Unstable to Stable: A Conceptual Model of the Higgs Field and Quantum Field Relationship

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Abstract

This paper proposes a conceptual relationship between the vacuum-unstable Higgs field and the vacuum-stable quantum field, considering their transformation across time and context as part of the universe's evolution. A future direction of inquiry includes the role of matter and antimatter as opposing agents in a structured cosmic ecosystem.

1 Introduction

The Higgs field, discovered through experiments at CERN, represents a quantum field responsible for assigning mass to particles via spontaneous symmetry breaking. In contrast, other quantum fields (e.g. photon, gluon fields) support massless or stable particle dynamics. This paper explores how quantum fields shift from vacuum instability to structured coherence.

2 Field Relationship Model

Our working model distinguishes between two primary field behaviors:

- **Higgs Field (Vacuum-Unstable)**: Associated with mass acquisition through field interactions. This instability is formalized via a potential function that allows spontaneous symmetry breaking.
- **Quantum Fields (Vacuum-Stable)**: Support behaviors like entanglement, superposition, and gauge invariance under symmetry-preserving transformations.

The distinction here is not oppositional but hierarchical in temporal behavior: the Higgs field evolves through a non-zero vacuum expectation value (VEV), stabilizing other field behaviors.

3 Mathematical Formulation: Field Collapse and Stabilization

We now introduce the Lagrangian structure associated with these fields. Consider a simplified Higgs potential:

$$\mathcal{L} = |\partial_\mu \phi|^2 - V(\phi), \quad V(\phi) = \mu^2 |\phi|^2 + \lambda |\phi|^4 \tag{1}$$

Here, ϕ is the Higgs field, $\mu^2 < 0$ leads to spontaneous symmetry breaking, and $\lambda > 0$ ensures vacuum stability. The vacuum expectation value $\langle \phi \rangle$ represents a stable field configuration, effectively "collapsing" the unstable symmetry.

3.1 Speculative Extension: Field Affinity Asymmetry Term

To represent asymmetric agent behavior, we propose an interaction term:

$$\mathcal{L}_{\text{asym}} = \eta (|\phi|^2 - |\bar{\phi}|^2)^2 \tag{2}$$

where ϕ and $\bar{\phi}$ represent matter and antimatter field modes, respectively. η is a coupling constant regulating competitive dynamics. This form introduces a preference toward one vacuum outcome in the presence of asymmetric initial conditions.

4 Speculative Foundation of Big Bang Dynamics

4.1 Transition from Instability to Structure

We hypothesize the Higgs field represents a phase of early cosmic instability. Its transition to a vacuum expectation state corresponds to the universe acquiring structure and particle mass.

In future work, this field transition could be embedded in a cosmological framework using the Friedmann-Lemaître-Robertson-Walker (FLRW) metric. This would explore how the Higgs field evolves over time and influences spacetime geometry through coupling to the energy-momentum tensor.

5 CP Symmetry Violation and Antimatter-Matter Asymmetry

CP violation provides a theoretical foundation for matter's dominance post-Big Bang. Sakharov conditions require:

- Baryon number violation
- C and CP violation

- Departure from thermal equilibrium

Our model introduces an extended metaphor:

> Matter and antimatter are agent-based field participants in an early cosmic ecosystem. Their asymmetry emerges through field-mediated dynamics analogous to competitive resource systems.

6 Future Work: Ecosystem Metaphor for Field Asymmetry

We envision a fungi-like agent consuming symmetric resources, leading to a dominance of one species. In this analogy:

- **Matter** behaves like a dominant species.
- **Antimatter** may have lower field affinity or collapse probability in asymmetric environments.
- **The Higgs field** acts as a thermodynamic selector or stabilizer.

Future modeling may adopt non-linear dynamics or simulation-based tools such as cellular automata or agent-based models to simulate competitive evolution of field values under symmetry-breaking conditions.

7 Conclusion

This paper proposes an interpretation of field transitions through a speculative but mathematically grounded model beginning with Higgs instability and collapsing into coherent quantum stability. We connect this collapse to symmetry breaking and CP-violating field behavior. Future work will continue to explore agent-based analogies and the field ecosystem that allowed matter to persist.