Abstract

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Title: Study of Spectral Properties of Partially Coherent Optical Fields and their Applications

Every realistic light field has some fluctuations associated with it. These fluctuations are too rapid to be observed directly. Coherence theory is a branch of physical optics used to extract useful information from these fluctuations in terms of correlation functions. The mutual coherence function, which is a two-time, two-point correlation function of a field, is used to classify light as coherent, incoherent and partially coherent. Similarly, the cross-spectral density, which is a two point, one frequency function of the field, is used to describe the properties of quasi-monochromatic light fields. Like the field function, correlation functions also obey certain propagations laws. Every realistic light source is partially coherent in nature. Partially coherent beams can be generated either by the distortion of a fully coherent laser beam using rotating ground-glass or by using a liquid crystal spatial light modulator. The field emitted from an incoherent source can be made partially coherent using van-Cittert Zernike theorem. Partially coherent light is less sensitive to phase distortion and other optical aberrations. Partially coherent optical fields can be used in free space-optical communication and to transfer energy through turbulent atmosphere because these are less affected by atmospheric turbulence. The above mentioned applications make partially coherent light superior to that of fully coherent laser light. Recently, Wolf has shown that polarization and coherence are both manifestation of the field correlation and formulated the "unified theory of coherence and polarization of light". The thesis presents results of experimental and theoretical studies on coherence and polarization properties of partially coherent optical fields. This thesis covers the concepts of spectral switching, application of partially coherent light such as dark hollow beam and its propagation properties and the second-order correlation functions of the field assisted by SPs. The work is divided into seven chapters.

In Chapter 1, we give a brief history of coherence and polarization of light. Extensive literature survey is also presented.

In Chapter 2, we discuss fundamentals of the optical coherence and partially coherent optical fields. It consists of a brief summary of different types of coherence such as spatial and temporal coherence and the basics of optical coherence theory. We then discuss about the partially coherent sources. Mathematical formalism of polarization will be studied in brief. We then explore other applications of the partially coherent optical fields. A brief introduction of dark hollow beam is also given.

Chapter 3 elucidates the theoretical and experimental procedure to demonstrate the effect of source polarization on spectral switch near phase singularity in the diffracted stochastic electromagnetic beam. The theoretical results showing the decrease in height of the valley between two peaks with decrease in source degree of polarization have been realized experimentally. For this purpose, a classical Young's double-slit is illuminated by a polychromatic light source. Spectral measurements are carried out in the first dark fringe of

the interference pattern. In this chapter, another type of singularity known as a coherence singularity is also examined by the experimental procedure. Spectral measurements are carried out in the vicinity of phase singularities of partially coherent, polychromatic wave fields which demonstrate the anomalous behaviour of the spectral degree of coherence.

Chapter 4 describes the experimental method to generate polychromatic partially coherent dark hollow beams (PCDHB). For this purpose instead of using quasi-monochromatic light, polychromatic light illuminates the axicon-lens system. Near the focal plane of the lens dark hollow beams are generated. The effect of source polarization and coherence on the polychromatic PCDHBs is investigated in detail. Experimental results show that a tunable dark region was obtained by varying the source degree of polarization (DOP). We find that longer the spatial coherence length of the input beam, larger the central dark size of the resultant PCDHB. Further it is shown that polychromatic PCDHB with low spatial coherence travel longer distance without being distorted than the beam with high spatial coherence.

The extension of the work presented in chapter 4 is included in Chapter 5.Experimental studies are carried out for evolution and propagation of generic singularities in focused partially spatially coherent wave-fields, generic singularities induced chromatic effects in the vicinity of focus, and spectral anomalies. The study might find potential applications to understand the evolution of achromatic zone (null intensity region) at the core of polychromatic PDHBs, chromatic effects at core as a function of coherence and propagation characteristics of generic singularities carrying beams in free-space.

In Chapter 6, a theoretical study of the optical transmission from a thin metallic double slit is carried out. The second-order correlation function, as a function of displacement of detectors, for different values of slit separation is studied. It is shown that surface plasmons excited at one slit and propagating to the other slit modulate the coincidence counts with the variation of slit separation. Sub-wavelength interference effect has also been observed for the field assisted by surface plasmons. It is also shown that the second order interference-diffraction pattern changes with slit separation and at some particular value of slit separation it changes into the Hanbury Brown and Twiss (HBT) effect.

The summary of the research work described in earlier chapters is presented in Chapter 7. We observed that both the coherence and polarization of the source affect the partially coherent optical fields either it is diffracted from Young’s double slit or passes through the axicon-lens system. The future aspects of the work presented in this thesis are also discussed.