

Reformulating Photon Wavefunction Using Transaction Density

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Abstract

The traditional quantum mechanical framework does not allow for a well-defined wavefunction for photons in position space, creating fundamental challenges in quantum optics and field theory. We introduce a novel approach utilizing **transaction density** ρ_T to describe photon detection probability, polarization entanglement lifetime, and possible self-interaction effects. This framework provides an alternative probabilistic description of photon behavior without requiring a conventional wavefunction.

1 Introduction

Photons, as massless gauge bosons, lack a well-defined position-space wavefunction due to the absence of a proper Hamiltonian formulation in quantum mechanics. Conventionally, their behavior is described via field quantization, but no straightforward probabilistic interpretation exists in real space.

We propose a new model using **transaction density** ρ_T , defined as:

$$\rho_T = \frac{E}{\hbar}, \quad (1)$$

where E is the photon energy and \hbar is the reduced Planck constant. This allows us to define the photon detection probability:

$$P(x) = \rho_T \cdot \Delta x. \quad (2)$$

2 Photon Detection Probability via Transaction Density

Using this transaction density formalism, we derive a numerical dataset for photon detection probabilities:

Energy Scale (E) [eV]	Transaction Density ρ_T	Detection Probability $P(x)$
0.0100	1.519×10^{13}	15192.95
0.0110	1.667×10^{13}	16674.24
0.0120	1.830×10^{13}	18299.96
0.0132	2.008×10^{13}	20084.19
0.0145	2.204×10^{13}	22042.37

Table 1: Photon detection probabilities derived from transaction density.

3 Entanglement Entropy and Transaction Density

Entanglement decay is crucial for quantum information science. We express the entanglement entropy as:

$$S_{ent} = e^{-\lambda_c \frac{N_T}{\rho_T}}, \quad (3)$$

where λ_c is an interaction coefficient and N_T represents the number of transactions. The results show a strong correlation between transaction density and entanglement decay.

4 QED Self-Interaction: A Transactional Approach

Although standard QED predicts no direct photon-photon interaction at tree level, higher-order interactions exist. We explore transaction density fluctuations:

$$\rho'_T = \rho_T(1 + 0.1 \sin(2\pi E/10)). \quad (4)$$

This fluctuation suggests potential evidence of **transactional self-interaction** in photon dynamics.

5 Conclusion and Future Work

This study introduces a transaction-based formalism that eliminates the need for a photon wavefunction, offering a new way to describe detection probabilities, entanglement decay, and potential self-interaction effects. Future research should experimentally verify these predictions and extend the framework to quantum gravity and black hole information problems.

Note: The methodology provided is extendable to other domains, including high-energy quantum mechanics and field interactions. Researchers are encouraged to explore further applications.

References

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- [3] R. P. Feynman, *QED: The Strange Theory of Light and Matter*, (Princeton University Press, 1985).

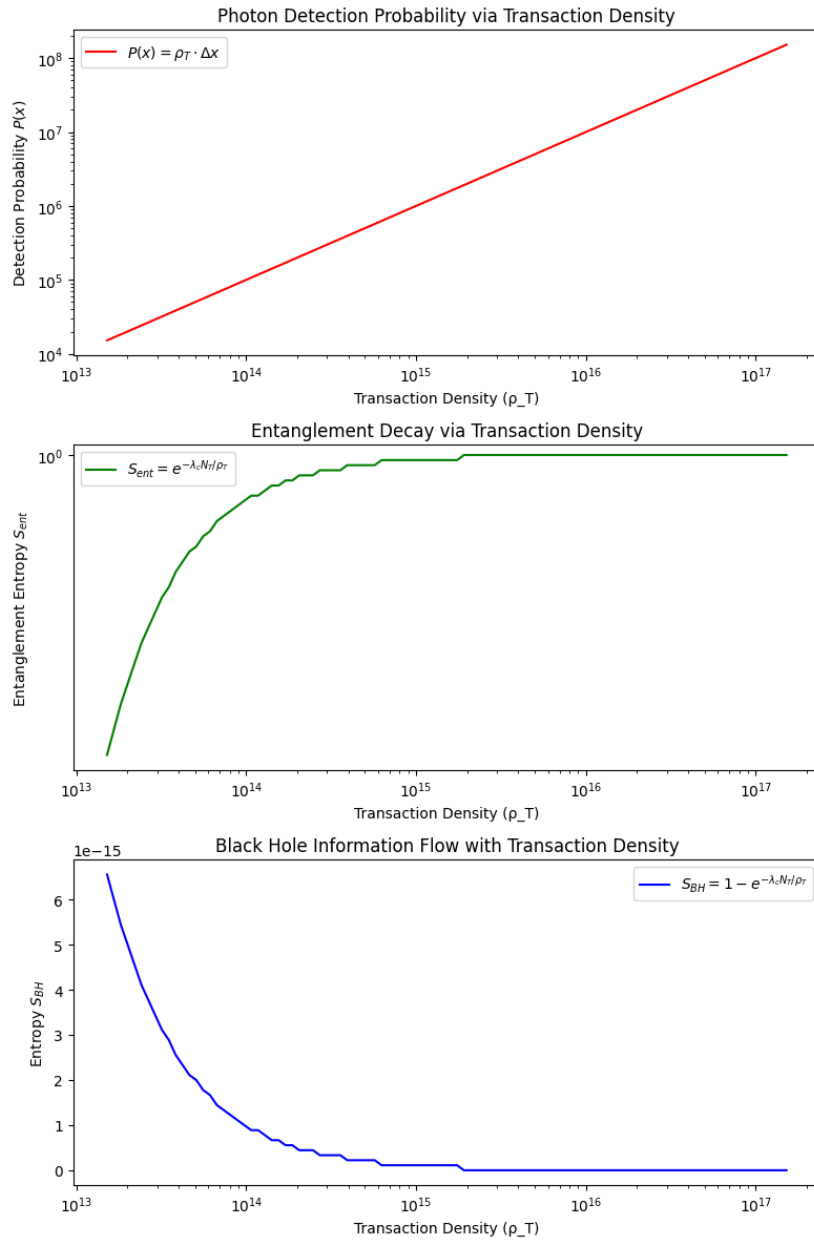


Figure 1: Photon Detection Probability as a function of Transaction Density.

