Academy of Sciences
of the Czech Republic

Luminescence and Energy Transfer in Ce^{3+} doped Multicomponent Garnets

Karol Bartosiewicz

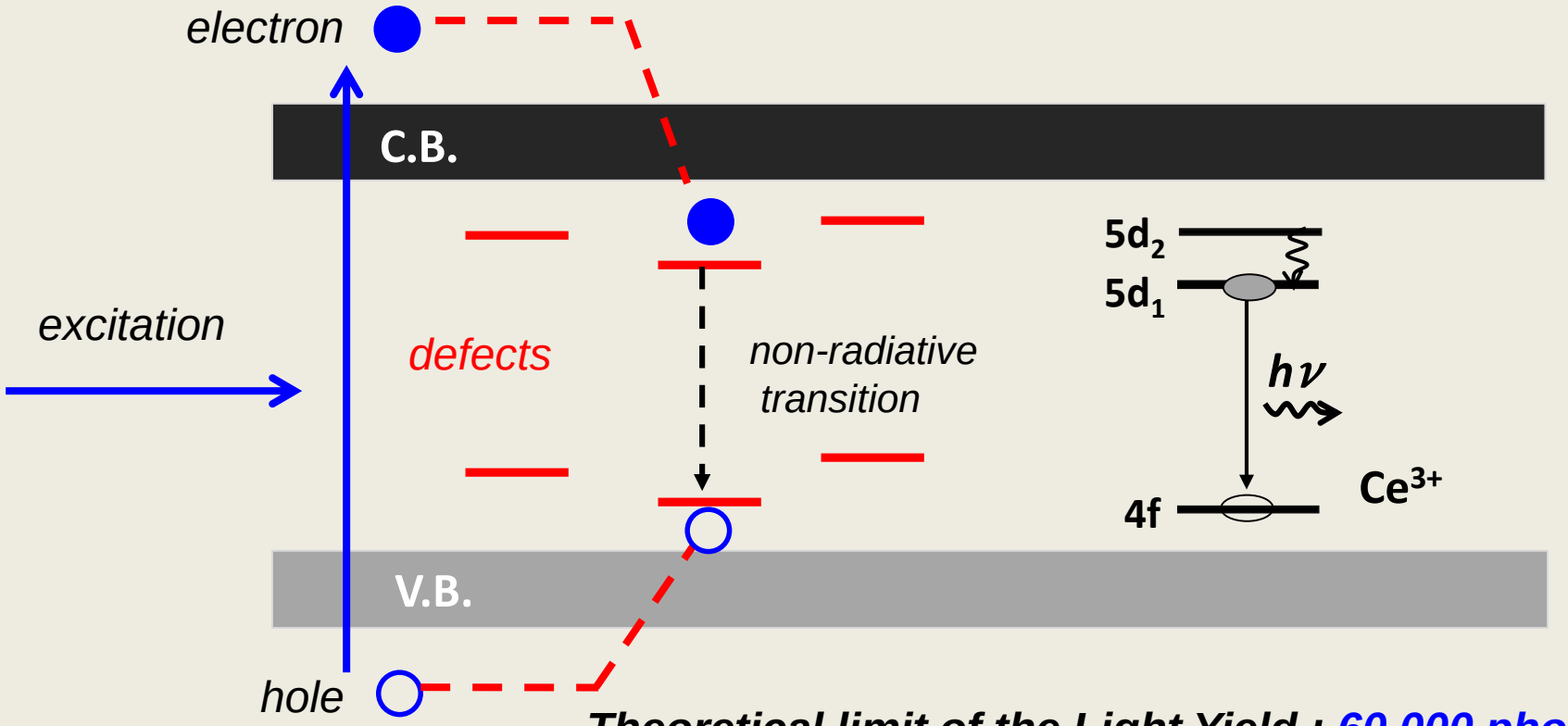
Outline

Outline

Introduction and Aims

Transport of the excitation energy through scintillator material:

