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**Field-Combination Dynamics and Energy-Level Redistribution in Electron-Positron Annihilation: A Rigorous Mathematical Physics Model Based on ABC Vortex Field Coupling**  
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 **Abstract**  
This paper constructs a rigorous quantum field theory framework for the electron-positron annihilation process. By introducing the ABC vortex field coupling mechanism (color charge field **B**, Higgs field **C**, electromagnetic field **A**), we unify the description of field-combination dynamics and energy-level redistribution. The model incorporates non-perturbative color charge field collapse, Higgs energy-level renormalization, and QED radiation processes into a self-consistent system for the first time. We derive the energy-momentum conservation law with **O(ε)** corrections and photon energy allocation formulas. The theory predicts a residual Higgs field fraction **ε < 10⁻⁵**, experimentally verifiable through angular distributions and energy spectra of diphoton final states in high-energy colliders. This work provides a new paradigm for precisely connecting quantum field theory gauge invariance, non-perturbative effects, and experimental observations.  
 **1. Introduction**  
Electron-positron annihilation (**e⁺e⁻ → γγ**) is a fundamental process in QED, yet traditional perturbation theory struggles to describe non-perturbative effects of color charge fields and Higgs field coupling. Based on the ABC vortex field mechanism (Li et al., *Phys. Rev. D* **108**, 036020 (2023)), we establish a field-combination dynamics model to address the following key issues:  
1. Mathematical formulation of instantaneous collapse of the color charge field **B**.  
2. Renormalization corrections to photon energy levels by the Higgs field **C**.  
3. Origin of **Δp^μ** in strict energy-momentum conservation.  
4. Experimental constraints on the observable parameter **ε**.  
 **2. Field Operators and Quantum State Definitions**  
 **2.1 Fermion Fields**  
**Electron field (spin-1/2):**

where and are electron/positron annihilation operators, and , are Dirac spinors.  
**Positron field (charge conjugation state):**

where is the charge conjugation operator satisfying .  
 **2.2 Gauge Boson Fields**  
**Photon field (spin-1):**

where is the photon annihilation operator, and satisfies the Lorentz gauge .  
 **3. Field-Combination Dynamics Evolution**  
**3.1 S-Matrix and Interaction Hamiltonian**  
The annihilation process is described by the **S-matrix**:

The interaction Hamiltonian contains three core mechanisms:  
 **3.2 Instantaneous Collapse of Color Vortex Field B**  
Non-perturbative effects induce exponential decay in the two-point function of the color charge field:

where is the QCD energy scale, contributing to initial-state renormalization in annihilation.  
 **3.3 Energy-Level Renormalization by Higgs Vortex Field C**  
The Higgs field mixes via :

where is the residual Higgs field fraction, experimentally constrained to (ATLAS Collaboration, *JHEP* **05**, 160 (2023)).  
 **3.4 Generation of Electromagnetic Vortex Field A**  
QED-dominated diphoton radiation is described by Feynman diagrams:

where is the virtual photon momentum, and is the metric tensor.  
 **4. Rigorous Energy-Momentum Allocation**  
 **4.1 Modified Energy-Momentum Conservation**  
Introducing energy-momentum carried by the Higgs field:

This correction originates from the non-zero vacuum expectation value of the field, violating strict energy-momentum conservation in traditional QED.  
 **4.2 Photon Energy Allocation**  
After quantum corrections, photon energies are:

where , is the scattering angle, and the term causes angular distribution deviations from QED predictions.  
 **4.3 Branching Ratio Constraints**  
The total decay width is corrected as:

The term arises from non-perturbative coupling between the Higgs field and photons.  
 **5. Experimental Verification Scheme**  
 **5.1 Angular Distribution Measurement**  
In the Belle II experiment, fit the differential cross-section for :

The correction induces forward/backward peak asymmetry, with current sensitivity reaching .  
 **5.2 Photon Energy Spectrum**  
Analyze the diphoton invariant mass spectrum in LEP data:

The shift is detectable by high-precision calorimeters (CMS Collaboration, *EPJC* **83**, 285 (2023)).  
 **6. Conclusion**  
This paper establishes a rigorous mathematical physics model for electron-positron annihilation, with core innovations including:  
1. **ABC Vortex Field Unified Framework**: Integrates color charge field collapse, Higgs renormalization, and QED radiation into a self-consistent system.  
2. **Energy-Momentum Conservation Correction**: First analytical expression for .  
3. **Experimental Verifiability**: The constraint is testable via Belle II/LEP data.  
The model strictly satisfies quantum field theory gauge invariance, providing a new paradigm for precisely connecting non-perturbative effects with experimental observations.  
 **References**  
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