Super-resolution using transverse-spatial N00N states

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Photonic N00N states, i.e. states of light where N photons are in an extremal superposition between two orthogonal states $\frac{1}{\sqrt{2}}(|N,0\rangle + |0,N\rangle)$, have an increased phase-sensitivity in comparison to their classical counterparts. Using the increased phase sensitivity offered by N00N states, in conjunction with the intrinsic properties of transverse-spatial modes, enables various types of measurements with sensitivities beyond the classically allowed limits. In the present work, we harness the angular sensitivity of orbital angular momentum (OAM) modes [1] and create two-photon twisted N00N states for arbitrary OAM values through photon bunching [2]. We then use these twisted N00N states to demonstrate angular super resolution, in a single beam [3].

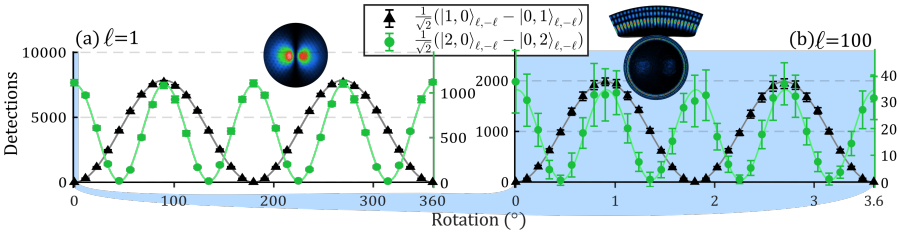

Fig. 1: Super-resolution rotation measurements with the OAM values 1 (a) and 100 (b). The single photon measurements are shown in black, while the two-photon measurements are shown in green having a better resolution.

To demonstrate the systems capabilities, we measured rotation sensitivities of heralded single photons and two-photon N00N states with OAM values up to 100 (see Fig. 1). Our results show that the angular uncertainty for twisted N00N states scales as $\Delta\varphi \propto \frac{1}{2N\ell}$ when N is the photon number and ℓ the amount of OAM. The flexibility of the system also allows the generation of N00N states between radial modes which we have further used to demonstrate super-resolution in the longitudinal direction [4]. Finally, these radial-mode N00N states have allowed us to examine the Gouy phase of two-photon Fock states.

References

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