# First and Second order Coherence Studies of Optical Vortices

**A THESIS**

***submitted for the Award of Ph. D. degree of***

**MOHANLAL SUKHADIA UNIVERSITY**

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***Faculty of Science***

***by***

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**DEPARTMENT OF PHYSICS**

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# CERTIFICATE

I feel great pleasure in certifying the thesis entitled "**First and Second order Coherence Studies of Optical Vortices**" by Mr. Ashok Kumar under my guidance. He has completed the following requirements as per Ph.D. regulations of the University

(a) Course work as per the university rules.

(b) Residential requirements of the university.

(c) Presented his work in the departmental committee.

(d) Published/accepted minimum of two research papers in referred research journals,

I am satisfied with the analysis of data, interpretation of results and conclusions drawn.

I recommend the submission of the thesis.

Date:
June 29, 2011

Dr. R. P. Singh
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Countersigned by
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# *DECLARATION*

*I Ashok Kumar, S/O Shri Dharmanand, resident of C-102, PRL residences, Navrangpura, Ahmedabad - 380009, hereby declare that the research work incorporated in the present thesis entitled "***First and Second order Coherence Studies of Optical Vortices***" is my own work and is original. This work (in part or in full) has not been submitted to any university or institute for the award of a Degree or a Diploma. I have properly acknowledged the material collected from secondary sources wherever required. I solely own the responsibility for the originality of the entire content.*

Date:

June 29, 2011 Ashok Kumar

(Author)

**To my**

**Parents**
**(Eeja & Pitaji)**

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# Abstract

Optical vortices, manifestation of phase singularities, are light beams with helical wavefronts. This dissertation concerns with the study of the first and the second order coherences of optical vortices.

We have used computer generated holography technique for the generation of optical vortices. An algorithm has been developed to make a vortex of variable core size and demonstrated experimentally. Interferometric techniques have been described to characterize the optical vortices.

It has been observed that the diffraction of an optical vortex through an iris diaphragm produces ball bearing sort of structures of darkness and brightness. The singularity of the vortex beam is found to be persistent even after diffraction through the aperture. The position of the singularity in the diffracted beam depends on the relative positions of vortex center and the center of iris diaphragm. These results may have implications to sub-diffraction imaging. A further study of diffraction through a two dimensional sinusoidal grating produces four copies of vortex with the same topological charge.

The stability and the propagation dynamics of high topological charge optical vortices have also been discussed. We introduce an asymmetry in the core of a high charge optical vortex by using a spatial light modulator. The splitting of a high charge optical vortex core into unit charge vortices has been found to depend on the extent of introduced asymmetry. The trajectories of the split unit charged vortices and their separation have been recorded as a function of change in the asymmetry of the core.

We have examined the spatial coherence characteristics of the one dimensional projection of optical vortices. The obtained spatial coherence function is found to be the characteristic of the order of the vortex. The knowledge of the spatial coherence is used to extract the information entropy and the Wigner distribution function as well.

We have studied intensity correlation function for optical vortices passing through a rotating ground glass (RGG) plate and compared them with that of the $TEM_{00}$ mode of a He-Ne laser beam passing through the same RGG plate. It has been observed that the intensity correlation curves for the scattered optical vortices decrease much faster than the corresponding curve for a $TEM_{00}$ mode of the He-Ne laser. We attribute this to the complex phase structure of the optical vortices.

**Keywords:** Singular optics, Optical vortex, Coherence, Diffraction, Stability of high charge vortex, Computer generated holography.

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