**Graviton-Mediated Proton Decay: Quantum Tunneling of Field Combinations and Topological Charge Transfer**

Authors: Zhijun Li, Guangyao Zhao

Abstract:  
Within the framework of the ABC theory, the graviton is the only boson that can interact with all field combination branches It is not only an excitation of the spacetime metric but also a fundamental portal connecting the positive-mass matter world vacuum) and the negative-mass dark matter world vacuum). This paper rigorously demonstrates that gravitons can catalyze the quantum tunneling of proton field combinations across a huge potential barrier, leading to their decay into dark matter field combinations, by providing virtual energy-momentum transfer. We construct the ground state representations of proton and dark matter field combinations, deriving the potential landscape and barrier height between them, By introducing the coupling term between the graviton and the kinetic energy term of the Higgs field,

and calculating the quantum tunneling amplitude using instanton path integrals,

we prove that the graviton background can induce a negative energy density effectively reducing the potential barrier thereby increasing the decay probability . Finally, the proton lifetime is estimated to be years, and the microscopic mechanism of field combination reorganization through topological charge transfer is elucidated.

Keywords: ABC theory; Graviton catalysis; Proton decay; Quantum tunneling; Instanton; Topological charge; Dark matter

1. **Introduction: Gravity as a Portal for Unified Interactions**

In the ABC theory, the graviton is the only boson that can interact with all field combination branches It is not only an excitation of the spacetime metric but also likely a fundamental portal connecting the positive-mass matter world vacuum) and the negative-mass dark matter world vacuum). This chapter will rigorously prove that gravitons can catalyze the quantum tunneling of proton field combinations across a huge potential barrier, leading to their decay into dark matter field combinations, by providing virtual energy-momentum transfer.

1. **Potential Landscape of Field Combinations and Decay Channels**

2.1 Ground State of Proton Field Combination

A proton (p) field combination can be represented as a topologically non-trivial soliton solution of the color charge field in the vacuum:

where is the normalization factor, and is the quark wave function envelope. This state is a color singlet and a local energy minimum (metastable state) in the vacuum.

2.2 Ground State of Dark Matter Field Combination

The hypothesized decay final state consists of two dark matter fermions and a positron (to conserve charge):

This state is the global energy minimum (true vacuum) in the vacuum.

2.3 Potential Landscape and Barrier

A huge potential barrier exists between the two vacua, whose height is determined by the self-coupling strength of the Higgs field:

where is the Higgs vacuum expectation value. Proton decay requires tunneling from the local minimum of the vacuum, across this barrier, to the global minimum of the vacuum.

1. **Catalytic Mechanism Mediated by Graviton**s

3.1 Effective Interaction Lagrangian

The coupling between the graviton and matter fields is governed by the energy-momentum tensor :

can be decomposed into contributions from various field combination branches:

We propose that the key catalytic term arises from the coupling between the graviton and the kinetic energy term of the Higgs field C:

This term can perturb the vacuum configuration of the Higgs field without directly transferring energy, thereby reducing the tunneling barrier.

3.2 Calculation of Quantum Tunneling Amplitude

Proton decay is a non-perturbative process. Its amplitude is given by the instanton path integral:

where the effective Lagrangian includes the matter fields, gravitational field, and their interactions.

Under the saddle-point approximation, this amplitude is dominated by the leading instanton solution :

where is the Euclidean action (obtained via Wick rotation

3.3 Mechanism of Graviton-Induced Barrier Reduction

Calculations show that there exists an instanton solution for the graviton background field, which induces an effective negative energy density in the Higgs field, thereby effectively lowering the barrier height:

where

Thus, the Euclidean action with graviton participation will be less than the action without gravitons :

This exponentially increases the decay probability:

By providing a “negative energy” background, gravitons effectively assist the Higgs field in overcoming the barrier, catalyzing the tunneling process.

1. **Estimation of Proton Lifetime**

The decay rate is related to the lifetime by

where is a huge dimensionless number. Dimensional analysis and order-of-magnitude estimation yield:

where is the energy scale of new physics (e.g., GeV). Substituting values:

Therefore,

This value is astonishingly large, but it can be reduced to the observationally acceptable range of around years by introducing additional catalytic mechanisms (e.g., higher-dimensional operators, a lower energy scale The key point is that the involvement of gravitons indeed gives the originally absolutely stable proton a finite, albeit extremely long, lifetime.

1. **Conclusion: Mechanism Elucidation**

Within the framework of Li Zhijun’s ABC theory, the mechanism of proton decay can be summarized as follows:

1. Initial State: The proton exists as a stable topological soliton (baryon number B=1) in the vacuum.
2. Catalytic Mediator: Virtual gravitons acting as mediators, couple with the kinetic energy term of the Higgs field generating a localized negative energy density fluctuation at a spacetime point.
3. Quantum Tunneling: This negative energy fluctuation effectively lowers the potential barrier between the and vacua, enabling the proton field combination to tunnel across the barrier via quantum tunneling.
4. Field Combination Reorganization: During tunneling, the topological charge (baryon number) of the color charge field is “neutralized” or “transferred,” and the sign of the Higgs field vacuum expectation value flips (from to
5. Final State: The reorganized field combination stabilizes in the vacuum, manifesting as dark matter particles and a positron (baryon number B=0).

**This process profoundly reveals**:  
\* Gravitons are the ultimate bridge connecting the visible and invisible worlds.  
\* The stability of matter (proton lifetime) is deeply connected to quantum gravitational effects (Planck scale) and new physics energy scales (e.g., Grand Unification scale).  
\* Baryon number may not be absolutely conserved but rather a topological charge that is approximately valid at low energies and can be violated at the quantum gravity level.

This mechanism provides the first mathematically self-consistent quantum field theory description for understanding the mutual transformation between matter and dark matter.

**References**  
[1] Li, Z. J. (2023). The ABC Mechanism in the Universe.  
[2] Hawking, S. W. (1979). The Path-Integral Approach to Quantum Gravity. In General Relativity: An Einstein Centenary Survey (pp. 746–789). Cambridge University Press.  
[3] ’t Hooft, G. (1976). Symmetry Breaking Through Bell-Jackiw Anomalies. Physical Review Letters, 37(1), 8–11.  
[4] Coleman, S. (1977). The Fate of the False Vacuum. I. Semiclassical Theory. Physical Review D, 15(10), 2929–2936.  
[5] Rubakov, V. A. (2002). Classical Theory of Gauge Fields. Princeton University Press.