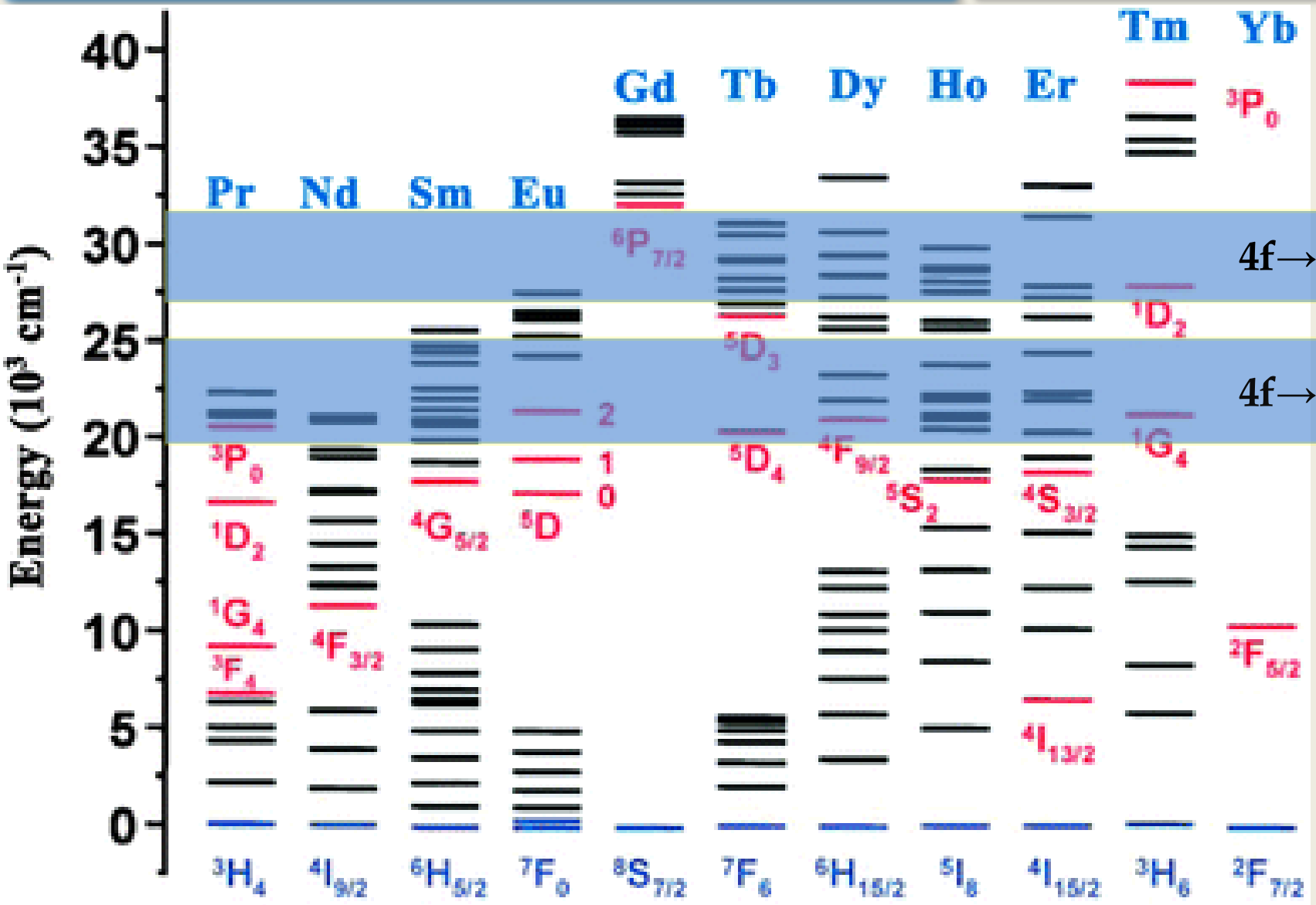
$Lu_3Al_5O_{12}:Ce^{3+}$



Theoretical limit of the Light Yield : 60 000 phot/MeV

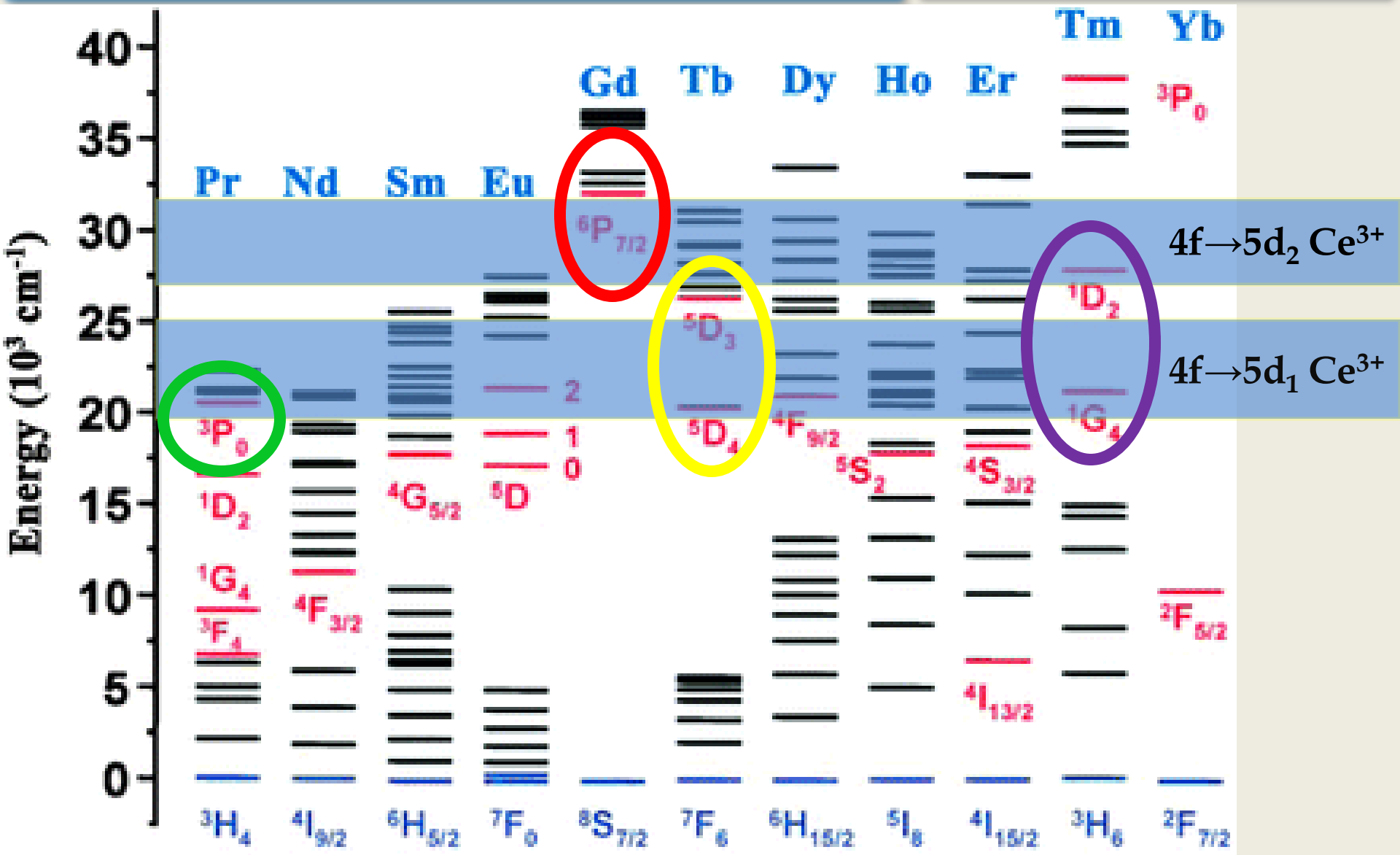
Measured value: 20-25 000 phot/MeV

Introduction and Aims



Dieke diagram of trivalent rare earth ions with 4f→5d (LuAG:Ce^{3+}) absorption bands

Introduction and Aims



Dieke diagram of trivalent rare earth ions with 4f→5d (LuAG:Ce^{3+}) absorption bands

