decays rather slowly. If the phase-conjugate wave was generated only by DFWM, the lack of only one of the three beams E_1, E_2 and E_3 would have stopped generation of the phase-conjugate wave. Therefore, it is inferred that the rapidly decaying component corresponds to the phase-conjugate wave which is generated by the DFWM. On the other hand, if spatially modulated information formed by E_1 and E_3 can be recorded in the DO-25 and DY-7 dyes in PMMA – MA polymer film, the phase-conjugate wave can still be generated when E_2 tries to read this stored information, during the lifetime of the holographic grating. Table 1 contains the results of comparison of PC reflectivity at different pump beam, probe beam and angle between them.

Table 1: Comparison of PC reflectivity of of samples :

S.No.	Measuring Parameter	DO-25	DY-7
1	Maximum PC reflectivity at pump beam intensity of 1.5 W/cm^2	0.28%	0.16%
2	Maximum PC reflectivity angle between forward pump and probe beam	7°	7°
3	Maximum PC reflectivity at probe beam intensity 0.11 W/cm^2	0.22%	0.17%

6. Conclusion

We have observed low-intensity optical phase-conjugation in DO-25 dye in PMMA – MA polymer matrix and DY-7 dye in PMMA – MA polymer matrix using a degenerate four-wave mixing set-up, employing 532 nm light radiation from a CW Nd;YAG laser. The phase-conjugate signal is found to have contributions from the DFWM and the holographic processes. The maximum phase-conjugate beam reflectivity observed in these dye films is about 0.22% in DO-25 doped PMMA-MA matrix and 0.17% in case of DY-7 doped PMMA-MA polymer matrix. The maximum PC reflectivity is achieved when the angle between probe and forward pump beam is 7 degrees. The effects of dye concentration, intensity of backward, forward pump and inter beam angle between probe and forward pump beam on phase conjugation reflectivity are also studied. PC signal strength first increases and then decreases. PC reflectivity is increased by increasing the intensity of the backward and forward pump beam. The polarization and intensity profile are verified to be preserved in the conjugate signal. The predominant phase conjugation signal is attributed to the facts that reverse saturable absorption and large third order susceptibility of the dye molecules. Since the DO-25 and DY-7 dyes in PMMA – MA polymer film are used at 534 nm and this may be suitable for low-power semiconductor lasers in the red wavelength region, DO-25/DY-7 dyes in PMMA – MA polymer film may be a promising material for real-time double-exposure phase-conjugate interferometry.

References

[1] Y.R. Shen, *The Principles of Nonlinear Optics*, Wiley, New York, pp. 450, 1975.
[2] C.R. Giuliano and L. D. Hess, "Nonlninear Absorption of Light: Optical Saturation of Electronic Transitions in Organic Molecules with High Intensity Laser Radiation", *IEEE J. Quant. Electron*. QE-3, pp. 338-367, 1967.
[3] G.S. He, Y. Lx, Y.P. Chi, M. Li, and P.N. Prasad, "Studies of two-photon pumped frequency up-converted lasing properties of a new dye material," *J. Appl. Phys.*, 81, pp. 2529-2537, 1997.
[4] P. V. Olga, J.H. Lim, D.J. Hagan, and E.W. Van Strayland, "Nonlinear light absorption of polymethine dyes in liquid and solid media," *J. Opt. Soc. Am. B*, 15, pp. 802-809, 1998.
[5] N. Mukherjee, A. Mukherjee, and B.A. Reinhardt, "Measurement of two-photon absorption cross sections of dye molecules doped in thin films of polymethylmethacrylate," *Appl .Phys. Lett.*, 70, pp. 1524-1526, 1997.
[6] J. W. Perry, in *Nonlinear Optics of Organic Molecules and Polymers*, eds. H. S. Nalwa and S. Miyata, (CRC Press, Boca Raton, Fla., 1997), Chap. 13, pp..813-840.
[7] R. A. Fisher, "*Optical Phase Conjugation*," (Academic Press, New York, NY, USA), 1983, pp. 1-30.
[8] A. Yariv, " Phase conjugate optics and real-time holography," *IEEE J Quantum Electron.* QE-14, 9 pp. 650 – 660, 1978.
[9] M. H. Majles Ara, S. Mehrabani, and R. Malekfar, Phase Conjugation Using Four-Wave Mixing in Fast Green FCF Dye-Doped Gelatin Film, Advances in Nonlinear Optics, Volume 2009 (2009), Article ID 371974, 4 pages. 2009. doi:10.1155/2009/371974
[10] H. Tanaka, A. Horikoshi, H. Fujiwara, and K. Nakagawa, "Phase conjugation in saturable absorbing dye films by degenerate four-wave mixing and holographic processes", *Optical Review* 9, 3, pp. 106-111, 2002.
[11] T. Geethakrishnan and P. K. Palanisamy, "Degenerate four wave mixing experiments in Methyl green dye-doped gelatin film," *Optik* 117, 6, pp. 282-286, 2006.
[12] R. A. Fisher, "*Optical Phase Conjugation*," (Academic Press, New York, NY, USA) 1983, pp. 1-30.
[13] M. Albota, D. Beljonne, J.W. Perry, G. Subramanium, and C. Xu., *Science*, 281, pp. 1653, 1998.
[14] B. A. Reinhardt, L.L. Brott, S.J. Clarson, R. Kannan and A.G. Dillard, In *Mater. Res. Soc. Sympo. Proc*. 479, MRS, 1997, pp. 3-8.
[15] S. Aithal, P. S. Aithal and N. G. Bhat, "Study of nonlinear absorption in a dye doped polymer film due to frequency up-converted fluorescence," *Proceedings of the International Conference on Laser, Material Science and Communication, India*, ed. U. Chatterjee and P.K. Chakrabarti, ISBN : 978-93-80813-14-1 pp. 107-109, 2011.
[16] T. Geethakrishnan and P. K. Palanisamy, Optical phase-conjugation in erioglaucine dye-doped thin film, Pramana - journal of physics, Vol. 66, No. 2, 2006, pp. 473–478.
[17] T. Geethakrishnan and P. K. Palanisamy, Demonstration of optical phase-conjugation in methyl green dye-doped thin film, American Journal of Applied Sciences, 2005, Vol.: 2, Issue: 8, pp. 1228-1231.
[18] A. Miniewicz, S. Bartkiewicz, and J. Parka, Optical phase conjugation in dye-doped liquid crystal, *Opt. Commun.* 149, pp. 89–95, 1997.
[19] C. V. Bindhu, S. S. Harilal, V. P. N. Nampoori, and C. P. G. Vallabhan, ''Studies of nonlinear absorption and aggregation in aqueous solutions of Rhodamine 6G

