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Selective excitation of fundamental and zeroth-order vector beams in few-mode fiber for sensing application

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1. Introduction

Selectively excited optical vector beams is utilized to experimentally demonstrate a highly sensitive strain sensor based on the phenomenon of intermodal interference caused between the LP_{01} and the chosen LP_{11} mode (TE_{01} and HE_{21}). A few-mode fiber sensing configuration is simple, cheap, rugged, eliminates the need for a reference fiber and the problem of its temperature drift. These findings are new and such a selective-mode intermodal sensing configuration (to the best of our knowledge) is not reported before.

2. Selective vector mode excitation

The mode conversion techniques inside a few mode fiber (FMF) is utilized to extract the fundamental mode (HE_{11}) and zeroth-order radially polarized TM_{01} mode, azimuthally polarized TE_{01} mode, and hybrid polarized HE_{21} mode [1]. These modes are excited using laboratory set-up shown in Fig.1 by controlling the tilt/offset of the incident Gaussian beam relative to the fiber axis (through a five-axis positioner). The excitation of vector modes in a few-mode fiber (Newport: SM-600 operated at a wavelength of 532 nm) by varying the input polarization states of Gaussian incident beam [2] at different off-axis/tilt conditions was first investigated. The linearly polarized two-lobe mode (III-row, Fig.2) is a special case in which the excited two-lobe mode can be attributed to the hybrid outcome of TE_{01} and HE_{21} modes [3]. Interestingly, the polarization content of the

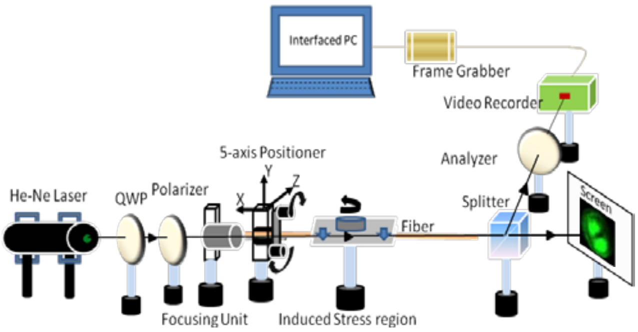

Fig.1: Schematic of the experimental setup used for the generation and characterization of optical vector beams.

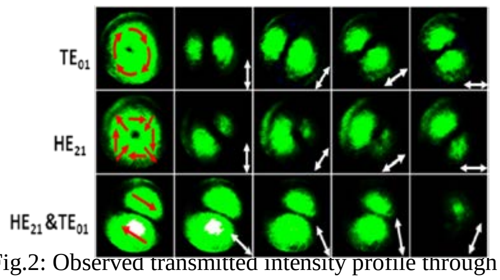

Fig.2: Observed transmitted intensity profile through the polarization analyzer at different off-axis conditions.

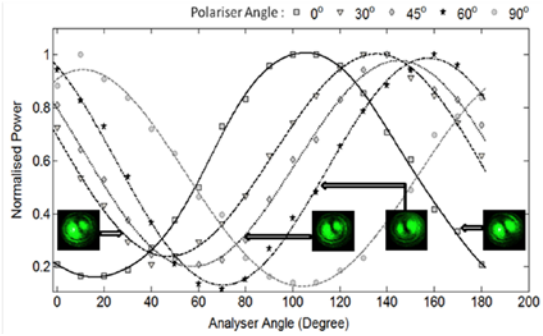

Fig.3 Average beam intensity as a function of analyzer rotation angle for various linearly polarized input beams.

beam exiting out of the FMF was measured to be rotating in accordance with the input plane of polarization depicting a light polarisation preserving propagation through a length of 65cm of FMF (See Fig.3).

3. Intermodal interference in FMF: strain sensor

Next, the sample of few-mode optical fiber with selective excited modes (HE_{11} & hybrid two-lobe pattern of TE_{01} & odd-HE_{21} modes) is used as a sensor head. A controlled transverse-stress is applied over the FMF to induce the appropriate linear birefringence and thereby suppress the

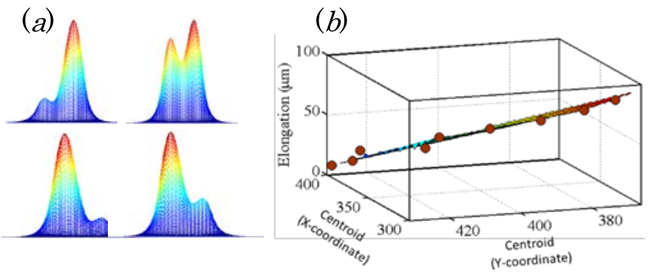

Fig. 4:(a)Theoretical power coupling between HE_{11} & hybrid two-lobe mode,(b)observed response of longitudinal strain sensor.

y-polarized odd-HE_{21} mode. The intermodal interference caused by external perturbation, axial strain or elongation in our case, result in power coupling in the two-lobe pattern (See Fig.4a). This output has been concerned as the change in the position of centroid (Fig.4b). The length of the fiber is so chosen that the linear polarization is preserved after propagation. The complete theoretical analysis and other crucial finding of this research would be presented in detail in the conference.

References

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