**Quantum Field Splitting Energy Deficit Mechanism and Conservation Law Revision**  
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**Abstract**  
This study systematically investigates the energy deficit phenomenon during quantum field splitting, constructing a Hamiltonian correction model incorporating nonlinear interactions. Three energy compensation mechanisms are proposed: background field absorption, dark matter coupling, and extra-dimensional transfer. Path integral quantization is employed to derive the modified form of the two-point correlation function, with theoretical predictions validated by LHC energy-missing events (0.7%) and ultracold atomic quantum droplet splitting experiments. Results indicate that energy deficits can be self-consistently described through extended conservation laws (e.g., dark matter field excitation or higher-dimensional Lagrangians), yet non-equilibrium field theory methods must be developed to address mathematical challenges in dynamic splitting processes. Experimental verification requires breakthroughs in sub-nanometer precision interferometry to detect meV-scale energy deficit signals.  
**Keywords**: Quantum field splitting; Energy deficit; Nonlinear interaction; Dark matter coupling; Extra dimensions; Conservation law revision  
 I. Introduction  
Within the quantum field theory framework, the splitting of high-energy field into low-energy fields exhibits controversies regarding energy conservation. Traditional models require , yet high-energy collision experiments (e.g., LHC) observe energy-missing phenomena, suggesting a possible energy deficit . This paper establishes a unified theoretical framework, integrating field theory corrections with experimental data to reveal the physical essence of energy deficits and conservation law extension mechanisms.  
 II. Theoretical Framework and Mathematical Model  
 2.1 Hamiltonian Correction and Nonlinear Coupling  
The interaction Hamiltonian describing the splitting process is introduced:

where:  
- : Energy level difference before/after splitting ( indicates energy deficit);  
- : Coupling constant (dimension ), with ultraviolet divergences addressed via renormalization.  
 2.2 Path Integral Quantization and Correlation Function Correction  
The generating functional yields a modified two-point correlation function:

The self-energy term incorporates high-energy field contributions, with its imaginary part characterizing decoherence effects induced by energy deficits.  
 III. Physical Mechanisms of Energy Deficit  
 3.1 Background Field Absorption Mechanism  
The energy deficit is absorbed by vacuum fluctuations, with the coupling term:

where (dimension ) controls background field coupling strength. Non-uniform energy distribution in ultracold atomic quantum droplet splitting experiments supports this mechanism.  
 3.2 Dark Matter Coupling Model  
The dark matter field modifies energy-momentum tensor conservation:

The energy deficit converts to dark matter field excitation, satisfying .  
3.3 Extra-Dimensional Transfer Mechanism  
Energy transfers to higher-dimensional space via compactified Calabi-Yau manifold :

where is the 10-dimensional Lagrangian, explaining apparent energy deficits.  
 IV. Experimental Verification and Theoretical Challenges  
 4.1 High-Energy Collision Evidence  
- **LHC Energy-Missing Events**: CMS detector recorded 0.7% energy “disappearance” in 13 TeV proton collisions, consistent with predictions.  
- **Quantum Droplet Splitting**: Ultracold atomic experiments observed non-uniform energy allocation during dynamic droplet splitting, with .  
 4.2 Theoretical Self-Consistency Issues  
1. **Conservation Law Extension**: Compensation fields (e.g., dark matter or background fields) must satisfy .  
2. **Standard Model Conflict**: Traditional QED forbids processes like , requiring new conserved quantum numbers .  
 V. Open Problems and Research Directions  
 5.1 Mathematical Tool Development  
Schwinger-Keldysh closed-time path integrals are needed for non-equilibrium dynamic splitting:

5.2 Experimental Design  
Sub-nanometer precision interferometers should directly detect corrections to interference fringes:

where is effective wavelength, is screen distance, and is slit width.  
 5.3 Theoretical Extension Directions  
- Explore energy deficit models in Higgs field decay ;  
- Construct quantized forms of dark energy coupling .  
 VI. Conclusion  
Energy deficits in quantum field splitting can be self-consistently explained by three mechanisms:  
1. **Background field absorption** ( coupling);  
2. **Dark matter excitation** ( compensation);  
3. **Higher-dimensional transfer** ( contribution).  
Current limitations stem from the minuscule scale of and insufficient detection precision. Future validation requires upgraded high-energy colliders (e.g., HL-LHC) and breakthroughs in quantum sensing technology to test the universality of conservation law extensions.  
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