An experimental investigation of spatial coherence and information entropy of optical vortices

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Unlike a Gaussian beam, the field associated with an optical vortex, $E(x,y)$, can not be written in a separable form $f(x)g(y)$. A useful way to study fields of such two dimensional (2D) beams is by means of their projections. Starting from the spatial coherence function- a two-point correlation function (TPCF) $\Gamma^{(2)}_{nm}(x,y;x',y') = \left\langle E^*(x,y)E(x',y')\right\rangle$, we have studied the degree of coherence, the information entropy and the Wigner distribution function (WDF) of the one dimensional (1D) projection of optical vortices [1, 2]. Shearing-Sagnac interferometer has been used for the experimental investigation of the TPCF. The TPCF obtained for a Gaussian beam and an optical vortex of order *l*=1 is shown in Fig. 1 (I). In Fig. 1(II), we show the TPCF for the 1D projection of a Gaussian and vortices of different orders. On comparing results shown in Fig. 1 (I) and Fig. 1 (II), one can easily find that the shape of the TPCF of a Gaussian beam and the TPCF of its 1D projection remains unchanged [Fig. 1(I a) and Figs. 1(II a, e)], while it changes for an optical vortex (*l*=1) [Fig. 1(I b) and Figs. 1(II b, f)]. A careful observation of the TPCF for the 1D projection of optical vortices (*l*=1,2,3) demonstrates that the numbers of side lobes are equal to the order of the vortex. Therefore, one can easily determine the vorticity of unknown beam from the TPCF of its 1D projection.

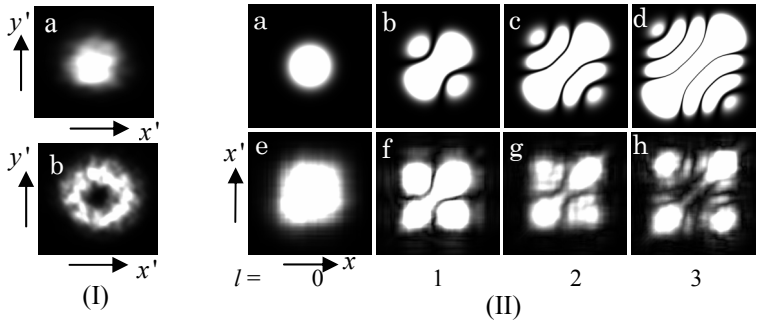

Fig. 1. Plots of the TPCF for (I) (a) Gaussian beam (b) Optical vortex of order 1, (II) the 1D projection of vortices with topological charge 0, 1, 2 and 3 (a-d) theoretical (e-h) experimental.

From the calculated results of the TPCF for the 1D projection of Gaussian and vortex beams, we also derive the degree of coherence, the information entropy and the WDF. The degree of coherence for the 1D projection of optical vortices has been found to decrease with increase of the order. On the other hand, the information entropy increases with increase in the order of the vortex. Therefore, one can say that higher order vortices will carry more information. The WDFs for optical vortices are also carrying characteristic features of vortices; they vanish at the centre while for a Gaussian field it is peaked at the centre. Thus an intensity minimum at the centre of an optical vortex is manifested in its WDF also. The experimental results are found to be in good agreement with the theoretical findings.

References:

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2. A. Kumar, S. Prabhakar, P. Vaity, and R. P. Singh, Opt. Lett. **36**, 1161-1163 (2011).