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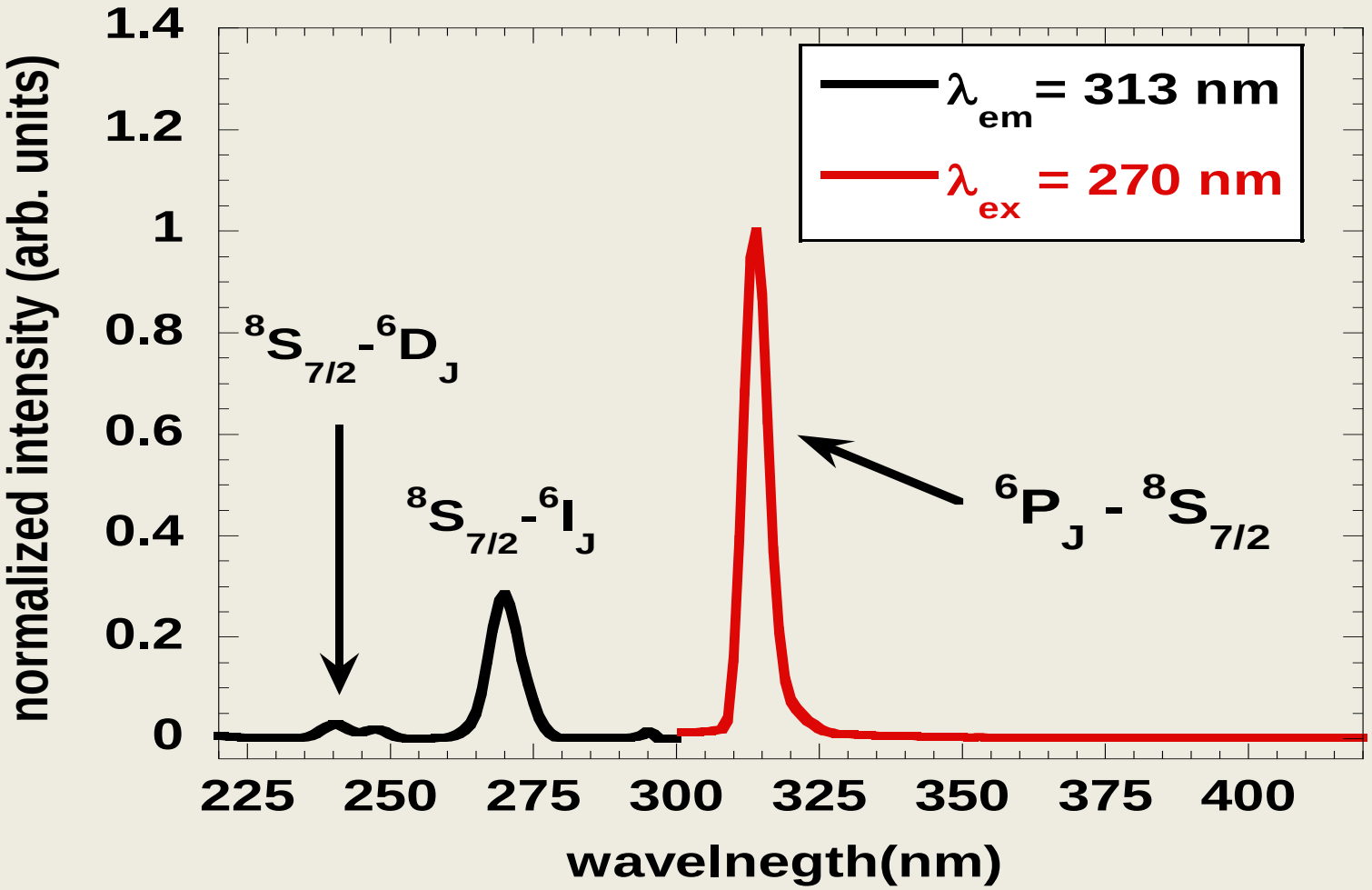
Results and Discussion