using a transient thermal lens technique,'' *J. Phys. D,* 32, pp. 407–411, 1999.

[20] S. Aithal, P. S. Aithal and N. G. Bhat, Study of Degenerate Four-Wave Mixing in Disperse Orange Dye-doped Polymer Film, Advanced Materials Research Journal, ISSN: 1662-8985, Trans Tech Publications (TTP), Switzerland, Vol. 584, pp 526-530, doi:10.4028/www.scientific.net/AMR.584.526 (2012).

Author Profile

Mrs. Shubhrajyotsna Aithal is belonging to Mangalore, India, born on 19/11/1970. She has M.Sc. in Material Science from Mangalore University, India, M.Sc. in Chemistry from Kuvempu University, India, and M.Phil. in Chemistry, Vinayaka University, India. Presently she is doing her Ph.D. in the field of Characterization of nonlinear optical materials in Rayalaseema University, India. She has 10 years teaching experience in teaching Chemistry for undergraduate students. Presently she is working as Senior Lecturer in Chemistry at Srinivas College, Pandeshwar, Mangalore, Karnataka State, India. Her research interests are in nonlinear absorption, nonlinear refraction, optical limiting and generation of Phase Conjugated signal in dye doped polymers. Mrs. Aithal has published 06 papers in refereed journals in the field of characterization of nonlinear optical materials.

Dr. P.S. Aithal is belonging to Udupi, India, born on 04/04/1966. He has M.Sc. in Physics from Mangalore University, India, M.Sc. in E-Business from Manipal University, India, M.Tech. in Information Technology from Karnataka University, India, Ph.D. in Physics from Mangalore University, India, and Ph.D. in Management from Manipal University, India. His major field of study are characterization of nonlinear optical materials, optical solitons, e-commerce and mobile business. He has two years post doctoral research experience at Physical Research Laboratory, Ahmedabad, India and one year post doctoral research experience at CREOL, University of Central Florida, USA, in the field of Characterization of nonlinear optical materials. He has about 22 years teaching experience both at UG and PG level in Electronics, Computer Science and Business management. Currently he is working as PRINCIPAL at Srinivas Institute of Management Studies, Mangalore, India. He has published about 55 research papers in peer reviewed journals and two text books on physics and Electronics for Engineering students. He has research interest in Nonlinear optical absorption, Optical Phase Conjugation, Photorefractive materials, e-business, m-business, ideal business, and nanotechnology business Opportunities. Dr. Aithal is member of World Productivity Council, U.K., member of Strategic Management Foruum, India, member of Photonics Society of India, CUSAT, Cochin, senior member of IEDRC.org, Singapore.

Dr. Gopalakrishna Bhat was born in Nellikalaya House of Badiadka Village, Kerala on 29/5/1975. He did his M.Sc. in Chemistry from Mangalore University, India and Ph.D. in Chemistry under the title "Studies on the complexing behavior and analytical applications of nitrogen, oxygen, and sulphur donor heterocyclic ligands and allied reagents**"** from Mangalore University, India. The major field of study is preparation and characterization of metal complexes, complexometry and spectrophotometry. He has 15 years of teaching experience. Presently he is working as Professor and HOD in Chemistry at Srinivas Institute of Technology, Mangalore, Karnataka, India. He has guided one M.Phil. student and guiding five Ph.D. students. He has published 25 research papers in national, international journals and in conferences. Dr. Bhat is the Member of Board of examination of Nitte Mahalingha Adyanthaya Institute of Technology, Nitte, Karkala, Karnataka, India.