Experimental measurement of Pancharatnam-Berry phase by interferometry using an optical vortex beam

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The experiment described in this paper is aimed at measuring Pancharatnam-Berry phase, which is the geometric phase associated with the traversal of polarization states along a closed path on a Poincaré sphere, whose magnitude can be equated to one half of the solid angle subtended by the surface enclosed by the closed path at the center of the sphere [1].

The technique used in the experiment involves studying the interference pattern of a Gaussian beam with an optical vortex (OV) beam with unit topological charge [2], realized using a Mach-Zehnder interferometer incident by a horizontally linear polarized beam from a He-Ne continuous wave laser source. The polarization state of the beam in one branch of the interferometer is altered in a cycle, being first transformed from horizontal linear polarization to right circular polarization, then into linear polarization at an angle θ with respect to the horizontal, and finally back into linear horizontal polarization, using a quarter wave plate, a polarizer and half wave plate. Meanwhile, in the other branch of the interferometer, a Gaussian beam is incident on a spatial light modulator which has been programmed with the computer generated hologram of a forked diffraction pattern, thus being transformed into an OV beam with unit topological charge. The polarization of the beam in the second branch is kept unchanged (linear horizontal polarization).

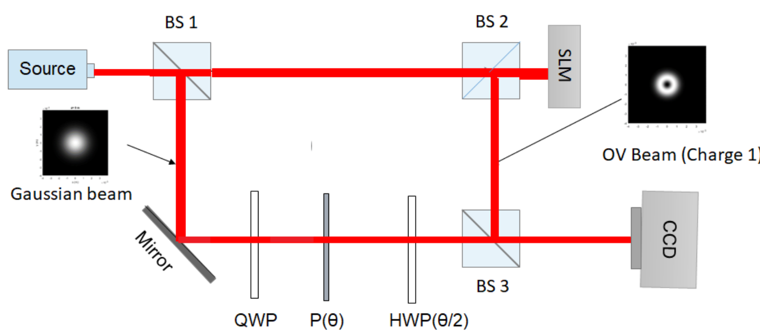

Figure 1: Experimental setup

The azimuthal phase dependence of the vortex beam results in an off-center dark spot in the interference pattern, on superposition with the Gaussian beam. When the geometric phase is varied by changing the intermediate polarization states in one branch, the bright spot revolves around the common center of the superposed beams by an angle equivalent to the geometric phase shift (φ_g).

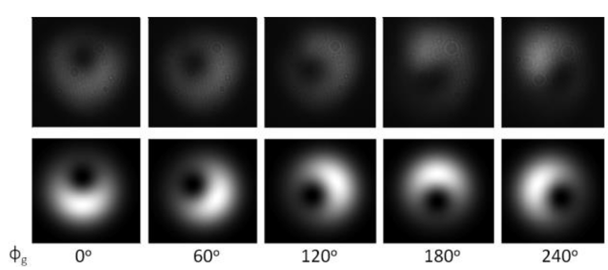

Figure 2: Interference pattern images obtained experimentally (top row) and by computer simulation (bottom row)

References

[1] M.V. Berry, “The adiabatic phase and Pancharatnam's phase for polarized light,” *J. Mod. Opt*. **34,** 1401 (1987).

[2] E. J. Galvez, P. R. Crawford, H. I. Sztul, M. J. Pysher, P. J. Haglin, R. E.Williams., "Geometric Phase Associated with Mode Transformations of Optical Beams Bearing Orbital Angular Momentum," *Phys. Rev. Lett.* **90**, 203901 (2003).