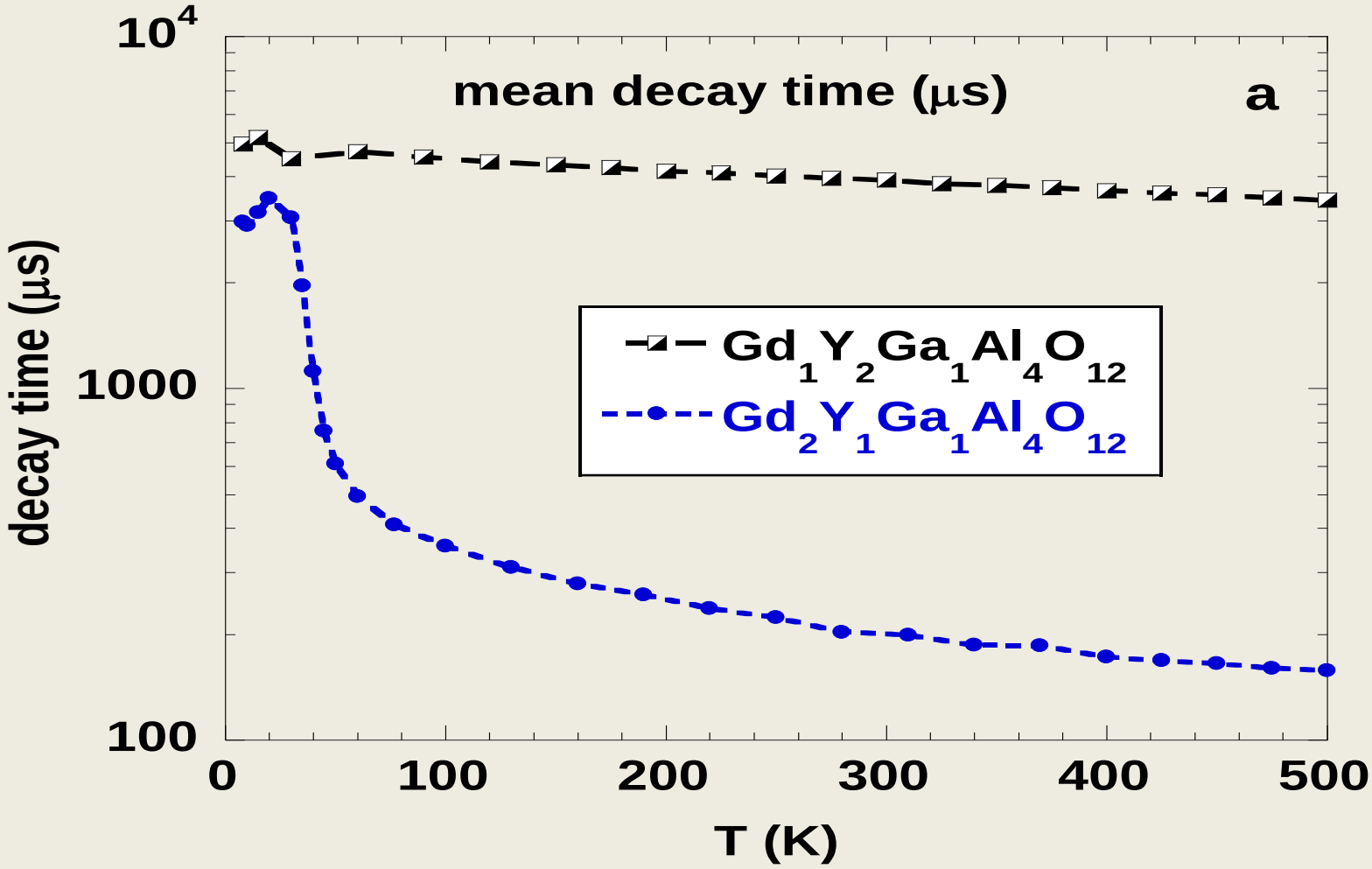
Excitation and emission characteristics



Excitation and emission spectra (measured at the maxima of emission and excitation peaks at λ_{em}=313 nm and λ_{ex}=275 nm, respectively) of $Gd_2Y_1Ga_1Al_4O_{12}$ single crystal, 8 K.

Results and Discussion

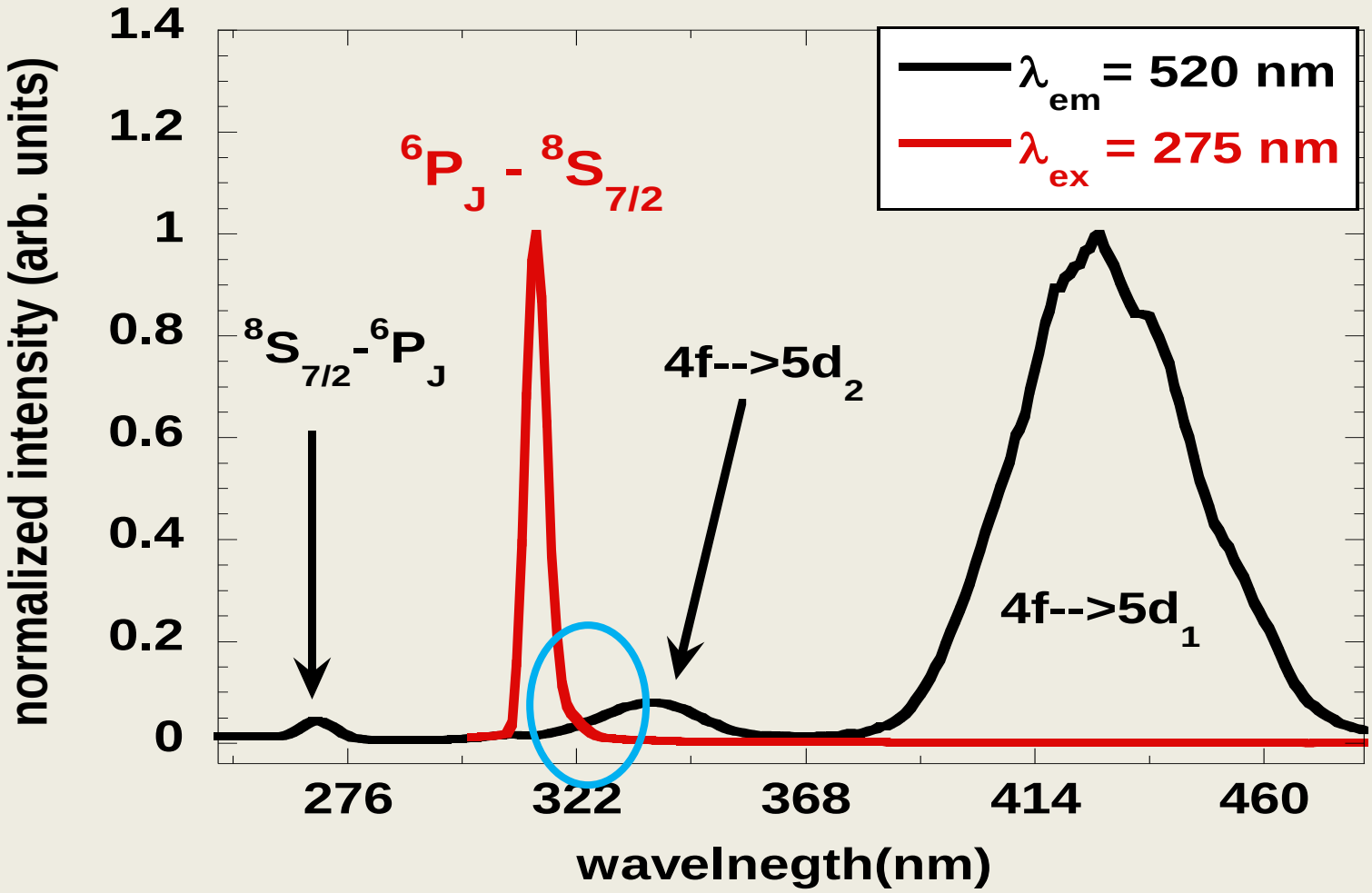
Temperature dependence of decay times related to $^6P_J \rightarrow {}^8S_{7/2}$ emission transition in the Gd^{3+}



Temperature dependence of the decay time of Gd^{3+} emission at 313 nm in the $Gd_1Y_2Ga_1Al_4O_{12}$ and $Gd_2Y_1Ga_1Al_4O_{12}$ single crystals under excitation at 275 nm

