INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Cylindrical vector beams have axially symmetric polarization profiles or electric field orientations in the pupil plane. Two important members of cylindrical vector beams are the radially polarized and the azimuthally polarized beams. When a linearly polarized beam (polarized along X) is focused by an aplanatic lens system, in the low numerical aperture (NA) case, the focal volume is primarily X polarized and there is only a negligible amount of Z polarized component. Thus it had appeared to be almost impossible to generate longitudinally polarized light in free space for many years. However, if the same X polarized beam is focused by a high NA lens, the focal volume will also contain a significant amount of Z polarized light where Z is the optical axis of the lens system. Consequently a radially polarized beam when focused gives rise to pure longitudinal polarization at the focal point as the transversely polarized fields interfere destructively. With the increase in the NA of the focusing lens the strength of the longitudinal field at the focus becomes greater than the maximum of the transverse field in the focal volume. The longitudinal field at the focus has certain unique properties, for instance, the corresponding field has non propagating power since it corresponds to a null Poynting vector. An azimuthally polarized beam on the other hand when focused gives rise to a doughnut like intensity distribution both under low NA and high NA conditions. The unique properties of cylindrical vector beams make them important in many applications. All such applications assume a perfect unaberrated radially polarized or azimuthally polarized beam. However any optical system essentially suffers from aberrations with a degree that may vary from one system to other. Therefore from the applications point of view it is imperative to ascertain the effect on the focal volume properties of the cylindrical vector beams due to the aberrations present in the beam. However, most of the past studies investigated only focal plane properties due to the presence of primary aberrations. Many applications of the cylindrical vector beam, in contrast, depend on the properties of the entire focal volume and not just the focal plane. Besides, an optical system may contain a combination of both primary and secondary aberrations. In this thesis we provide a comprehensive study on the effect of both primary and secondary aberrations on the entire focal volume properties of cylindrical vector beams. The energy density in the focal volume of a linearly polarized beam in the low NA case can be calculated using Scalar Diffraction theory. However, the same can not predict the focal volume in the high NA case. In such cases a vectorial version of the diffraction theory needs to be used. An integral form of the vectorial diffraction theory was elaborated in the work of Richards and Wolf. We employ the Fourier Transform form of the vectorial diffraction theory to compute the various focal volume parameters. Our theoretical investigation revealed several important phenomena involving the cylindrical vector beams. Some of the observations include generation of a boat-shaped intensity distribution near the focus of the coma aberrated azimuthally polarized beam, astigmatism resilience of Gaussian like beam derived from an azimuthally polarized beam, appearance of propagating power on the optical axis of a coma aberrated radially polarized beam and so on. We also made use of an experimental arrangement to verify the numerically obtained results in the low NA case.