AN INVESTIGATION OF NONCLASSICAL PROPERTIES OF LIGHT USING AN OPTICAL TOMOGRAM

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by

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ABSTRACT

By analyzing the optical tomogram of a linear superposition of coherent states, we show that distinctive signatures of the macroscopic superposition states are displayed directly in the optical tomograms of the states. We also study the effect of decoherence on the optical tomograms of the macroscopic superposition states. We consider the amplitude decay and phase damping models of decoherence and show the direct manifestations of decoherence in the optical tomogram. Since the wave packet fractional revivals are associated with the generation of macroscopic superposition states, these signatures help in visualizing the revivals and fractional revivals occurring in a nonlinear medium directly in the optical tomogram of the time-evolved state. We have investigated the optical tomogram of the time-evolved state obtained by the evolution of an initial wave packet, corresponds to an ideal cohrent state, in a Kerr-like medium. We found that the optical tomogram of the time-evolved state at the instants of fractional revivals show structures with sinusoidal strands. At k-subpacket fractional revival time, the optical tomogram of the time-evolved state shows a structure with k sinusoidal strands. The sinusoidal strands are completely absent when the initial wave packet collapses during the evolution in the medium. The structures with sinusoidal strands are not lost when the interaction of the system with its external environment is for a short time.

Using a class of initial superposed wave packets evolving in the Kerr-like medium, we further show that the condition for the occurrence of fractional revival phenomenon depends on the number of wave packets composing the initial superposition state. The initial state considered for this purpose is the superposed coherent states which are the eigenstates of the powers of annihilation operator. Analyzes based on the expectation values of observables, Rényi uncertainty relation and Wigner function are also used to support our findings. For an initial superposed coherent states, the number of sinusoidal strands in the optical tomogram of the time-evolved state at k-subpacket fractional revival is k times the number of sinusoidal strands present in the optical tomogram of the initial state.

In the case of a two-mode electromagnetic field, we investigate the entanglement of the state directly using the optical tomogram. We study the optical tomograms of maximally entangled states generated at the output modes of a beam splitter. We take even and odd coherent states in one of the input modes and vacuum state in the other input mode of the beam splitter. We have shown that the signatures of entanglement can be observed directly in the single-mode optical tomogram of the state without reconstructing the density matrix of the system. Two distinct types of optical tomograms are observed in any one of the output modes of the beam splitter based on the quadrature measurement in the other output mode if the output modes are entangled. The different features shown by the optical tomograms are verified by investigating the photon number statistics of the corresponding state. We also analyze the effect of decoherence on the optical tomograms of the entangled states.

Further, we examine the optical tomograms of the entangled states generated using a beam splitter with a Kerr medium placed into one of its input modes. The entanglement dynamics of the initial coherent state captures the signatures of revival and fractional revivals. The dynamics of entanglement using von Neumann entropy plot shows local minima at the instants of fractional revivals. The maximum amount of entanglement is obtained at the instants of collapses of wave packets during the evolution in the medium. The maximum value of entanglement increases with an increase in the field strength. We have found the signatures of entanglement in the optical tomogram for the entangled states generated at the instants of two- and three-subpacket fractional revival times.