American Journal of Nanoscience and Nanotechnology
2014; 2(2): 28-31
Published online April 20, 2014 (http://www.sciencepublishinggroup.com/j/nano)
doi: 10.11648/j.nano.20140202.13

Optical nonlinear absorption coefficient of PbS nano particles studied by the Z-scan technique

M. B. Askari[1], P. Jalilpour[1], F. Ahmadi[2]

[1]Department. of Physics Azad University, North branch, Tehran, Tehran, Iran
[2]faculty of Physics, Shahid Rajaee Teacher Training University, Tehran, Iran

Email address:
MB_Askari@yahoo.com (M. B. Askari), parisa11555@yahoo.com (P. Jalilpour), fateahmadi@yahoo.com (F. Ahmadi)

To cite this article:
M. B. Askari, P. Jalilpour, F. Ahmadi. Optical Nonlinear Absorption Coefficient of PbS Nano Particles Studied by the Z-Scan Technique. *American Journal of Nanoscience and Nanotechnology.* Vol. 2, No. 2, 2014, pp. 28-31. doi: 10.11648/j.nano.20140202.13

Abstract: Nonlinear optics to study various phenomena in which the optical properties of the material changes in the presence of light. Polarization of a material system depends non-linearity upon the strength of the applied optical field in this mediums. The Z-scan technique is the best method that by this method we can determine nonlinearity optical properties namely, nonlinearity refraction index and nonlinearity absorption coefficient in the present of high-intensity lights. It should be noted that the advantage of the Z-scan method than the other methods is, that by this method can determined the nonlinearity optical properties with precision and simultaneously. We were determined the nonlinear refraction index and nonlinear coefficient of 'PbS' that suspended in alcohol by coding in fortran environment.

Keywords: Nonlinearity Absorption Coefficient, Nonlinear Optical Environment, PbS Nanoparticals, Z-Scan Technique

1. Introduction

Different factors cause waste of light in different materials, such as light scattering and dispersion of light, light absorption. Usually the light absorption is due to the existence of impurities in the material. Also, due to some structural fluctuations in some specific wavelengths occurs. Coefficient of absorption of matter for energy absorbed by an object to the total radiant energy it is defined on the object. Scattering of light due to the change of the light, toward a beam release by the heterogeneous with feedback and irregularities in the material. For this reason the refractive index and absorption coefficient in the review article finds that the importance we in this article how to obtain the absorption coefficient based on the PbS nanoparticles Z-scan method. The Z-scan method has gained rapid acceptance by the nonlinear optics community as a standard technique for separately determining the nonlinear changes in index and changes in absorption. This acceptance is primarily due to the simplicity of the technique as well as the simplicity of the interpretation. In most experiments the index change, Δn, and absorption change, $\Delta\alpha$, can be determined directly from the data without resorting to computer fitting. However, it must always be recognized that this method is sensitive to all nonlinear optical mechanisms that give rise to a change of the refractive index and/or absorption coefficient, so that determining the underlying physical processes present from a Z-scan is not in general possible. A series of Z-scans at varying pulse widths, frequencies, focal geometries etc. along with a variety of other experiments are often needed to unambiguously determine the relevant mechanisms.

In this article we use high intensity laser light to determine the coefficient of absorption of NANO-particles have used PbS Vine leads to nonlinear optics for optical environment becomes an environment Usually in optics, nonlinear absorption is associated with nonlinear failure are different for measuring refractive index there Like Nonlinear interference[1,2] The degeneration of wave4 phase and combination[3] The incorporation of the degeneration of wave 3[4] Elliptic rotation[5] Measure of distortion-beam[6]

But the methods mentioned, requires a highly sophisticated laboratory equipment and are only for the measurement of the refractive index to work, while the Z-scan technique, is a very simple method that can be used this method for the measurement of nonlinear optical properties of two important environment namely the nonlinear absorption coefficient and the refractive index.

