



# Spectral and Raman Analysis of Dy<sup>3+</sup> ions doped Phosphate Glasses for Solid State Laser and Sensor Applications

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**ABSTRACT:** Glass of the system: (40-x)P<sub>2</sub>O<sub>5</sub>: 10ZnO: 10Li<sub>2</sub>O: 10PbO: 10WO<sub>3</sub>: 10Ta<sub>2</sub>O<sub>5</sub>: 10Al<sub>2</sub>O<sub>3</sub>:xDy<sub>2</sub>O<sub>3</sub>. (where x=1, 1.5,2 mol %) have been prepared by melt-quenching technique. The amorphous nature of the prepared glass samples was confirmed by X-ray diffraction. Raman, Optical absorption and Fluorescence spectra were recorded at room temperature for all glass samples. Judd-Ofelt intensity parameters  $\Omega_\lambda$  ( $\lambda=2, 4$  and  $6$ ) are evaluated from the intensities of various absorption bands of optical absorption spectra. The radiative properties like spontaneous emission probability (A), branching ratio ( $\beta$ ), radiative life time( $\tau_R$ ),stimulated emission cross-section( $\sigma_p$ )and thermal properties have been evaluated.

**KEYWORDS:** ZLLTAP Glasses, Optical Properties, Judd-Ofelt Theory, Raman Analysis.

## I. INTRODUCTION

Rare earth doped ceramic glasses have several applications such as optical fiber amplifiers, laser action and frequency-conversion materials [1-5]. Ceramic glass as host materials for active optical ions has attracted great interest recently due to their potential application in optical data transmission, optical devices and solid state ionic devices [6-8]. Among different host matrices, phosphate glasses have high transparency, high gain density, high thermal expansion coefficient low melting point, high thermal stability good physical and chemical stability [9-11]. They have a high transparency from near Ultra Violet to mid-Infrared region and weak upconversion [12, 13]. They present superior properties that include high refractive index, high transparency, low melting point, high rare earth ions solubility, high gain density and high thermal expansion coefficient [14-16]. Phosphate glasses are very well known for their excellent optical properties. The addition of network modifier (NWF) Li<sub>2</sub>O is to improve physical, electrical and mechanical properties of such glasses [17-18].

The present work reports on the preparation and characterization of rare earth doped heavy metal oxide (HMO) glass systems for lasing materials. I have studied on the absorption and emission properties of Dy<sup>3+</sup> doped zinc lithium lead tungsten tantalum alumino phosphate glasses. The intensities of the transitions for the rare earth ions have been estimated successfully using the Judd-Ofelt theory, The laser parameters such as radiative probabilities(A),branching ratio ( $\beta$ ), radiative life time( $\tau_R$ ) and stimulated emission cross section( $\sigma_p$ ) are evaluated using J.O.intensity parameters( $\Omega_\lambda$ ,  $\lambda=2,4$  and  $6$ ).

## II. EXPERIMENTAL TECHNIQUES

### Preparation of glasses

The following Dy<sup>3+</sup>doped phosphate glass samples ((40-x)P<sub>2</sub>O<sub>5</sub>: 10ZnO: 10Li<sub>2</sub>O: 10PbO: 10WO<sub>3</sub>: 10Ta<sub>2</sub>O<sub>5</sub>: 10Al<sub>2</sub>O<sub>3</sub>: xDy<sub>2</sub>O<sub>3</sub>. (where x=1,1.5 and 2 mol%) have been prepared by melt-quenching method. Analytical reagent grade chemical used in the present study consist of P<sub>2</sub>O<sub>5</sub>, ZnO, Li<sub>2</sub>O, PbO, WO<sub>3</sub>,Ta<sub>2</sub>O<sub>5</sub>, Al<sub>2</sub>O<sub>3</sub> and Dy<sub>2</sub>O<sub>3</sub>. They were thoroughly mixed by using an agate pestle mortar. then melted at 1055<sup>o</sup>C by an electrical muffle furnace for 2h., After complete melting, the melts were quickly poured in to a preheated stainless steel mould and annealed at temperature of 350<sup>o</sup>C for 2h to remove thermal strains and stresses. Every time fine powder of cerium oxide was used for polishing the samples. The glass samples so prepared were of good optical quality and were transparent. The chemical compositions of the glasses with the name of samples are summarized in **Table 1**.

