Experiments in Fiber Optics

Maitrey Sharma*
School of Physical Sciences,
National Institute of Science Education and Research,
HBNI, Jatni-752050, India.

(Dated: November 25, 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.

II. OBJECTIVES

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

1. To study the basics of non- linear optical properties by using Z-scan technique.
2. Taking measurements of transmitted power for open and closed aperture by translating the material in the z-direction.
3. By fitting these data with the appropriate formulas, we will find the medium's nonlinear absorption coefficient and non- linear refractive index for different samples.
4. To compare the difference between non-linear refractive index of a sample in two forms: as a *thin film coating* and as a *solution*.

* maitrey.sharma@niser.ac.in;
Roll No.: 1911093

III. THEORY

IV. THE EXPERIMENTS

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 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

[1] N. D. Birell and P. C. W. Davies, *Quantum Fields in Curved Space* (Cambridge University Press, 1982).
[2] R. P. Feynman, Phys. Rev. **94**, 262 (1954).
[3] A. Einstein, Yu. Podolsky, and N. Rosen (EPR), Phys. Rev. **47**, 777 (1935).
[4] J. G. P. Berman and J. F. M. Izrailev, Stability of nonlinear modes, Physica D **88**, 445 (1983).
[5] E. B. Davies and L. Parns, Trapped modes in acoustic waveguides, Q. J. Mech. Appl. Math. **51**, 477 (1988).
[6] E. Witten, (2001), hep-th/0106109.
[7] E. Beutler, in *Williams Hematology*, Vol. 2, edited by E. Beutler, M. A. Lichtman, B. W. Coller, and T. S. Kipps (McGraw-Hill, New York, 1994) Chap. 7, pp. 654–662, 5th ed.
[8] E. Beutler, in *Williams Hematology*, Vol. 2, edited by E. Beutler, M. A. Lichtman, B. W. Coller, and T. S. Kipps (McGraw-Hill, New York, 1994) 5th ed., Chap. 7, pp. 654–662.
[9] D. E. Knuth, in *Fundamental Algorithms*, The Art of Computer Programming, Vol. 1 (Addison-Wesley, Reading, Massachusetts, 1973) Section 1.2, pp. 10–119, 2nd ed., a full INBOOK entry.
[10] J. S. Smith and G. W. Johnson, Philos. Trans. R. Soc. London, Ser. B **777**, 1395 (2005).
[11] W. J. Smith, T. J. Johnson, and B. G. Miller, Surface chemistry and preferential crystal orientation on a silicon surface (2010), J. Appl. Phys. (unpublished).
[12] V. K. Smith, K. Johnson, and M. O. Klein, Surface chemistry and preferential crystal orientation on a silicon surface (2010), J. Appl. Phys. (submitted).
[13] U. Ünderwood, N. Ñet, and P. P̄ot, Lower bounds for wishful research results (1988), talk at Fanstord University (A full UNPUBLISHED entry).
[14] M. P. Johnson, K. L. Miller, and K. Smith, personal communication (2007).
[15] J. Smith, ed., *AIP Conf. Proc.*, Vol. 841 (2007).
[16] W. V. Oz and M. Yannakakis, eds., *Proc. Fifteenth Annual*, All ACM Conferences No. 17, ACM (Academic Press, Boston, 1983) a full PROCEEDINGS entry.
[17] Y. Burstyn, Proceedings of the 5th International Molecular Beam Epitaxy Conference, Santa Fe, NM (2004), (unpublished).
[18] B. Quinn, ed., *Proceedings of the 2003 Particle Accelerator Conference, Portland, OR, 12-16 May 2005* (Wiley, New York, 2001) albeit the conference was held in 2005, it was the 2003 conference, and the proceedings were published in 2001; go figure.
[19] A. G. Agarwal, Proceedings of the Fifth Low Temperature Conference, Madison, WI, 1999, Semiconductors **66**, 1238 (2001).
[20] R. Smith, Hummingbirds are our friends, J. Appl. Phys. (these proceedings) (2001), abstract No. DA-01.