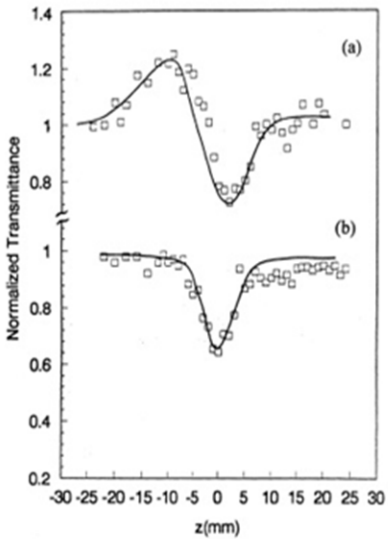

Chart 1. *a: the chart move Z-scan, a PbS nanoparticles in the presence of pore size of 0.7. b:Transmission diagram Z-scan, in the absence of the openings of the PbS nanoparticles.*

(1) in this article with the Z-scan technique without the use of Aperture with Aperture is obtained. In such a way that in this article we're going to help form (1-b) and the corresponding formula, nonlinear absorption coefficient by a k dnoshte joins PbS nanoparticles in Fortran have gotten.

2. Installation and Testing Method of Z-Scan

Laboratory equipment used in the testing of

1. detector (D1) the initial energy of the laser light is recorded by the detector
2. Convex lens: light rays to converge off the laser used
3. A substance that would determine the absorption coefficient
4. detector (D2) of laser light energy out of the article by the detector
5. Aperture: to limit the laser light has come to detector (D_2) (The openings for the State that we want to measure the refractive index measurement of absorption coefficient in the openings we don't use because there is no need to limit the laser beams.) The layout of the test is shown in the following figure:

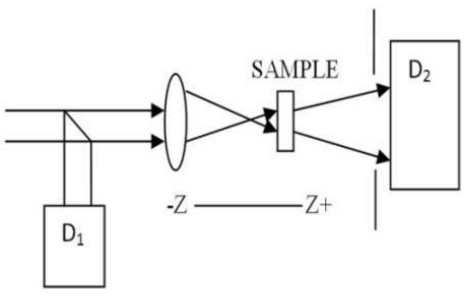

Figure 2. *test the Z-scan so that comparison (D_2)/(D_1) as a function of the sample is recorded the location z.*

The first test there in the absence of the Z-scan aperture do, in such a way that the primary energy of laser light at first, detector number (1) is registered, then the action of Z-scan from the – z start, at first because the radiation beam, the ratio is very low, compared to the article (D_2)/(D_1) remains constant and almost equal to a, but when brought near to the Center, because of the incident laser light intensity increase relative to the article, The amount of light absorbed by the substance and other than (D_2)/(D_1) do not remain fixed and because at most the amount of absorption occurs, so relative (D_2)/(D_1) means the quantity of energy transferred (T) has its own minimum amount Again when the instance of the Center will be gone away than (D_2)/(D_1) close to a fixed value.) (1-b) is derived from this chart). If before detector D2 a aperture optical beams to the limit and then the same steps to move the sample from-z to + z, do, (figure (1-a) diagram of this experiment) can be obtained from the diagram to determine the refractive index.

3. Find the Coefficient of Nonlinear Absorption Article with Many Laboratory Theory and Results

In this test the third-order polarization PbS nanoparticles have withdrawal are taken into account, to a large refractive index n in terms of nonlinear refractive index n2 (esu) or m^2/W)) γ, as follows:

$$n = n_0 + \frac{n_2}{2}|E|^2 = n_0 + \gamma I \quad (1)$$

High intensity laser light on the relationship between the I and E the electric field inside a typical peak and linear refractive index article n0. Since that experiment, detector cannot measure the energy of laser light intensity (I) first, then the amount of energy transferred by the article for the theory to be included, so that we can get to a laboratory results and the results of the theory of the coefficient of absorption of the substance. Since the unit highly J/cm ² s , So to be on the order of the amount of laser light intensity, we have to get diverted energy from the laser light intensity relationship towards an integral location to get to be a transition of power in the hands of the migration, and then we moved up to the time integral energy.