Table 1

Chemical composition of the glasses

Sample	Glass composition (mol %)
ZLLTTAP (UD)	40P <sub>2</sub> O <sub>5</sub> : 10ZnO: 10Li <sub>2</sub> O: 10PbO: 10WO <sub>3</sub> : 10Ta <sub>2</sub> O <sub>5</sub> : 10Al <sub>2</sub> O <sub>3</sub>
ZLLTTAP DY(1.0)	39P <sub>2</sub> O <sub>5</sub> : 10ZnO: 10Li <sub>2</sub> O: 10PbO: 10WO <sub>3</sub> : 10Ta <sub>2</sub> O <sub>5</sub> : 10Al <sub>2</sub> O <sub>3</sub> :1 Dy <sub>2</sub> O <sub>3</sub> .
ZLLTTAP DY(1.5)	38.5P <sub>2</sub> O <sub>5</sub> : 10ZnO: 10Li <sub>2</sub> O: 10PbO: 10WO <sub>3</sub> : 10Ta <sub>2</sub> O <sub>5</sub> : 10Al <sub>2</sub> O <sub>3</sub> :1.5 Dy <sub>2</sub> O <sub>3</sub> .
ZLLTTAP DY(2.0)	38P <sub>2</sub> O <sub>5</sub> : 10ZnO: 10Li <sub>2</sub> O: 10PbO: 10WO <sub>3</sub> : 10Ta <sub>2</sub> O <sub>5</sub> : 10Al <sub>2</sub> O <sub>3</sub> :2Dy <sub>2</sub> O <sub>3</sub> .

ZLLTTAP (UD) -Represents undoped zinc lithium lead tungsten tantalum alumino phosphate glass specimens.

ZLLTTAP (DY) -Represents Dy<sup>3+</sup> doped zinc lithium lead tungsten tantalum alumino phosphate glass specimens.

### III.THEORY

#### 3.1 Oscillator Strength

The intensity of spectral lines are expressed in terms of oscillator strengths using the relation [ 19].

$$f_{\text{expt.}} = 4.318 \times 10^{-9} \int \varepsilon(\nu) d\nu \quad (1)$$

where,  $\varepsilon(\nu)$  is molar absorption coefficient at a given energy  $\nu$  (cm<sup>-1</sup>), to be evaluated from Beer–Lambert law.

Under Gaussian Approximation, using Beer–Lambert law, the observed oscillator strengths of the absorption bands have been experimentally calculated [20], using the modified relation:

$$P_m = 4.6 \times 10^{-9} \times \frac{1}{cl} \log \frac{I_0}{I} \times \Delta\nu_{1/2} \quad (2)$$

where c is the molar concentration of the absorbing ion per unit volume, l is the optical path length, log I<sub>0</sub>/I is optical density and  $\Delta\nu_{1/2}$  is half band width.

#### 3.2. Judd-Ofelt Intensity Parameters

According to Judd [21] and Ofelt [22] theory, independently derived expression for the oscillator strength of the induced forced electric dipole transitions between an initial J manifold |4f<sup>N</sup>(S, L) J> level and the terminal J' manifold |4f<sup>N</sup>(S', L') J'> is given by:

$$\frac{8\pi^2 m c \bar{\nu}}{3h(2J+1)n} \frac{1}{n} \left[ \frac{(n^2+2)^2}{9} \right] \times S(J, J') \quad (3)$$

Where, the line strength S (J, J') is given by the equation

$$S(J, J') = e^2 \sum_{\lambda=2, 4, 6} \Omega_{\lambda} \langle 4f^N(S, L) J \| U^{(\lambda)} \| 4f^N(S', L') J' \rangle^2 \quad (4)$$

In the above equation m is the mass of an electron, c is the velocity of light,  $\bar{\nu}$  is the wave number of the transition, h is Planck's constant, n is the refractive index, J and J' are the total angular momentum of the initial and final level respectively,  $\Omega_{\lambda}$  ( $\lambda=2, 4$  and 6) are known as Judd-Ofelt intensity parameters .

