Experiments in Fiber Optics

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(Dated: November 26, 2022)

In this experiment, we have explored a simple method to measure non-linear properties of different optical materials - Single Beam Zscan. The experiments were performed with a TEM_{00} Gaussian laser with a wavelength of 532 nm. We have analyzed the data using Python and calculated the non-Linear Refractive Index and the non-Linear absorption coefficient for diffrent samples. We have also examined certain improvements to our setup that could give better results.

I. INTRODUCTION

In the early 1840s Paris, Daniel Colladon and Jacques Babinet first demonstrated the guiding of light by refraction and by the 19th century, a team of doctors from Vienna were able to guide light through bent glass rods to illuminate body cavities. Over the next century practical applications followed and in 1953, Dutch scientist Bram van Heel first demonstrated image transmission through bundles of optical fibers with a transparent cladding.

Today, optical fibers form the backbone of our communications systems, permitting transmission of data over longer distances and at higher bandwidths (data transfer rates) than electrical cables. They suffer less loss and suffer less electromagnetic interference than their metal counterparts. Their usage extends beyond data transmission to various specialized instrumentations like sensors and lasers.

Optical fibers typically include a core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a waveguide. Fibers that support many propagation paths or transverse modes are called *multi-mode fibers*, while those that support a single mode are called *single-mode fibers*.

II. OBJECTIVES

There are several major objectives that will be achieved as part of this experiment. They are:

1. The preparation of an optical fiber for experiments will be understood.
2. We will calculate numerical aperture of both single-mode and multi-mode fibers.
3. We will calculate the mode field diameter of a single-mode fiber.
4. We will be studying the effects of microbending loss and will explore its applications in sensing for multi-mode fibers.
5. Finally, we will also be studying the mechanics of bend-induced in a single-mode fiber.

III. EXPERIMENTAL SETUP

IV. THE EXPERIMENTS

A. Fiber-end preparation and coupling

B. Numerical Aperture measurements

1. Multi-mode fiber

2. Single-mode fiber

C. Mode field diameter of a single-mode fiber

D. Microbending loss in a multi-mode fiber

E. Bend-induced loss in a single-mode fiber

V. DISCUSSIONS

1. While taking observations, we noticed that there were some places near the focus where we found some sudden fluctuations in transmittance. To remove the dip, we tried reducing the power. The magnitude of the fluctuations was somewhat minimized but they could not be removed completely.
2. During data analysis, we employed Python's SciPy package and used its subroutine to remove the fluctuations (based on the Savitzky–Golay filter) for a better fit to the our theoretical model.
3. In the case of the organic sample in thin film form, there were multiple dips after the focus resulting in sub-par data. In case of solution of the same

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sample, the data obtained was not presentable due to too much dominance of the multiple interference fluctuations.

4. This may be due to high absorption coefficient for the sample so that the refractive index changes very rapidly due to significant thermal variation along

5. We performed the experiment for the same sample and verified that the refractive index and absorption coefficient were within the margin of error. The discrepancies could be explained by the relative instability of the cuvette when performing the experiment with solution.

VI. CONCLUSIONS

1. We can use Z-scan experimental configuration to obtain nonlinear refractive index and nonlinear absorption coefficients of any standard samples.

2. The sign and magnitude of nonlinear refractive index of the samples can measured.

3. Using the equations of normalized transmittance and fitting them with the data points and will report the refractive index and nonlinear absorption coefficients.

4. The property of non-linear sample to change refractive index on changing intensity can be used to make a optical transistor type of thing.

VII. PRECAUTIONS AND SOURCES OF ERROR

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