We want to be moved by a Gaussian beam $TEM_{0,0}$that can be released to industry-driven z we account the characteristic parameters of Gaussian beam to be defined. ω_0 : The radius of the beam waist ω: The radius of the beam R: The radius of curvature of the Wave front Z_0: The length of the break light inside $E_0(t)$: Radiant electric field at the Center. For there is a Gaussian wave relationship [8]

$$\nabla t^2 E + \frac{\partial^2 E}{\partial Z^2} + \frac{w^2}{c^2} n^2 E = 0 \quad (2)$$

If Gaussian beam independent field of longitudinal phase, consider using the relationship (2), the following relationship can be achieved [9]

$$E(z,r,t) = E_0(t)\frac{\omega_0}{\omega(z)} \exp(\frac{-r^2}{\omega^2(z)} - \frac{ikr^2}{2R(z)})e^{-i\Phi} \quad (3)$$

As the Z-scan method is known for their thin materials, materials that it uses is less than the length of the beam is focused on failures, a better answer the issue carefully, as well as to be able of nonlinear scattering beam diameter on inside changes regardless, should assume a small length samples.

On the other hand know I'm √ domain electric field as a function of ź (within the depth of the sample beam emission), SVER approximation, it can be as follows:

$$\frac{dl}{dz} = -\alpha(I)\ I \quad (4)$$

Meanwhile, in relation to (4), the linear absorption coefficient α I)) and it is also this nonlinear relationship between reducing the light intensity of the laser after passing through the article. Usually attract a lot of material because of the nonlinear absorption absorption saturation facility or a few photons.

If there is a nonlinear absorption, a Z-scan without the openings towards non-sensitive nonlinear failure and Z-scan no aperture is expected T-Z chart than to be symmetrical and can be downloaded from the chart that attracted a few facility somewhere happened that there is minimum saturation of absorption and transmission where the transmission happened that there is maximum. as a result of the nonlinear absorption coefficient can be transferred easily to the curves of the Won. If (4), α (I) for the linear absorption coefficient α in and β nonlinear absorption coefficient,

$$\alpha = \alpha + \beta I \quad (5)$$

In this case it can be made out of light intensity (Ie) is achieved as follows:

$$\frac{dIe}{Ie} = (\alpha + BIe^{-\alpha z})dz \quad (6)$$

The integral relationship between the parties is with the top up it can be highly out of the article wrote the following settings for:

$$\frac{Ie^{-\alpha L}}{1+q(x,r,t)} \quad (7)$$

So in the above relation q (z, r, t) and can be expressed as follows $L_{eff:}$

$$q(z,r,t) = \beta I\ Leff \quad (8)$$

$$Leff = \frac{1-e^{-\alpha L}}{\alpha} \quad (9)$$

As was described, you must use the relationship (7) towards an integral location, in this case, be transferred to the following form:

$$\mathrm{P}(z,t) = p_i(t)e^{-\alpha L}\frac{ln(1+q^{0(z,t)})}{q^{0(z,t)}} \quad (10)$$

On the relationship between high Pi (t) and q_0 (z, t) are considered as follows:

$$\mathrm{P}_i(t) = \frac{\pi {w_0}^2 I_0(t)}{2} \quad (11)$$

$$q_0(z,t) = \frac{\beta I_0(t)Leff}{1+\frac{Z^2}{{Z_0}^2}} \quad (12)$$

Now to find the energy transferred from the relationship (10) relative to the integral time can, in this case on the following transfer of power comes in the form of:

$$\mathrm{T}(Z,S=1) = \frac{1}{q_0\sqrt{\pi}} * \int_{-\infty}^{+\infty} \ln(1+q_0 e^{-t^2})dt \quad (13)$$

Using the relationship (13), can be used to specify a different z-β and the quantity of energy transferred. In this study, action on Z-scan nanoparticles suspended in PbS laboratory alcohol under the terms in which the laser light intensity I0 = 3 GW/cm ² and the size of nanoparticles suspended in alcohol and the length of the laser pulses of approximately 15nm 50ps وZ0 = -1 2وcm = α 70μm and wavelength of laser light is 1060nm, has been carried out, so that the results of this experiment with reference results [11].

