Dirección de Formación Académica

CENTRO DE INVESTIGACIONES EN OPTICA, A.C.

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Thesis: "GENERATION OF HYPERENTANGLED N00N STATES WITH RADIAL AND ORBITAL ANGULAR MOMENTUM LAGUERRE-GAUSS MODES AND DETECTION BASIS CONTROL"

Summary:

Hyperentanglement of photonic light modes, or entanglement occurring in systems with one or more degrees of freedom, offers a valuable resource in quantum communication and information processing. Communication systems, for example, use hyperentanglement to increase channel capacity. Hyperentanglement, however, has not been the only valuable quantum resource. Maximally path-entangled states, or N00N states, have led the development of quantum information protocols. To advance quantum technology, it is necessary to establish reliable protocols that can generate both hyperentangled and N00N states. In this dissertation, we propose two methods for the generation of hyperentangled N00N states in the spatial degrees of freedom of light. The first approach centers on (but is not limited to) the radial degree of freedom of Laguerre-Gauss modes. In this study, the pump beam is shaped by superpositions of Laguerre-Gauss radial modes to generate hyperentangled radial N00N states via spontaneous parametric down-conversion. This method illustrates how the spatial spectrum of the down-converted state can be modulated by engineering

the input pump. The resultant state, however, is noisy in nature and the cross-correlated terms limit the generation of clean, useful entangled states. The second method is a novel protocol based on the interference of two optical nonlinearities and the control of the detection basis in the orbital angular momentum degree of freedom. This configuration can produce both maximally-entangled and hyper-entangled states in at least four dimensions.

The resultant state in the four-dimensional case can be characterized as a generalization of the N00N state. As long as experimental imperfections are excluded, the production of this state is "perfect" i.e., noiseless. Using the presented setup, a vast parameter space of arbitrarily large dimensionality can be searched for other states of interest using control over the detection and pumping protocols. In addition, we demonstrate the versatility of this system through a few specific examples