Decoherence and the quantum-to-classical transition of a symmetry breaking coherent control scenario in an optical lattice

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An experimentally accessible way to study the quantum-to-classical (hbar ? 0) transition of a symmetry breaking coherent control scenario, in both isolated systems and in the presence of tunable amounts of decoherence, is proposed. The setup exploits the experimental control over the depth of the potential wells in optical lattices to define an effective hbar that, in principle, can be experimentally manipulated. Simulations of the transition show that the symmetry breaking effect survives in the classical limit and hence that matter interference effects are not required for the emergence of coherent laser control. Even when the average photoinduced momentum (i.e. the net degree of symmetry breaking) approaches smoothly its classical limit, the probability distribution of the observable does not, having an extremely fine oscillatory structure superimposed on the classical background that has little effect on the average. This fine structure due to quantum coherences is extremely fragile to environmental decoherence in the small hbar limit and a very small amount of decoherence is required to ensure the classical limit. We conclude that the detrimental effects induced by interaction with environmental degrees of freedom in this coherent laser control scheme are due to a decay of the temporal correlations in the system's dynamics, and not due to a decay of matter interference effects due to decoherence.

Measuring High-Order Coherences of Chaotic and Coherent Optical States

by
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We demonstrate a new approach to measuring high-order temporal coherences that uses a four-element superconducting nanowire single-photon detector (SNSPD) in which four independent, single-photon-sensitive elements are interleaved over a single spatial mode of the optical beam. We show the power of this technique by measuring nth-order coherences (n = 2,3,4) both of a chaotic, pseudo-thermal source that exhibits high-order photon bunching (up to n!), and of a coherent state source for which all coherences are ~1. Our results demonstrate that using multiple detector elements to parse an optical beam over dimensions smaller than the minimum diffraction-limited spot size can be equivalent-and in some cases superior-to using multiple beamsplitters and discrete detectors that each sample a replica of the entire mode.