#### 3.3 Radiative Properties

The  $\Omega_{\lambda}$  parameters obtained using the absorption spectral results have been used to predict radiative properties such as spontaneous emission probability (A) and radiative life time ( $\tau_R$ ), and laser parameters like fluorescence branching ratio ( $\beta_R$ ) and stimulated emission cross section ( $\sigma_p$ ).

The spontaneous emission probability from initial manifold  $|4f^N(S', L') J' \rangle$  to a final manifold  $|4f^N(S, L) J \rangle$  is given by:

$$A[(S', L') J'; (S, L) J] = \frac{64 \pi^2 \nu^3}{3h(2J'+1)} \left[ \frac{n(n^2+2)^2}{9} \right] \times S(J', \bar{J}) \quad (5)$$

$$\text{Where, } S(J', J) = e^2 [\Omega_2 \|U^{(2)}\|^2 + \Omega_4 \|U^{(4)}\|^2 + \Omega_6 \|U^{(6)}\|^2]$$

The fluorescence branching ratio for the transitions originating from a specific initial manifold  $|4f^N(S', L') J' \rangle$  to a final manifold  $|4f^N(S, L) J \rangle$  is given by

$$\beta[(S', L') J'; (S, L) J] = \sum_{S, L, J} \quad (6)$$

where, the sum is over all terminal manifolds.  
The radiative life time is given by

$$\tau_{rad} = \sum_{S, L, J} A[(S', L') J'; (S, L) J] = \quad (7)$$

where, the sum is over all possible terminal manifolds. The stimulated emission cross-section for a transition from an initial manifold  $|4f^N(S', L') J' \rangle$  to a final manifold

$|4f^N(S, L) J \rangle$  is expressed as

$$\sigma_p(\lambda_p) = \left[ \frac{\lambda_p^4}{8\pi c n^2 \Delta\lambda_{eff}} \right] \times A[(S', L') J'; (\bar{S}, \bar{L}) \bar{J}] \quad (8)$$

where,  $\lambda_p$  the peak fluorescence wavelength of the emission band and  $\Delta\lambda_{eff}$  is the effective fluorescence line width.

#### IV. RESULT AND DISCUSSION

##### 4.1 XRD Measurement

Figure 1 presents the XRD pattern of the sample contain  $P_2O_5$  which is show no sharp Bragg's peak, but only a broad diffuse hump around low angle region. This is the clear indication of amorphous nature within the resolution limit of XRD instrument.

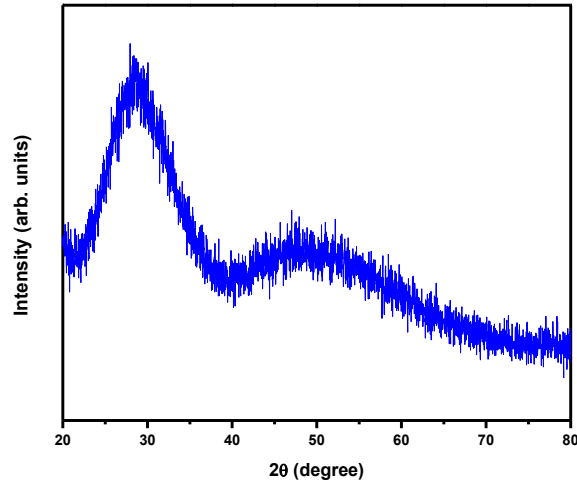


Fig. 1 X-ray diffraction pattern of ZLLTTAP DY(1.0) glass.

#### 4.2 Raman Spetra

The Raman Spectrum of zinc lithium lead tungsten tantalum alumino phosphate ZLLTTAP DY(1.0) glass specimen is recorded and shown in Fig.2. The specimen peaks located at 395 and 775  $\text{cm}^{-1}$ . The band 395  $\text{cm}^{-1}$  is related to the bending motion of phosphate polyhedral  $\text{PO}_4$  units. The broad band at 775  $\text{cm}^{-1}$  is due to symmetric stretching of P-O-P bridging oxygen bonds in  $(\text{P}_2\text{O}_7)_4$  units.