Results and Discussion

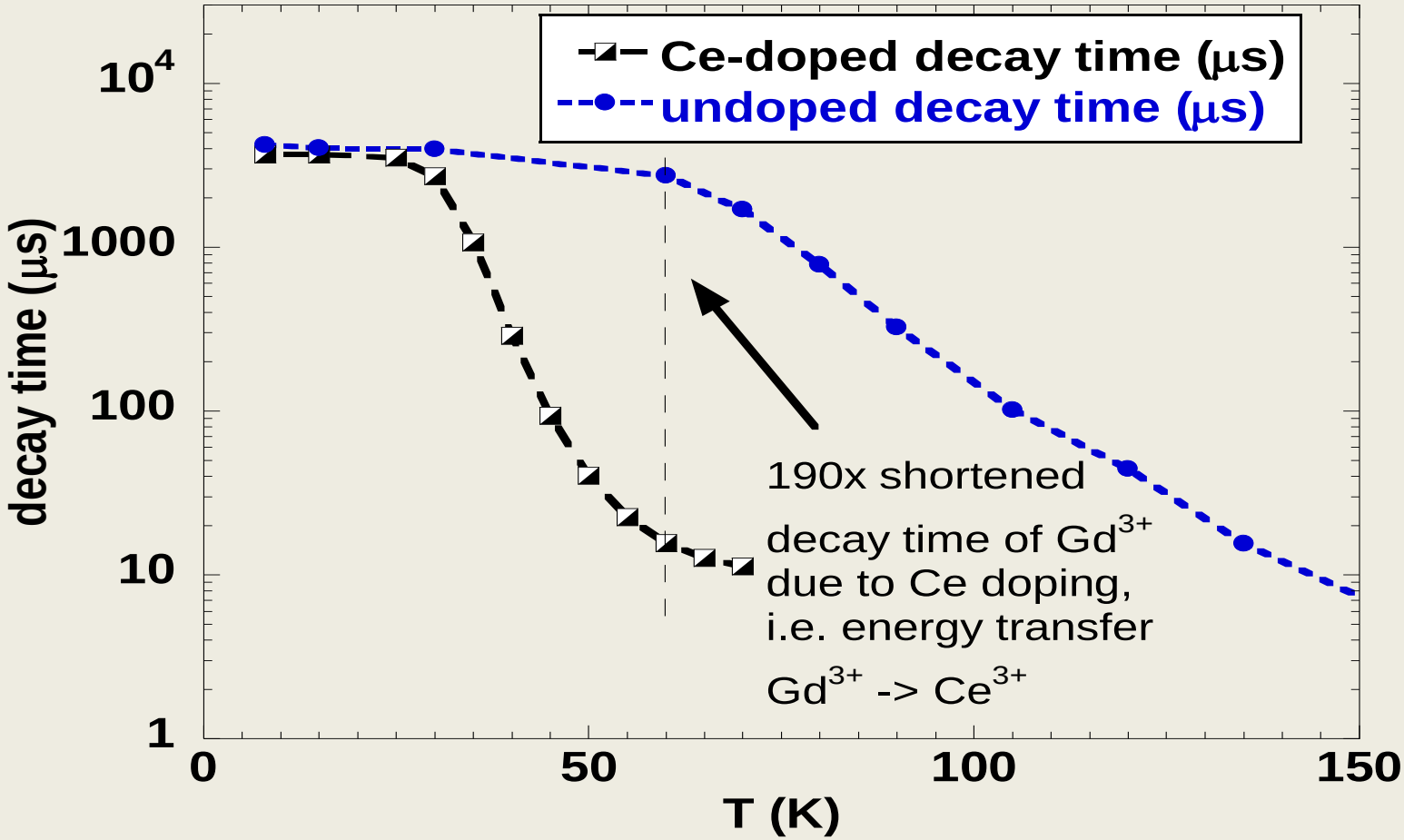
Excitation and emission characteristics



Excitation and emission spectra (measured at the maxima of emission and excitation peaks at λ_{em}=520 nm and λ_{ex}=275 nm, respectively) of the undoped and Ce-doped $Gd_3Ga_3Al_2O_{12}$ single crystal, 8 K.

Results and Discussion

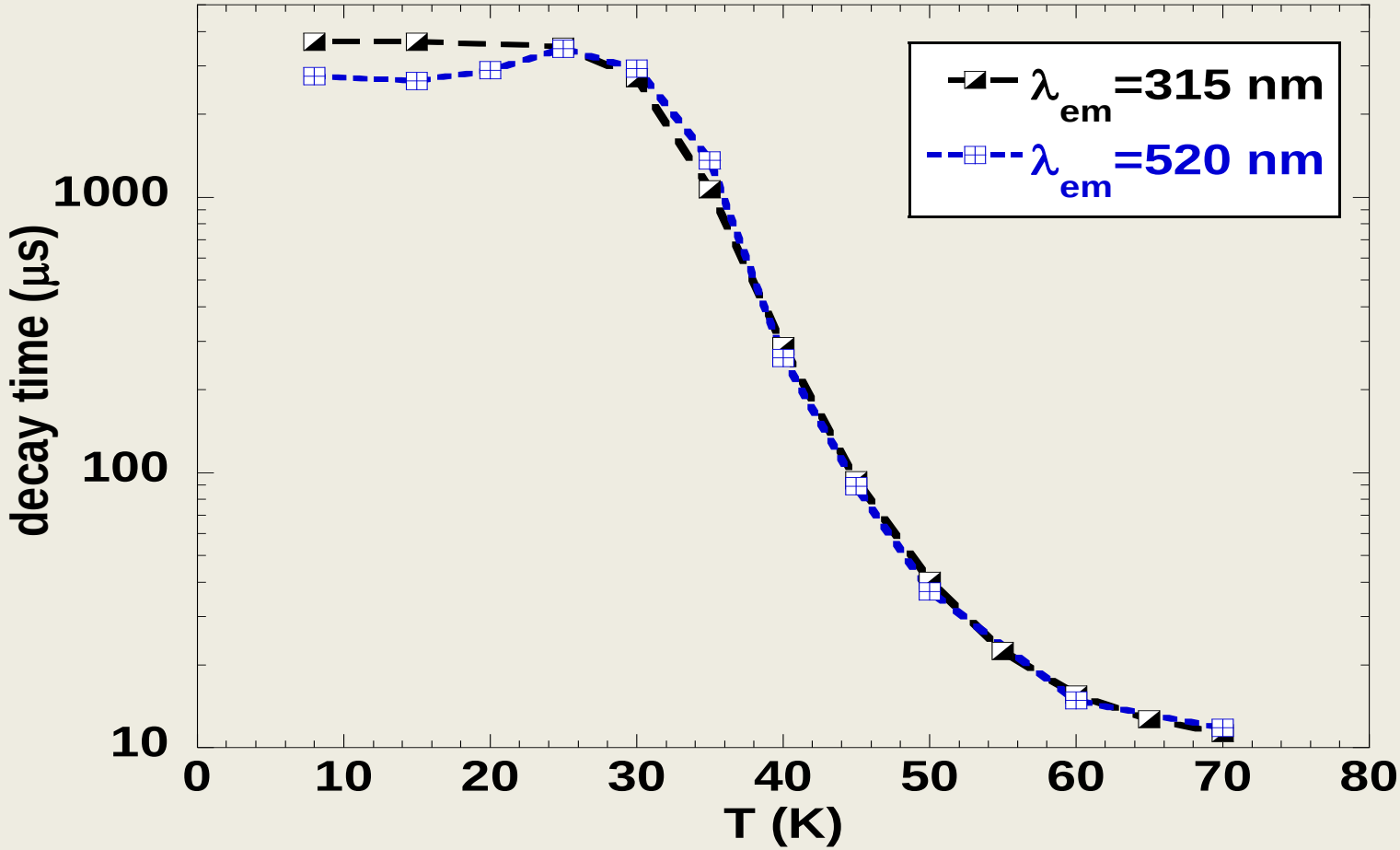
Temperature dependence of the decay times related to $^6P_J \rightarrow {}^8S_{7/2}$ emission transition in Gd^{3+} ions in un-doped and Ce^{3+} -doped $Gd_3Ga_3Al_2O_{12}$ single crystals