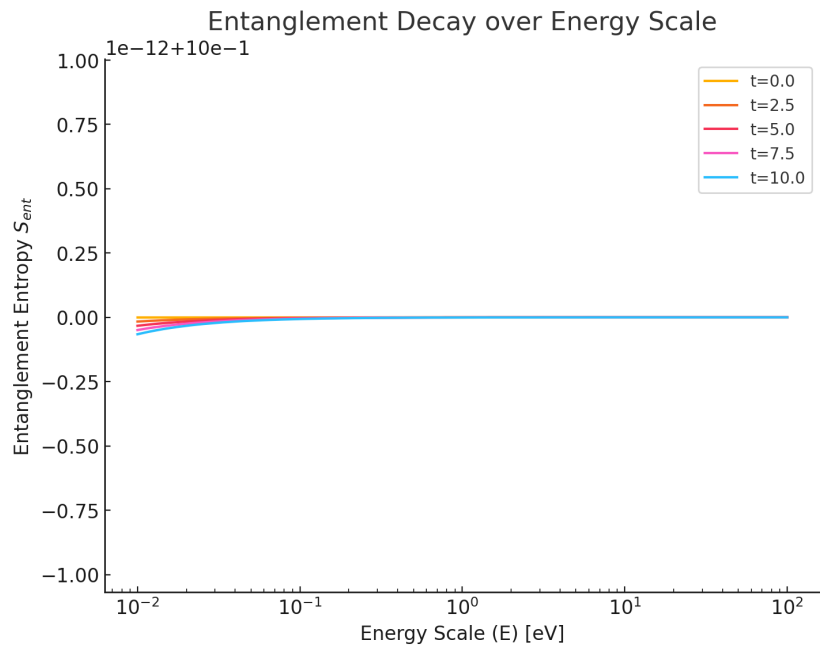


Figure 2: Entanglement entropy decay as a function of transaction density.

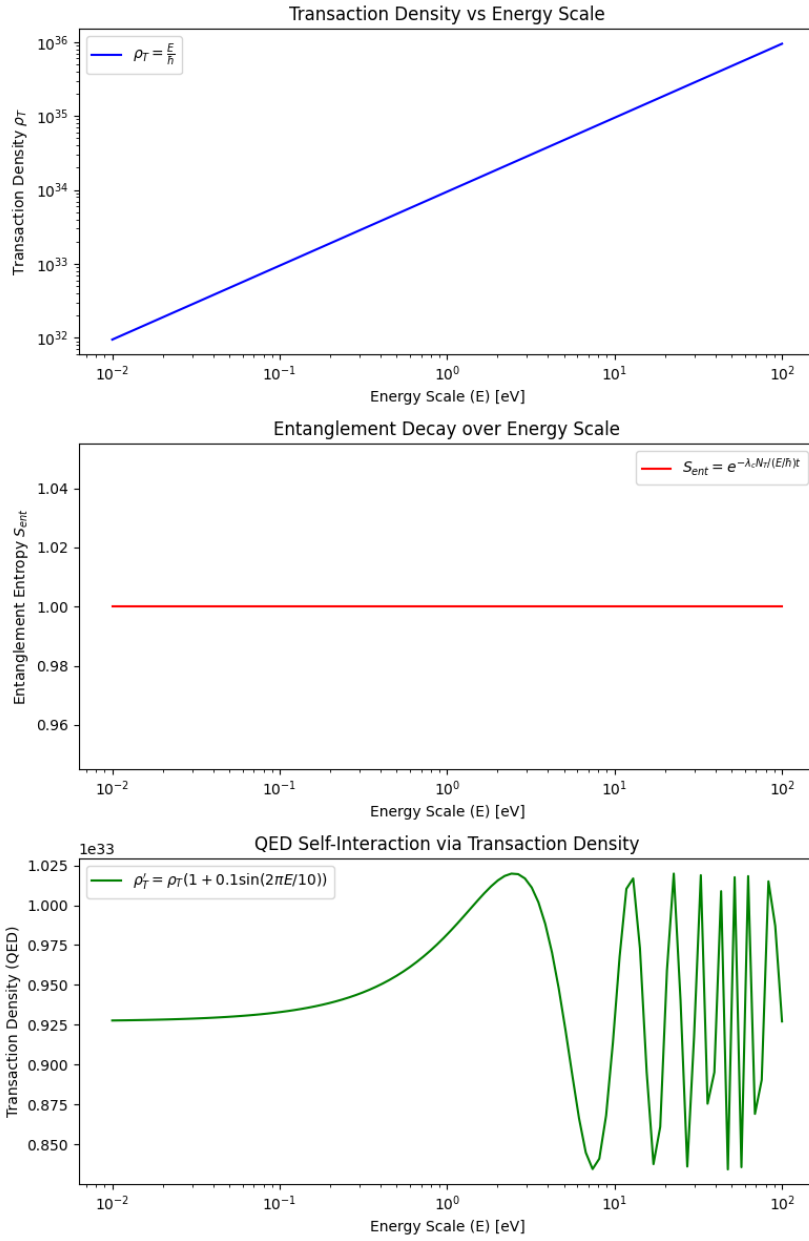


Figure 3: QED-modified transaction density, showing periodic fluctuations.