon field is:

Yielding equations of motion:

**3.2 Vortex Field Interpretation of Color Confinement**  
As quark separation , the vortex field energy density diverges, leading to:

This aligns with the linear confinement potential from lattice QCD (Lucini et al., 2015).  
 **4. Heavy Fermion Decay: Triplet-Triplet Combination Mechanism**  
 **4.1 Mathematical Structure of Triplet-Triplet Field**  
Heavy fermions transform under , decaying via the Higgs vortex field :

where is the spin tensor.  
 **4.2 Decay Width Calculation**  
In the center-of-mass frame, the decay width is:

where is the 26-dimensional theory cutoff.  
 **5. Cosmological Dynamics**  
 **5.1 Vortex Field-Driven Singularity Explosion**  
At Planck scales, the vortex field restorative force and energy quantum coupling jointly drive singularity explosions:

Modifying the Friedmann equation:

**5.2 Inflation Mechanism and Black Hole Collapse Suppression**  
- **Inflation Trigger**: When particle density satisfies , the universe enters exponential expansion:

- **Black Hole Suppression**: Negative-mass dark matter () generates an effective gravitational potential:

When , collapse is suppressed.  
 **6. Theoretical Verification and Experimental Predictions**  
 **6.1 Primordial Gravitational Wave Spectrum**  
Vortex field oscillations produce a gravitational wave energy spectrum:

Testable via CMB B-mode polarization (LiteBIRD satellite) and high-frequency detectors (e.g., atomic interferometers).  
 **6.2 Heavy Fermion Decay Signals**  
In LHC 14 TeV collisions, heavy fermion decay channels exhibit:

Expected cross-section (detectable in ATLAS/CMS high-luminosity runs).  
 **6.3 Cosmological Observational Constraints**  
- **Inflation Parameters**: Tensor-to-scalar ratio (Planck 2018) requires .  
- **Dark Matter Fraction**: (Planck 2020) aligns with negative-mass dark matter models.  
 **7. Conclusion and Outlook**  
This work achieves a unified description of strong interactions, heavy fermion decay, and cosmological dynamics within 26-dimensional combinatorial space:  
1. **Strong Interactions**: Color confinement reproduced via the vortex field .  
2. **Heavy Fermion Decay**: Triplet-triplet coupling predicts detectable high-energy signals.  
3. **Cosmology**: Vortex field restorative force and particle pressure drive singularity explosions and inflation; negative-mass dark matter suppresses black hole formation.  
**Future Work**:  
- Symmetry breaking: Compactification from 26D to 4D spacetime.  
- Renormalization: Loop corrections for precise experimental predictions.  
- Quantum gravity effects: Vortex field-spacetime coupling at Planck scales.  
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 **Figure Captions**  
**Fig. 1**: Decomposition of 26-dimensional combinatorial space.  
- Fiber bundle structure , with base manifold as spacetime and fiber containing color, weak, and hypercharge degrees of freedom.  
**Fig. 2**: Feynman diagram for heavy fermion decay.  
- Triplet-triplet combination decaying to leptons and jets via Higgs vortex field .  
**Fig. 3**: Predicted primordial gravitational wave spectrum.  
- Characteristic peak from vortex field oscillations () vs. quantum gravity background ().  
**Fig. 4**: Three-stage cosmological dynamics.  
- (a) Singularity explosion: Dominated by vortex field restorative force .  
- (b) Inflation: Particle pressure breaches vortex field boundary.  
- (c) Black hole suppression: Negative-mass dark matter counteracts gravitational collapse.  
> **Innovations**:  
> 1. **Theoretical Unification**: First unification of strong, electroweak, gravitational, and new physics (heavy fermions) in 26-dimensional space.  
> 2. **Mathematical Completeness**: All interaction terms rigorously derived via tensor algebra, satisfying gauge invariance and general covariance.  
> 3. **Experimental Testability**: Three-tier verification system (particle physics, cosmology, gravitational waves) across multiple energy scales.