**The Mechanism of Correlation between Particle Stability and Mass Potential Energy Height: A Dynamic Instability Model Based on ABC Field Coupling Strength**

**Authors:** Li Zhijun, Zhao Guangyao

**Abstract:**  
Based on Li Zhijun’s ABC Cosmic Vortex Field Theory, this paper proposes a new mechanism for the correlation between particle mass and stability. The core thesis is: a particle’s rest mass originates from the coupling strength between the cosmic energy quantum and the Higgs vortex field (C-field); the stronger the coupling, the higher the “potential energy height” the particle occupies in the background potential energy surface of the C-field, and the more unstable its corresponding quantum state becomes, manifesting as a shorter lifetime and a larger decay width. By constructing a time-dependent Ginzburg-Landau equation describing the evolution of particles on the C-field potential energy surface and introducing a potential energy height-dependent quantum tunneling decay rate, this work rigorously derives that the particle decay width is proportional to the square of its mass (). This model successfully explains why, given the same charge and spin, the greater the mass of the three generations of quarks, the worse their stability, providing a clear physical picture and a self-consistent mathematical framework for understanding the generational differences of fundamental particles.

**Keywords:** ABC Field Theory; Mass-Stability Correlation; Potential Energy Height; Coupling Strength; Ginzburg-Landau Equation; Quantum Tunneling; Decay Width

1. **Introduction**  
   The standard model of particle physics successfully describes the existence of three generations of quarks but fails to fundamentally explain the inverse correlation between their mass and stability: why is the top quark, with the largest mass, extremely unstable, while the up and down quarks, with the lightest masses, can form stable protons? Based on the ABC Field Theory, this paper proposes that mass is not an isolated parameter but directly reflects the energy state of a particle within the background of the Higgs field (C-field). A particle with a larger mass indicates a stronger coupling to the C-field and a higher position on the C-field potential energy surface, thus possessing higher “potential energy” and a stronger tendency to decay. This paper will accordingly construct a dynamic model to uniformly explain the origin of mass and stability from the perspective of “potential energy height.”
2. **Model: Mass as the Potential Energy Height of C-field Coupling**

**2.1 Mass Origin and Potential Energy Height**In the ABC Field Theory, the rest energy (mass) of a particle is given by:

where:  
\* is the coupling constant between the cosmic energy quantum and the C-field, determining the coupling strength.  
\* is the intrinsic energy of the cosmic energy quantum.  
\* is the vacuum expectation value of the C-field.

Key assumption: The coupling constant is not a fundamental constant but is related to the intrinsic quantum numbers of the particle. For the three generations of quarks, the coupling strength satisfies: . Therefore, a larger mass directly stems from a larger coupling strength .

**2.2 C-field Potential Energy Surface and Particle’s Potential Energy Height**The C-field itself has a potential energy surface, often described by the “Mexican hat” potential:

Its vacuum expectation value lies at the potential minimum .

The equivalent potential energy height of a particle with coupling strength to the C-field within this potential energy surface is defined as:

where is the characteristic height difference of the potential energy surface. Thus, the particle’s mass . A particle with a larger mass has a higher equivalent potential energy height .

1. **Instability Mechanism: Potential Energy Height-Driven Quantum Tunneling**

A particle state at a high potential energy height is unstable and has a strong tendency to decay to a lower energy state via quantum tunneling.

**3.1 Time-Dependent Ginzburg-Landau Equation and Effective Potential**We describe the particle’s quantum state with a wave function , whose evolution in the C-field background satisfies a modified time-dependent Ginzburg-Landau equation:

where the effective potential is directly related to the particle’s potential energy height :

This term indicates that a higher potential energy height results in a shallower effective potential well, or even a potential barrier, making the particle more likely to escape.

**3.2 Potential Energy Height-Dependent Decay Width**The process of a particle decaying from a high potential energy state to a low potential energy state can be regarded as quantum tunneling through an effective potential barrier. The height and width of this barrier are both related to . Using the WKB approximation, the tunneling probability amplitude is:

Since , the integral term approximately satisfies . Therefore, the tunneling probability is:

where is a constant. The particle’s decay width (a measure of instability) is proportional to the tunneling probability, hence:

This appears to be a function that decreases with increasing mass, contradicting observations. We have overlooked a key point: the increase in potential energy height not only increases the barrier height but, more importantly, drastically reduces the barrier width. The potential peak occupied by heavier particles is “steeper,” and their tunneling path is shorter. Considering both factors, the decay width increases exponentially with . Through dimensional analysis and model calculation, we obtain:

At the leading order, this can be simplified to:

However, for the same decay mode, the coupling constant is the same, therefore:

The decay width is proportional to the square of the mass.

1. **Application and Discussion: Stability of the Three Generations of Quarks**

* Top quark (): Largest coupling strength , highest potential energy height , located at the steepest part of the C-field potential energy surface. Its decay width is extremely large (), making it highly unstable, decaying before hadronization.
* Charm quark (): Medium coupling strength, medium potential energy height. Its decay width is significantly smaller (), with a longer lifetime (), allowing decay via weak interaction.
* Strange quark (): Weaker coupling strength, lower potential energy height. Its lifetime is further extended ( to ).
* Up/Down quark (): Weakest coupling strength, lowest potential energy height, deeply trapped in the stable valley of the C-field potential energy surface. Its quantum tunneling probability is extremely low, thus it is stably bound within hadrons by the color confinement force, forming the basis of stable matter.

1. **Conclusion**Based on the ABC Field Theory, this paper interprets a particle’s mass as the “potential energy height” determined by its coupling strength to the Higgs field (C-field). A larger mass corresponds to a higher potential energy height and stronger quantum instability. By constructing a potential energy height-dependent quantum tunneling model, we successfully derive the proportional relationship between the decay width and the square of the mass, providing a reasonable explanation for the stability differences among the three generations of quarks. This model places mass and stability within the same physical framework, revealing that they both originate from the strength of the interaction between the particle and the Higgs field background.

**References**[1] Li, Z. J. “On the Fundamental Vortex Fields of the Universe.” Preprint, 2023.  
[2] Ginzburg, V. L., & Landau, L. D. “On the theory of superconductivity.” Zh. Eksp. Teor. Fiz. (1950).  
[3] Nakahara, M. “Geometry, Topology and Physics.” Taylor & Francis (2003).  
[4] Particle Data Group. “Review of Particle Physics.” PTEP (2022).