Angular super-resolution using OAM entangled photons

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Abstract: The interference between two orbital-angular-momentum (OAM) entangled photons provides a way to observe angular super-resolution. In addition, single-photon avalanche detector (SPAD) arrays provide the ability to measure the spatial distribution of single photons without scanning in quantum experiments. Here we discuss an angular super-resolution experiment using OAM entangled photons and a SPAD array. The results predict a higher angular resolution can be achieved in two-photon quantum interference when compared to the classical case.

The classical interference between two coherent light beams provides the standard resolution for conventional metrology. However, higher resolution can be achieved based on the interference between quantum states. For example, a quantum NOON state provides an N times improvement over the classical resolution [1], e.g. twice the classical resolution when N=2. For photons carrying orbital angular momentum [2], the quantum interference pattern between + l-order and –l-order modes provides an angular resolution of $\frac{\pi}{l}$. If NOON states with N=2 in the orbital angular momentum degree of freedom are generated, the two-photon quantum interference pattern is given by

$$\mathrm{N}(\theta_1, \theta_2) \propto 1 + \cos l(\theta_1 + \theta_2). \qquad (1)$$

We outline the system for measuring this OAM two-photon interference pattern in figure 1. Here we use a SPAD array, which detects over 320 by 240 pixels, to measure the spatial distribution of the two-photon interference pattern. We will discuss the theoretical predictions of NOON state interference for OAM states of light and discuss the experimental approach to the measurement.

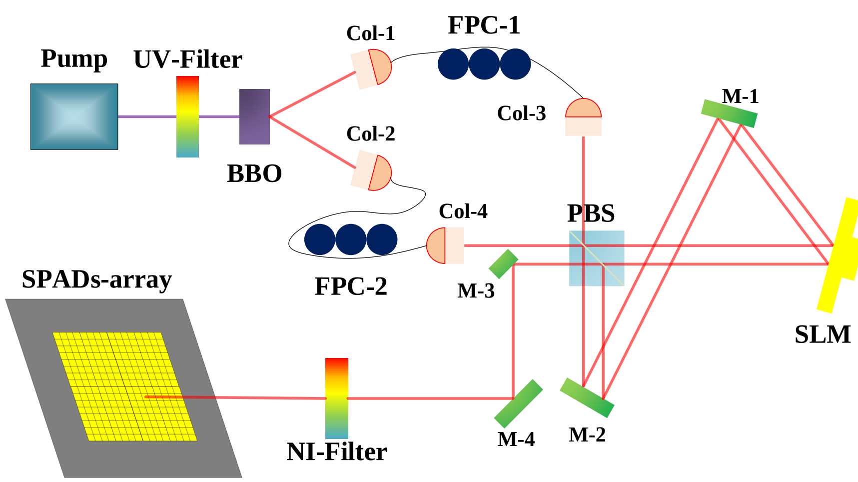

Fig 1. Experimental schematic. M ~ mirror. FPC ~ fiber polarization controller. Col ~ fiber collimator.

References

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[2] L. Allen, *et al.*, “Orbital angular momentum of light and the transformation of Laguerre-Gaussian laser modes,” *Phys. Rev. A* **45,** 8185 (1992).