[21] J. Smith, Proc. SPIE **124**, 367 (2007), required title is missing.
[22] T. Térrific, *An $O(n \log n / \log\log n)$ Sorting Algorithm*, Wishful Research Result 7 (Fanstord University, Computer Science Department, Fanstord, California, 1988) a full TECHREPORT entry.
[23] J. Nelson, TWI Report 666/1999 (Jan. 1999) required institution missing.
[24] W. K. Fields, ECE Report No. AL944 (2005) required institution missing.
[25] Y. M. Zalkins, e-print arXiv:cond-mat/040426 (2008).
[26] J. Nelson, U.S. Patent No. 5,693,000 (12 Dec. 2005).
[27] J. K. Nelson, M.S. thesis, New York University (1999).
[28] É. Masterly, *Mastering Thesis Writing*, Master's project, Stanford University, English Department (1988), a full MASTERSTHESIS entry.
[29] S. M. Smith, Ph.D. thesis, Massachusetts Institute of Technology (2003).
[30] S. R. Kawa and S.-J. Lin, J. Geophys. Res. **108**, 4201 (2003), DOI:10.1029/2002JD002268.
[31] F. P. Phony-Baloney, *Fighting Fire with Fire: Festooning French Phrases*, PhD dissertation, Fanstord University, Department of French (1988), a full PHDTHESIS entry.
[32] D. E. Knuth, *Seminumerical Algorithms*, 2nd ed., The Art of Computer Programming, Vol. 2 (Addison-Wesley, Reading, Massachusetts, 1981) a full BOOK entry.
[33] J. C. Knvth, The programming of computer art, Vernier Art Center, Stanford, California (1988), a full BOOKLET entry.
[34] R. Ballagh and C. Savage, Bose-einstein condensation: from atomic physics to quantum fluids, proceedings of the 13th physics summer school (World Scientific, Singapore, 2000) cond-mat/0008070.
[35] R. Ballagh and C. Savage, Bose-einstein condensation: from atomic physics to quantum fluids, in *Proceedings of the 13th Physics Summer School*, edited by C. Savage and M. Das (World Scientific, Singapore, 2000) cond-mat/0008070.
[36] W. Opechowski and R. Guccione, Introduction to the theory of normal metals, in *Magnetism*, Vol. IIa, edited by G. T. Rado and H. Suhl (Academic Press, New York, 1965) p. 105.
[37] W. Opechowski and R. Guccione, Introduction to the theory of normal metals, in *Magnetism*, Vol. IIa, edited by G. T. Rado and H. Suhl (Academic Press, New York, 1965) p. 105.
[38] W. Opechowski and R. Guccione, Introduction to the theory of normal metals, in *Magnetism*, Vol. IIa, edited by G. T. Rado and H. Suhl (Academic Press, New York, 1965) p. 105.
[39] J. M. Smith, Molecular dynamics (Academic, New York, 1980).

[40] V. E. Zakharov and A. B. Shabat, Exact theory of two-dimensional self-focusing and one-dimensional self-modulation of waves in nonlinear media, Zh. Eksp. Teor. Fiz. **61**, 118 (1971), [Sov. Phys. JETP **34**, 62 (1972)].

[41] J. M. Smith, in *Molecular Dynamics*, edited by C. Brown (Academic, New York, 1980).

[42] D. D. Lincoll, Semigroups of recurrences, in *High Speed Computer and Algorithm Organization*, Fast Computers No. 23, edited by D. J. Lipcoll, D. H. Lawrie, and A. H. Sameh (Academic Press, New York, 1977) 3rd ed., Part 3, pp. 179–183, a full INCOLLECTION entry.

[43] A. V. Oaho, J. D. Ullman, and M. Yannakakis, On notions of information transfer in VLSI circuits, in *Proc. Fifteenth Annual ACM*, Boston, 1982, All ACM Conferences No. 17, edited by W. V. Oz and M. Yannakakis, ACM (Academic Press, New York, 1983) pp. 133–139, a full INPROCEDINGS entry.

[44] L. Manmaker, *The Definitive Computer Manual*, Chips-R-Us, Silicon Valley, silver ed. (1986), a full MANUAL entry.