Reciprocal spin-orbit interaction effects

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Abstract: We present here experimental results, categorized as reciprocal spin-orbit interaction (R-SOI) effects, that arise due to propagation of paraxial light beam along different curvature trajectory in weakly anisotropic inhomogeneous medium. Mutual interaction between the trajectory and the intrinsic- and extrinsic- angular momentum degrees of freedom lead to the observation of the R-SOI effects which are quantified.

1. Introduction

Mutual interaction between the trajectory of a paraxial light beam and its intrinsic- and extrinsic- angular momentum degrees of freedom, mediated by the medium characteristics are broadly classified as spin-orbit interaction (SOI) of light [1,2]. As many of the SOI effects investigated are a manifestation of light-matter interaction, the medium's inhomogeneity, which changes the direction of propagation of light, and its anisotropy, which induces a phase change between two eigen polarization of light play critical role in the overall behavior. Instead of limiting the investigation of the SOI effects independently to inhomogeneous (but isotropic) and anisotropic (but homogeneous) systems, we consider here a graded-index (GRIN) rod wherein both inhomogeneity and anisotropy are present simultaneously and play a role together. Exploiting this combination, we carry out interferometry, polarimetry and weak measurements to observe and quantify all the reciprocal-SOI effects.

2. Experiment and results

Schematic of the experimental setup is shown in Fig. 1. The GRIN rod used is 3.93 mm long, 1.8 mm in diameter and of effective focal length 1.71 mm, having numerical aperture (NA) of 0.55. The on-axis refractive index of the GRIN rod is $n_0 = 1.629$ and the gradient constant is 0.384 mm^{-1}. The parabolic transverse refractive index profile of the GRIN rod is cylindrically symmetric with reference to the input beam axis and required asymmetry is introduced by horizontally shifting the rod with reference to the beam axis. Measurements are carried out on the output beam from the GRIN rod as a function of the input beam position (y), SAM (σ) and IOAM (l) to characterize the R-SOI effects.

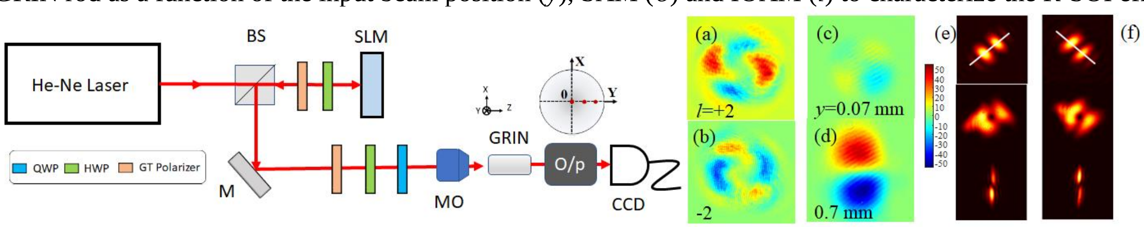

Fig. 1. Experimental setup and measurements of (a), (b) reciprocal spin-to-orbital angular momentum conversion; (c), (d) reciprocal spin-Hall effect and (e), (f) reciprocal orbital-Hall effect of light. Red and blue color in (a) – (d) correspond to right and left spin components in the beam.

The reciprocal spin-to-orbital AM conversion effect (converting l of the beam to σ) is realized by propagating $\sigma = 0$ and $l = \pm 2$ beam through the GRIN rod; in reciprocal spin-Hall effect of light, input $\sigma = 0$ light beam propagating through the GRIN rod separates into right- ($\sigma = +1$) and left- ($\sigma = -1$) circular polarized components and spin-Hall shift as a function of the curvature of the path; and equivalently, working in the orbital AM domain, changing the path and hence the trajectory curvature of the paraxial HG beam with $l = 0$, leads us to the appearance of $l \neq 0$ in the output beam. The results are shown in Fig. 1 as a demonstration of the R-SOI effects in the GRIN rod, characterized via Stokes polarimetry, interferometry and weak measurements. More details of the results and their understanding will be presented at the conference.

3. Acknowledgement: The authors acknowledge financial support from SERB and DST-INSPIRE.

4. References

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