Had to get the non-linear absorption coefficient, PbS nanoparticles using experimental data obtained and (13) the program is written in Fortran for a hypothetical β for the various T-Z by the relationship (13) and then calculated the difference between the experimental T ها achieved وT calculated (ΔT) and then the best coefficient of absorption, i.e. the coefficient is the least absorbed ΔT. The nonlinear absorption coefficient β-derived nanoparticles PbS, that we in this way, the coefficient of nonlinear absorption nano particles suspended in alcohol about PbS 45.1 cm/GW, we have gained.

4. Conclusions

There are a variety of methods and techniques for determining the nonlinear optical response, each with its own weaknesses and advantages. In general, it is advisable to use as many complementary techniques as possible over a broad spectral range in order to unambiguously determine the active nonlinearities. Z-scan is one of the simpler experimental methods to employ. Despite the wide range of available methods, it is rare that any single experiment will completely determine the physical processes behind the nonlinear response of a given material. A single measurement of the nonlinear response of a material, at a single wavelength, and a single pulse width may give very little information on the material. In general such limited data should not be used to judge the device performance of a material or to compare one material to another. In the environment, i.e. the linear optics where the light intensity is very low, the coefficient of absorption of matter in the form of a fixed number. But in the nonlinear optics, optical properties of light being shined on the effectiveness of environment with very much intensity (laser light) is changed, in other environments such as the coefficient of absorption coefficient of absorption has not been fixed and the article includes linear and nonlinear absorption coefficient (α), (β). One of the ways that the nonlinear absorption coefficient can be (β) for thin materials, calculation of Z-scan method. In this article the Z-scan method we've tried to capture the nonlinear coefficient of suspended in PbS nanoparticles we calculate alcohol, attaining with this β obtained the nonlinear optical properties can be studied in this article. As well as using graphs (1-a), and (1-b) can be used to study nonlinear refractive index. The Z-scan has only recently been introduced as a useful technique for measuring nonlinearities and there are still relatively few measurements of organic materials using this technique. However, its use as both an absolutely calibrated method for determining standards and as a relative measurement method is increasing. The Z-scan signal as a function of irradiance and/or Z can give useful information on the order of the nonlinearity as well as its sign and magnitude.

References

[1] M.J.Weber, D.Milam, and, W.L.Smith "Nonlinear refractive Index of glasses And crystals ".Opt.Eng.Vol.pp. .463469.1978.

[2] M.J.Moran, C.Y.She,and R .L.Carman,"Interferometric easurements Of nonlinear refractive index coefficient relative to CS_2 in laser –system-related materials,"IEEE J.Quantum Electron .,vol.QE-11,PP.256-263,1975.

[3] S.R.Fribergand P.W.Smith,"Nonlinear optical glasses for ultrafast optical switches,"IEEE J. Quantum Electron.,vol.QE-23,PP.2089-2091,1987

[4] R.Adir.L.L. Chace.and S.A.payne, "Nonlinear refractive index measurement of glasses using three-wave frequency mixing,"J.Opt.Soc.Amer.B.vol.4.pp.8-75-881, 1987.

[5] Owyoung, "Elipse rotations studied in laser host materials ,"IEEE J.Quan tum Electron.,vol.QE-9.PP.1064-1069 ,1973.

[6] W. E. William, M.J.soileau, and E.W. Van stryland,"optical switching and n_2 measurements in CS_2 ,"Opt .Commune ., vol.50.pp.256-260,1984.

[7] "Simple direct measurements of n2" In proce.15th Annu .symp. opt. Mater Ials for high Power laser, boulder, co, 1983.

[8] "Nonlinear optics ,Robert W.Boyd.the institute of optics university of Ro Chester New York USA

[9] Electro-dynamic laser, Joseph

[10] Sensitive measurement of optical nonlinearities using a single beam,"IEEE JOURNAL OF QUANTUM ELECTRONICS vol, 26, no.4, April 1990.

[11] Baolong Yu,Guosheng Yin,Congshan Zhu, Fuxi Gan.Optical nonlinear properties of PbS nanoparticales studied by the Z-scan technique,1998