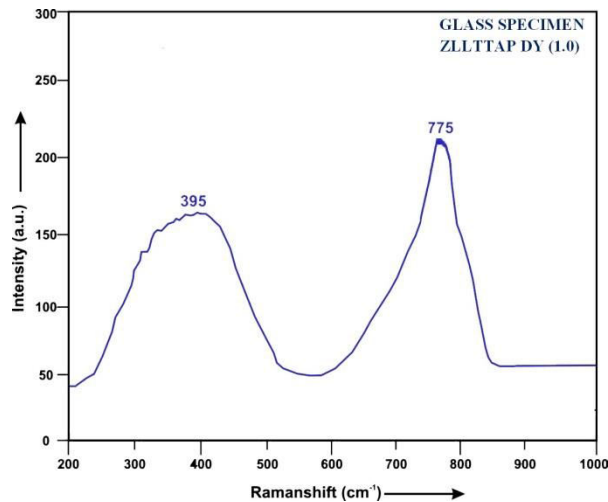


Fig.2: Raman spectra of ZLLTTAP DY(1.0) glass.

#### 4.3 Absorption Spectrum

The absorption spectra of ZLLTTAP DY(1.0) glass specimens has been presented in Figure 3 in terms of Intensity versus wavelength. Thirteen absorption bands have been observed from the ground state  ${}^6\text{H}_{15/2}$  to excited states  ${}^6\text{H}_{13/2}$ ,  ${}^6\text{H}_{11/2}$ ,  ${}^6\text{H}_{9/2}+{}^6\text{F}_{11/2}$ ,  ${}^6\text{H}_{7/2}+{}^6\text{F}_{9/2}$ ,  ${}^6\text{F}_{7/2}+{}^6\text{H}_{5/2}$ ,  ${}^6\text{F}_{5/2}$ ,  ${}^6\text{F}_{3/2}$ ,  ${}^6\text{F}_{9/2}$ ,  ${}^4\text{I}_{15/2}$ ,  ${}^4\text{G}_{11/2}$ ,  ${}^6\text{F}_{7/2}+{}^4\text{I}_{13/2}$ ,  ${}^6\text{M}_{19/2}+4(\text{P},\text{D})_{3/2}$  and  ${}^4\text{G}_{9/2}+{}^6\text{P}_{3/2}$  for ZLLTTAP DY(1.0) glass.

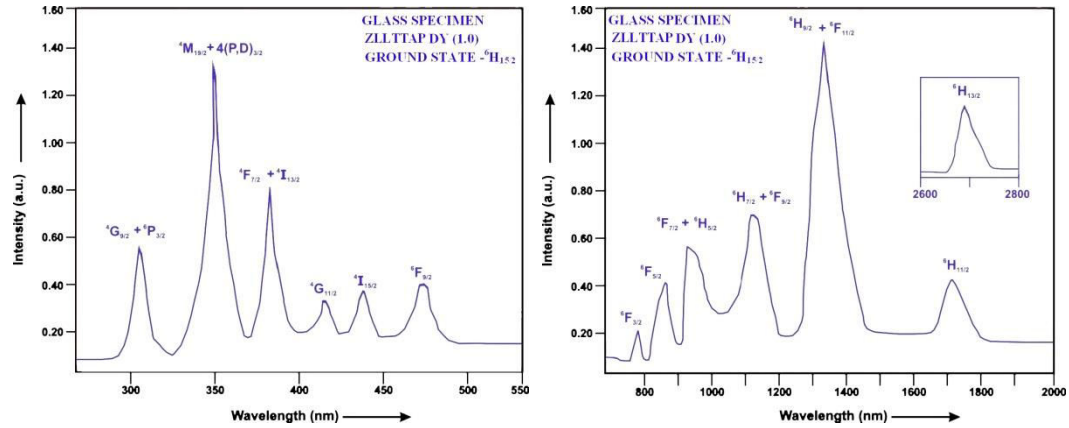


Fig. (3) Absorption spectrum of ZLLTTAP DY(1.0) glass.

