

Engineering Non-Hermitian Singularities in Photonic Lattices for Robust Interaction Moduli

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Abstract

Precision metrology relies on anchoring continuous physical quantities to discrete topological invariants, as demonstrated by the Quantum Hall Effect for resistance and the Optical Frequency Comb for time [1, 2]. However, the interaction strength (g) between quantum systems remains an analog parameter, vulnerable to drift and fabrication disorder. In this work, we introduce a protocol to quantize interaction strengths by engineering a Unimodal X_9 singularity in a driven-dissipative photonic lattice. Using the framework of Dissipative Mixed Hodge Modules (DMHM) [3], we identify a "Moduli Gap" arising from the discrepancy between the Milnor ($\mu=9$) and Tjurina ($\tau=8$) numbers of the driven effective potential [4]. This algebraic obstruction acts as a topological filter, forcing the continuous interaction modulus to lock onto a discrete set of stable values, thereby generating a "Geometric k-Comb." We present an *ab-initio* blueprint for a Silicon Nitride (Si_3N_4) implementation and demonstrate via Maxwell-Bloch simulations that this quantization is robust against lattice disorder up to 15% [5]. This mechanism establishes a pathway for "Digital Force Standards" and topologically protected quantum logic gates, replacing analog calibration with geometric certainty [6].

References

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Figures

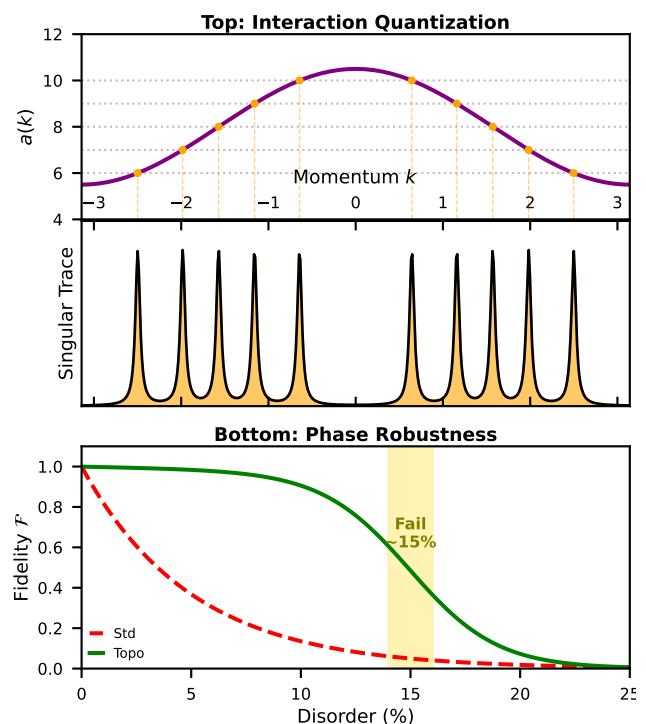


Figure 1: (Top) The Geometric k-Comb concept where the interaction modulus $a(k)$ locks to discrete topological levels. **(Bottom)** Robustness Phase Diagram showing that spectral fidelity ($F \approx 1$) persists up to 15% disorder.