The temperature dependence of PL decays of Gd^{3+} ion (λ_{ex}=270 nm, λ_{em}=315 nm) in $Gd_3Ga_3Al_2O_{12}$:Ce^{3+} and $Gd_3Ga_3Al_2O_{12}$ single crystals.

Results and Discussion

Temperature dependence of decay time for the $^6P_J \rightarrow {}^8S_{7/2}$ in Ce^{3+} -doped $Gd_3Ga_3Al_2O_{12}$ single crystal



Temperature dependence of PL decays of Gd^{3+} ions λ_{em}=315 nm and Ce^{3+} ions λ_{em}=520 nm under excitation at λ_{ex}=270 nm, in $Gd_3Ga_3Al_2O_{12}$:Ce^{3+} single crystal.

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1 Introduction and Aims

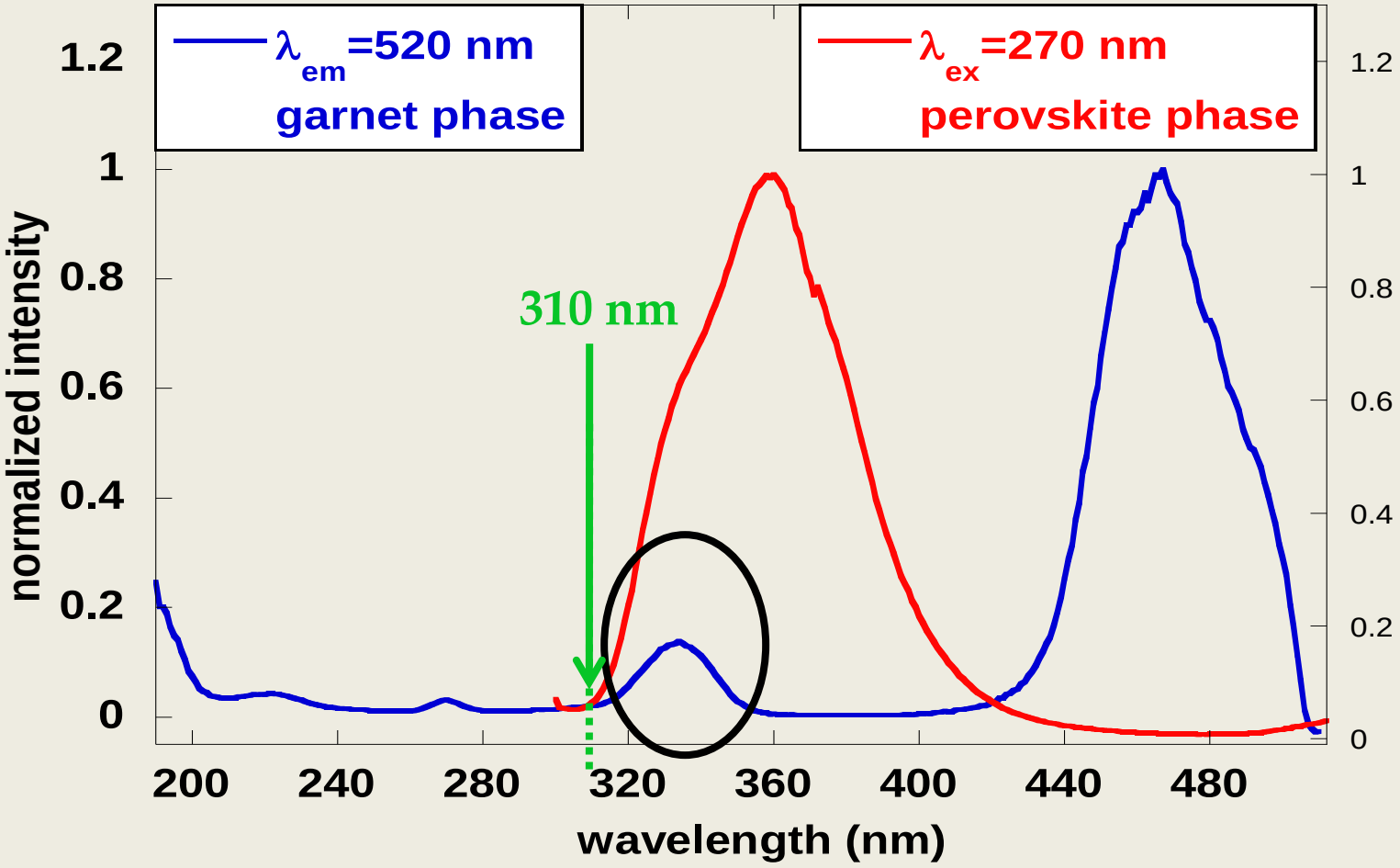
3 Results and Discussion

- 3a $Gd_xY_{3-x}Ga_xAl_{5-x}O_{12}$ and $Gd_xY_{3-x}Ga_xAl_{5-x}O_{12}:Ce^{3+}$
- **3b $Gd_xY_{3-x}Al_5O_{12}:Ce^{3+}$**
- 3c $Tb_xLu_{3-x}Al_5O_{12}:Ce^{3+}$