The experimental and calculated oscillator strength for Dy<sup>3+</sup> ions in ZLLTTAP glasses are given in Table 2.

Table 2: Measured and calculated oscillator strength ( $P_m \times 10^{+6}$ ) of Dy<sup>3+</sup> ions in ZLLTTAP glasses.

Energy level from <sup>6</sup> H <sub>15/2</sub>	Glass ZLLTTAP DY(1.0)		Glass ZLLTTAP DY(1.5)		Glass ZLLTTAP DY(2.0)	
	P <sub>exp.</sub>	P <sub>cal.</sub>	P <sub>exp.</sub>	P <sub>cal.</sub>	P <sub>exp.</sub>	P <sub>cal.</sub>
<sup>6</sup> H <sub>13/2</sub>	3.52	3.16	3.50	3.15	3.47	3.14
<sup>6</sup> H <sub>11/2</sub>	2.76	3.20	2.73	3.19	2.71	3.17
<sup>6</sup> H <sub>9/2</sub> + <sup>6</sup> F <sub>11/2</sub>	11.97	12.02	11.95	11.99	11.92	11.97
<sup>6</sup> H <sub>7/2</sub> + <sup>6</sup> F <sub>9/2</sub>	6.98	6.71	6.95	6.69	6.93	6.68
<sup>6</sup> F <sub>7/2</sub> + <sup>6</sup> H <sub>5/2</sub>	6.04	5.86	6.02	5.82	6.00	5.79
<sup>6</sup> F <sub>5/2</sub>	2.93	2.94	2.91	2.92	2.87	2.90
<sup>6</sup> F <sub>3/2</sub>	1.12	0.55	1.10	0.55	1.07	0.55
<sup>6</sup> F <sub>9/2</sub>	1.17	0.45	1.13	0.45	1.10	0.45
<sup>4</sup> I <sub>15/2</sub>	1.20	1.15	1.17	1.14	1.14	1.13
<sup>4</sup> G <sub>11/2</sub>	1.02	0.13	1.00	0.14	0.98	0.14
<sup>6</sup> F <sub>7/2</sub> + <sup>4</sup> I <sub>13/2</sub>	4.95	5.18	4.92	5.15	4.89	5.13
<sup>6</sup> M <sub>19/2</sub> +4(P,D)3/2	9.03	10.49	9.01	10.49	8.98	10.49
<sup>4</sup> G <sub>9/2</sub> + <sup>6</sup> P <sub>3/2</sub>	2.95	3.14	2.93	3.13	2.90	3.11
r.m.s. deviation	0.5743		0.5715			

The values of Judd-Ofelt intensity parameters are given in Table 3.

Table 3: Judd-Ofelt intensity parameters for Dy<sup>3+</sup> doped ZLLTTAP glass specimens

Glass Specimen	$\Omega_2(\text{pm}^2)$	$\Omega_4(\text{pm}^2)$	$\Omega_6(\text{pm}^2)$	$\Omega_4 / \Omega_6$	Ref.
ZLLTTAP DY(1.0)	3.683	1.299	2.482	0.5234	P.W.
ZLLTTAP DY(1.5)	3.672	1.306	2.464	0.5300	P.W.
ZLLTTAP DY(2.0)	3.654	1.313	2.447	0.5366	P.W.
LLCTMBB (DY)	2.347	1.471	1.116	1.3181	[23].
LLTB (DY)	8.750	2.620	2.070	1.2657	[24].
PKMAF (DY)	7.040	1.730	1.570	1.1019	[25].

#### 4.4 Excitation Spectrum

The Excitation spectra of ZLLTTAP DY(1.0) glass specimens have been presented in Figure 4 in terms of Excitation Intensity versus wavelength. The excitation spectrum was recorded in the spectral region 315–465 nm fluorescence at 575nm having different excitation band centered at 321,354, 365, 385, 425, 455 and 473 nm are attributed to the  ${}^6P_{3/2}$ ,  ${}^6P_{7/2}$ ,  ${}^4P_{3/2}$ ,  ${}^4I_{13/2}$ ,  ${}^4G_{11/2}$ ,  ${}^4I_{15/2}$  and  ${}^4F_{9/2}$  transitions, respectively. The highest absorption level is  ${}^4I_{13/2}$  and is at 385nm. So this is to be chosen for excitation wavelength.

