Consistency of the Retro-Beam Transactional Framework with Conservation of Energy and Momentum

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August 25, 2025

Abstract

This paper explains how the Retro-Beam Transactional Framework (RBTF) upholds conservation of energy and momentum, integral to quantum mechanics. In RBTF, each transaction forms a self-consistent handshake between offer and confirmation waves (retro-beams), ensuring that conserved quantities are exchanged precisely between emitters and absorbers. This aligns with the Transactional Interpretation (TI), where transactions only actualize when boundary conditions for conservation are met. We provide a mathematical proof and three numerical examples demonstrating this consistency. ¡grok-card data-id="e22d0a" data-type="citation$_{c}ard$" >< $/grok-card$ >< $grok-carddata-id =$ "$467fe1$"$data-type =$ "$citation_{c}ard$" >< $/grok-card >$

1 Introduction

Conservation laws for energy, momentum, and angular momentum arise from symmetries in physical laws via Noether's theorem and are fundamental in quantum mechanics. RBTF, extending the Transactional Interpretation, incorporates retro-causality through retro-beams while preserving these laws. Transactions occur only when the net exchange of conserved quantities satisfies quantum boundary conditions, preventing violations.¡grok-card data-id="bf4856" data-type="citation$_{c}ard$" >< $/grok-card$ >< $grok-carddata-id =$ "$7fbff2$"$data-type =$ "$citation_{c}ard$" >< $/grok-card > The hand shake integrates over the spacetime path, making the process akin to a stationary action principle that inher$

RBTF passes this test as the retro-beam ensures matching of initial and final states, with probabilistic actualization maintaining overall conservation statistically.

2 Proof of Conservation

In RBTF, the total wavefunction $\Psi = \psi_o + R_c$ satisfies the field equations, such as the Dirac or Klein-Gordon equation, which are derived from a Lagrangian $\mathcal{L}$ invariant under spacetime translations (energy-momentum conservation).

By Noether's theorem, the conserved current is $j^\mu = \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi)} \delta\phi - T^\mu_\nu \xi^\nu$, leading to $\partial_\mu j^\mu = 0$.

For a transaction, the handshake forms a closed loop in spacetime, where the advanced and retarded waves cancel outside the emitter-absorber interval, ensuring zero net flux of conserved quantities beyond the transaction boundaries.¡grok-card data-id="35dfec" data-type="citation$_c ard$" >< /$grok - card$ >

Mathematically, the action $S = \int \mathcal{L}\, d^4x$ is stationary for the transactional solution, $\delta S = 0$, implying conservation along the path. Energy-momentum transfer equals $\Delta p^\mu = \int j^\mu d\sigma$, matching between emitter and absorber states.

Thus, no transaction forms unless $\Delta E = 0$ and $\Delta \mathbf{p} = 0$ in the center-of-mass frame, proving conservation.

3 Numerical Examples

3.1 Example 1: Atomic Transition in Hydrogen

Consider a hydrogen atom transitioning from n=2 to n=1, emitting a photon.

Energy levels: $E_n = -\frac{13.6}{n^2}$ eV.

$\Delta E = E_2 - E_1 = -3.4 - (-13.6) = 10.2$ eV.

In RBTF, the retro-beam from the future absorber (e.g., detector) confirms the photon energy matches 10.2 eV, conserving energy. Momentum is negligible for atomic recoil, but $\mathbf{p}_\gamma = \frac{E_\gamma}{c}\hat{k}$, balanced by atomic recoil $\mathbf{p}_a = -\mathbf{p}_\gamma$.

Numerical: Photon wavelength $\lambda = \frac{hc}{\Delta E} \approx \frac{1240}{10.2} \approx 121.6$ nm, conserved as per transaction.

3.2 Example 2: Compton Scattering

An X-ray photon scatters off a free electron.

Incident photon energy $E_i = 100$ keV, scattering angle $\theta = 90^\circ$.

Compton formula: $\Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta) = 0.00243(1 - 0) = 0.00243$ nm.

Initial wavelength $\lambda_i = \frac{hc}{E_i} \approx \frac{1240}{100000} = 0.0124$ nm.

Scattered $\lambda_f = 0.0124 + 0.00243 = 0.01483$ nm, $E_f = \frac{hc}{\lambda_f} \approx 83.6$ keV.

Electron kinetic energy $K_e = E_i - E_f \approx 16.4$ keV, conserving energy.

Momentum: Initial $\mathbf{p}_i = \frac{E_i}{c}\hat{i}$, final photon $\mathbf{p}_f = \frac{E_f}{c}(\cos 90^\circ \hat{i} + \sin 90^\circ \hat{j}) = \frac{E_f}{c}\hat{j}$, electron $\mathbf{p}_e = \mathbf{p}_i - \mathbf{p}_f$.

In RBTF, the transaction handshakes only if these match, conserving via the retro-beam.

3.3 Example 3: Electron-Positron Annihilation

Two-photon annihilation: $e^- + e^+ \to \gamma + \gamma$.

Rest energy $2m_e c^2 = 1.022$ MeV.

In center-of-mass, each photon $E_\gamma = 0.511$ MeV, back-to-back for momentum conservation ($\mathbf{p}_1 = -\mathbf{p}_2$).

Numerical: If relative velocity v=0 (at rest), photons at $180^\circ, p_\gamma = E_\gamma/c = 0.511 MeV/ceach, totalp = 0$.

In RBTF, retro-beams from future absorbers confirm the energy/momentum match, forming the transaction only for conserving outcomes.

4 References

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