4 Conclusions

Results and Discussion

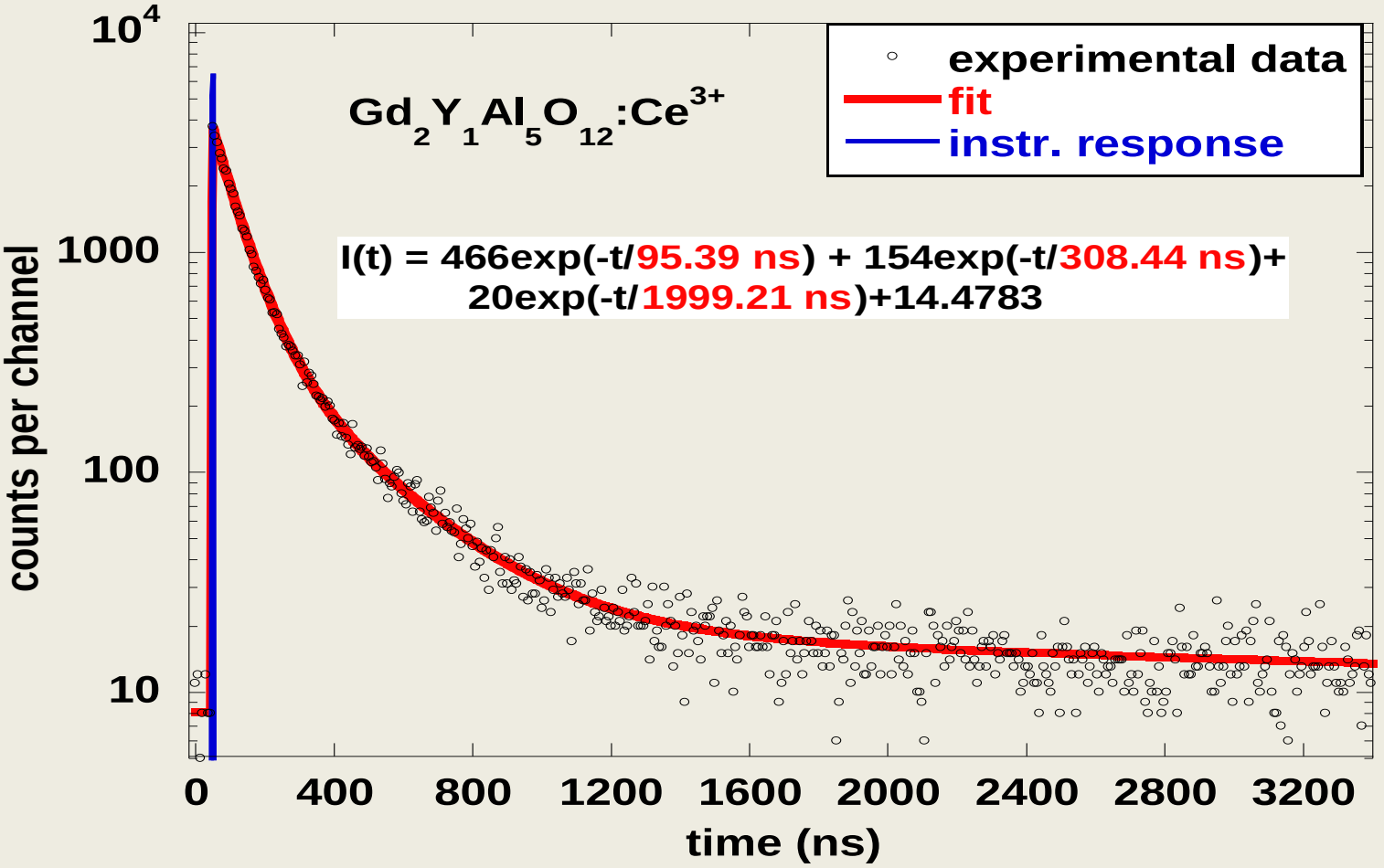
Excitation and Emission Characteristics



*The excitation spectrum of the Ce^{3+} luminescence related to **garnet phase** and emission spectrum under excitation into Ce^{3+} absorption band in **perovskite phase** in $Gd_2Y_1Al_5O_{12}:Ce^{3+}$*