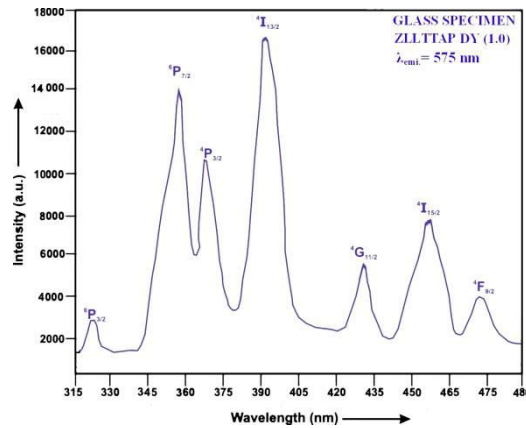


Fig. (4) Excitation spectrum of ZLLTTAP DY(1.0) glass.

#### 4.5. Fluorescence Spectrum

The fluorescence spectrum of ZLLTTAP DY(1.0) zinc lithium lead tungsten tantalum alumino phosphate glass is shown in Figure 5. There are four broad bands observed in the Fluorescence spectrum of ZLLTTAP DY(1.0) glass. The wavelengths of these bands along with their assignments are given in Table 4. The peak with maximum emission intensity appears at 485nm, 575 nm , 665 nm and 752 nm and corresponds to the ( ${}^4F_{9/2} \rightarrow {}^6H_{15/2}$ ), ( ${}^4F_{9/2} \rightarrow {}^6H_{13/2}$ ), ( ${}^4F_{9/2} \rightarrow {}^6H_{11/2}$ ) and ( ${}^4F_{9/2} \rightarrow {}^6H_{9/2}$ ) transitions.

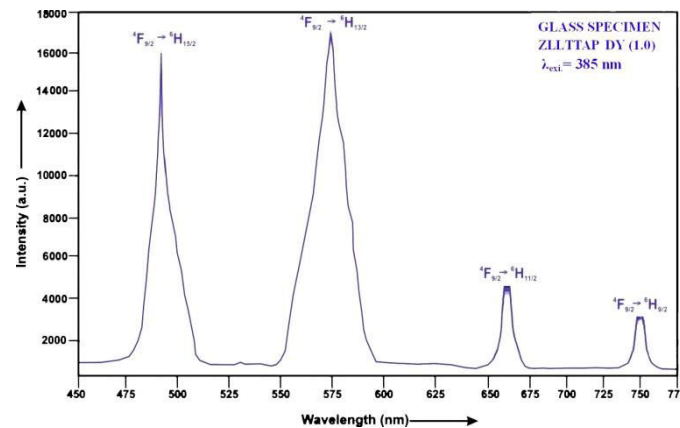


Fig (5) Fluorescence spectrum of doped with ZLLTTAP DY(1.0) glass

**Table4: Emission peak wave lengths ( $\lambda_p$ ),radiative transition probability ( $A_{rad}$ ),branching ratio ( $\beta$ ),stimulated emission cross-section( $\sigma_p$ ) and radiative life time( $\tau_R$ ) for various transitions in Dy<sup>3+</sup> doped ZLLTTAP glasses.**

