Soutenance de thèse

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Bell inequalities with Orbital Angular Momentum of Light

We shall present a theoretical description of paraxial beams, showing the propagation modes that arise from the solution of the paraxial equation in free space. We then discuss the angular momentum carried by light beams, with its decomposition in spin and orbital angular momentum and its quantization.

We present the polarization and transverse modes of a beam as potential degrees of freedom to encode information. We define the Spin-Orbit modes and explain the experimental methods to produce such modes. We then apply the Spin-Orbit modes to perform a BB84 quantum key distribution protocol without a shared reference frame.

We propose a Bell-like inequality criterion as a sufficient condition for the spin-orbit non-separability of a classical laser beam. We show that the notion of separable and non-separable spin-orbit modes in classical optics builds a useful analogy with entangled quantum states, allowing for the study of some of their important mathematical properties. We present a detailed quantum optical description of the experiment in which a comprehensive range of quantum states are considered.

Following the study of Bell's inequalities we consider bipartite quantum systems characterized by a continuous angular variable θ. We show how to reveal non-locality on this type of system using inequalities similar to CHSH ones, originally derived for bipartite spin 1/2 like systems. Such inequalities involve correlated measurement of continuous angular functions and are equivalent to the continuous superposition of CHSH inequalities acting on two-dimensional subspaces of the infinite dimensional Hilbert space. As an example, we discuss in detail one application of our results, which consists in measuring orientation correlations on the transverse profile of entangled photons.

Key words: Bell inequalities, quantum information, optical angular momentum, wave optics, quantum cryptography.

Attention !
Jour, heure et lieu inhabituels

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