Transition	ZLLTTAP DY (1.0)					ZLLTTAP DY (1.5)					ZLLTTAP DY (2.0)				
	$\lambda_{rad}$ (nm)	$A_{rad}(s^{-1})$	$\beta$	$\sigma_p (10^{-20} cm^2)$	$\tau_R(\mu s)$	$A_{rad}(s^{-1})$	$\beta$	$\sigma_p (10^{-20} cm^2)$	$\tau_R(\mu s)$	$A_{rad}(s^{-1})$	$\beta$	$\sigma_p (10^{-20} cm^2)$	$\tau_R (10^{-10} cm^2)$		
$^4F_{9/2} \rightarrow ^6H_{13/2}$	485	127.60	0.2240	0.232	1755.41	127.05	0.2236	0.226	1759.87	126.55	0.2234	0.218	1765.46		
$^4F_{9/2} \rightarrow ^6H_{15/2}$	575	375.98	0.6600	1.439		375.16	0.6602	1.404		374.02	0.6603	1.350			
$^4F_{9/2} \rightarrow ^6H_{11/2}$	665	37.68	0.0661	0.170		37.62	0.0662	0.159		37.52	0.0662	0.156			
$^4F_{9/2} \rightarrow ^6H_{13/2}$	752	28.41	0.0499	0.170		28.38	0.0499	0.176		28.33	0.0500	0.171			

### V. CONCLUSION

In the present study, the glass samples of composition (40-x)P2O5: 10ZnO: 10Li2O: 10PbO: 10WO3: 10Ta2O5: 10Al2O3:xDy2O3 (where x =1, 1.5and 2mol %) have been prepared by melt-quenching method. The value of stimulated emission cross-section ( $\sigma_p$ ) is found to be maximum for the transition (4F9/2→6H13/2) for all glass specimens. This shows that (4F9/2→6H13/2) transition is most probable transition. The results show that the Dy3+ doped phosphate glasses could be potential candidate for solid state laser and sensor applications.

### REFERENCES

- [1].Meena,S.L.(2026).Spectral, Thermal and Raman Analysis Tm3+doped in Bismuth borate,Int.J.Inno.Res.Sci.Eng.Tech.15,9617-9624.
- [2]. Senu,M.,Secu,C.,Bartha,C.(2021).Optical properties of transparent rare earth doped sol-gel derived nano-glass ceramics,Mat.14,6871,1-23.
- [3]. Meena,S.L.(2026). Spectral, Transmittance and Thermal Properties of Pr3+ doped Bismuth Borate Glasses with Large Fluorescence life time
- [4].Sailaja,P.,Mahamuda,Sk.,Dedeepya,G.,Alzahrani,J.S.,Swapna,K.,Venkateswarlu,M.,Rao,A.S.,Alrowaili,Z.A.,Olarin oye,I.O.,Al-Buriah,M.S.(2024).Effect of Eu3+ ions concentration on visible red luminescence and radiative shielding properties of SrO-Al2O3-BaCl2-B2O3-TeO2 glasses,Rad.Phys.Chem.216,111467.
- [5].Meena,S.L.(2026). Spectral,Transmittance and Thermal analysis of Tb3+ doped ytterbium zinc lithium calcium tungsten borogermanate glasses,IOSR Appl.Phys.18,31-38.
- [6]. Taherunnisa,S.,Rudramamba,K.S.,Krishna Reddy, D.V., Venkateswari,T., Zhydachevskyy,Y., Suchochi,A.,Piasecki,M.,RamiReddy,M.(2020).Efficient 2.01μm mid-infrared(MIR) and visible emission in Ho3+ doped phosphate glasses enhanced by Er3+ ions,Infr.Phys.Techn.107,103294.
- [7]. Singh,H.,Singh,D.,Singh,S.P.(2025).Er3+,Nd3+,Tm3+:Up-conversion in Lead Borophosphate Glasses for Visible Emission,J.Flu.35,5145-5157.
- [8].Meena,S.L.(2026). Structural, Thermal and Spectral features of Ho3+doped Borophosphate Glasses for Photonic and Laser Materials Applications,Int.J.Res.App.Sci.Eng.Tech.14,2520-2527.
- [9]. Milankovic, A.M., Gajovic, A. and Day, D.E. (2003).Spectroscopic investigation of MoO3–Fe2O3–P2O5 and SrO–Fe2O3–P2O5 glasses. J of Non-Crystalline Solids. 325:76-84.
- [10]. Meena,S.L.(2026).Spectral, Transmittance and Luminescent Properties of Sm3+ Doped Borophosphate Glasses for Visible Lasers and Display device Applications
- [11].Basavapoornima,C.H.,Masthanaiah,E.,Vijay,N.,Depuru,S.R.,Kaewkhao,J.,Pecharapa,W.,Jayasankar,C.K.(2024).Spectroscopic investigation and local structure of Eu3+ ions in lead phosphate glasses for optical device applications,Optik,300,171667.
- [12].Kilic,G.,Ilik,E.,Mahmoud,K.A.,Mallawany,R.El,Agawany,El(2020).Novel zinc vanadyl borophosphate glasses:ZnO-V2O5-P2O5-B2O3:Physical,thermal and nuclear radiation shielding properties,Ceram.Int.46,19318-19327.

- [13] Madhu,A.,Eraiah,B.,Manasa,P.,Basavapoornima, Ch.(2018).Er<sup>3+</sup> ions doped lithium-bismuth boro phosphate glass for 1532 nm emission and efficient red emission up conversion for telecommunication and lasing application,J.Non-Cryst.Solids,495,35-46.
- [14].Meena,S.L.(2022).Spectroscopic properties of Er<sup>3+</sup> doped in zinc lithium calcium potassiumniobate phosphate glasses,Int.J.Res.Appl.Sci.Eng.Tech.10,32-37.
- [15].Ji,Y.,Xiao,Y.B.,Wang,W.C.,Huang,S.J.,Liu,J.L.,Zhang,Q.Y.(2019).Optical properties of Nd<sup>3+</sup> doped fluoro-sulfo-phosphate glasses,J.Non-Cryst.Solids,512,155-160.
- [16].Meena,S.L.(2018).Spectral and Thermal properties of Tb<sup>3+</sup> doped in lead lithium borophosphate glasses,Int.Cem.Phys.Sci.7,1-8.
- [17].Mahraz,Z.A.S.,Sazali,E.S.,Sahar,M.R.,Anuran,N.U.,Yaacob,S.N.S.,Aziz,S.M.,Mawlud,S.Q.,Noor,F.M.,Harum,A.N.(2019).Spectroscopic investigations of near infrared emission from Nd<sup>3+</sup> doped zinc phosphate glasses,Judd-Ofelt evaluation,J.Non-Cryst.Solids,509,106-114.
- [18]. Kozhanov, V.O.,Zaderko,A.N.,Boldyrieva,O.Y.,Lisnyak,V.L.(2016).Judd-Ofelt analysis of Nd<sup>3+</sup> doped phosphate glass: The effect of Ba/Sr ratio,Mol.Cryst.Liq.Cryst.639,78-86.
- [19].Meena,S.L.(2021). Spectral and Thermal properties of Pr<sup>3+</sup> doped lead lithium sodium tungsten borophosphate glasses,IOSR Appl.Phys.13,1-7.
- [20].Meena,S.L.(2021). Spectral and Raman Analysis of Er<sup>3+</sup> doped Zinc Lithium Antimony Sodalime Tellurite Glasses,Int.J.Eng.Sci.Inv.10,09-15.
- [21]. Judd, B.R. (1962). Optical Absorption Intensities of Rare Earth Ions. Physical Review, 127, 750.
- [22]. Ofelt, G.S. (1962). Intensities of Crystal Spectra of Rare Earth Ions. The J. Chem. Phys., 37, 511.
- [23].Meena,S.L.(2020).Spectroscopic Properties of Dy<sup>3+</sup> doped Lead Lithium Cadmium Tantalum Magnesium Bismuth Borate Glasses,Int.J.Chem.Phys.Sci.9,5-12.
- [24].Saleema,S.A.,Jamalaiah,B.C.,Jayasimhadri,M.,Rao,A.S.,Jang,K.,Moorthy,R.(2011).Luminescent studies of Dy<sup>3+</sup> ion in alkali lead tellurofluoroborate glasses, J.Quant.Spect.Rad.Trans.78-84.
- [25].Sardar,D.K.,Bardely,W.M.,Yow,R.M.,Gruber,J.B.,Zandi,B.(2004).Optical transitions and absorption intensities of Dy<sup>3+</sup>(4f<sup>9</sup>) in YSGG laser host,J.Lumin.106,195-203.



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