Results and Discussion

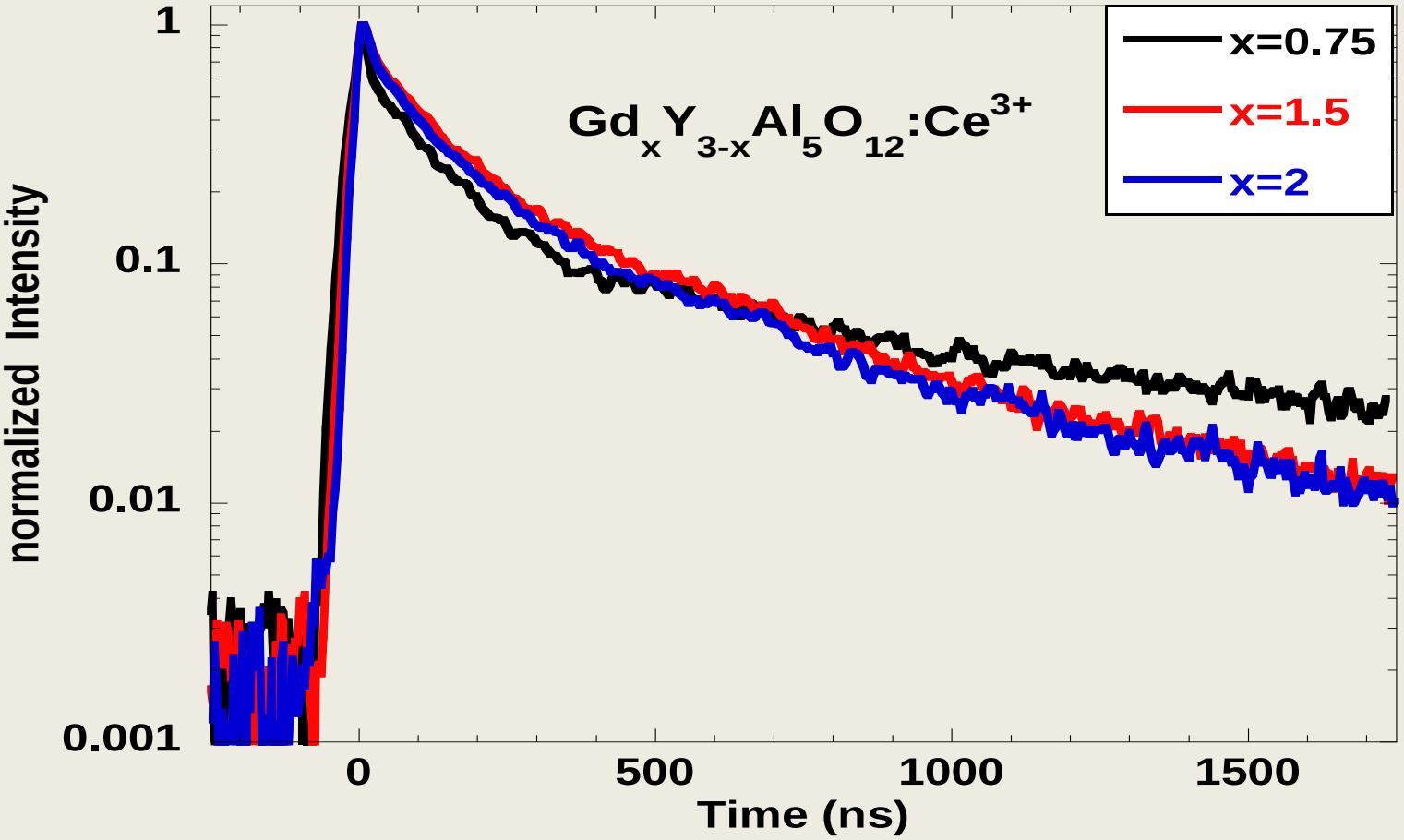
Decay kinetics



The $5d_1$-$4f$ decay curve of the Ce^{3+} luminescence in garnet phase measured at λ_{em}=560 nm and under excitation at λ_{ex}=310 nm corresponding to perovskite phase in $Gd_2Y_1Al_5O_{12}:Ce^{3+}$

Results and Discussion

Scintillation decays



Scintillation decay times of the Ce^{3+} emission in $Gd_xY_{3-x}Al_5O_{12}$ (x=0.75, 1.25 and 2) excited by 662 keV photons of ^{137}Cs radioisotope at room temperature

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1 Introduction and Aims

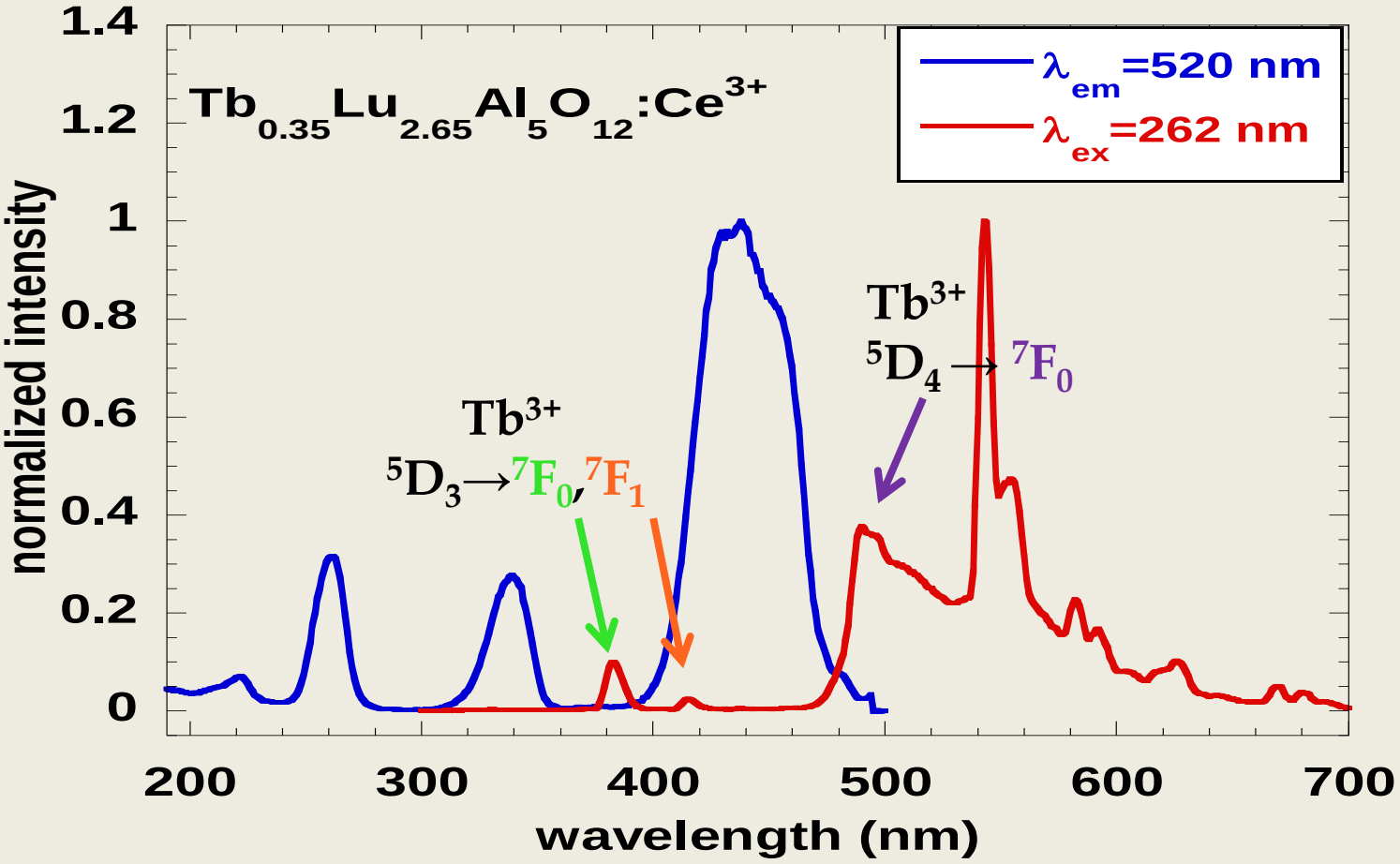
3 **Results and Discussion**

- 3a $Gd_xY_{3-x}Ga_xAl_{5-x}O_{12}$ and $Gd_xY_{3-x}Ga_xAl_{5-x}O_{12}:Ce^{3+}$
- 3b $Gd_xY_{3-x}Al_5O_{12}:Ce^{3+}$
- 3c $Tb_xLu_{3-x}Al_5O_{12}:Ce^{3+}$

4 Conclusions

Results and Discussion

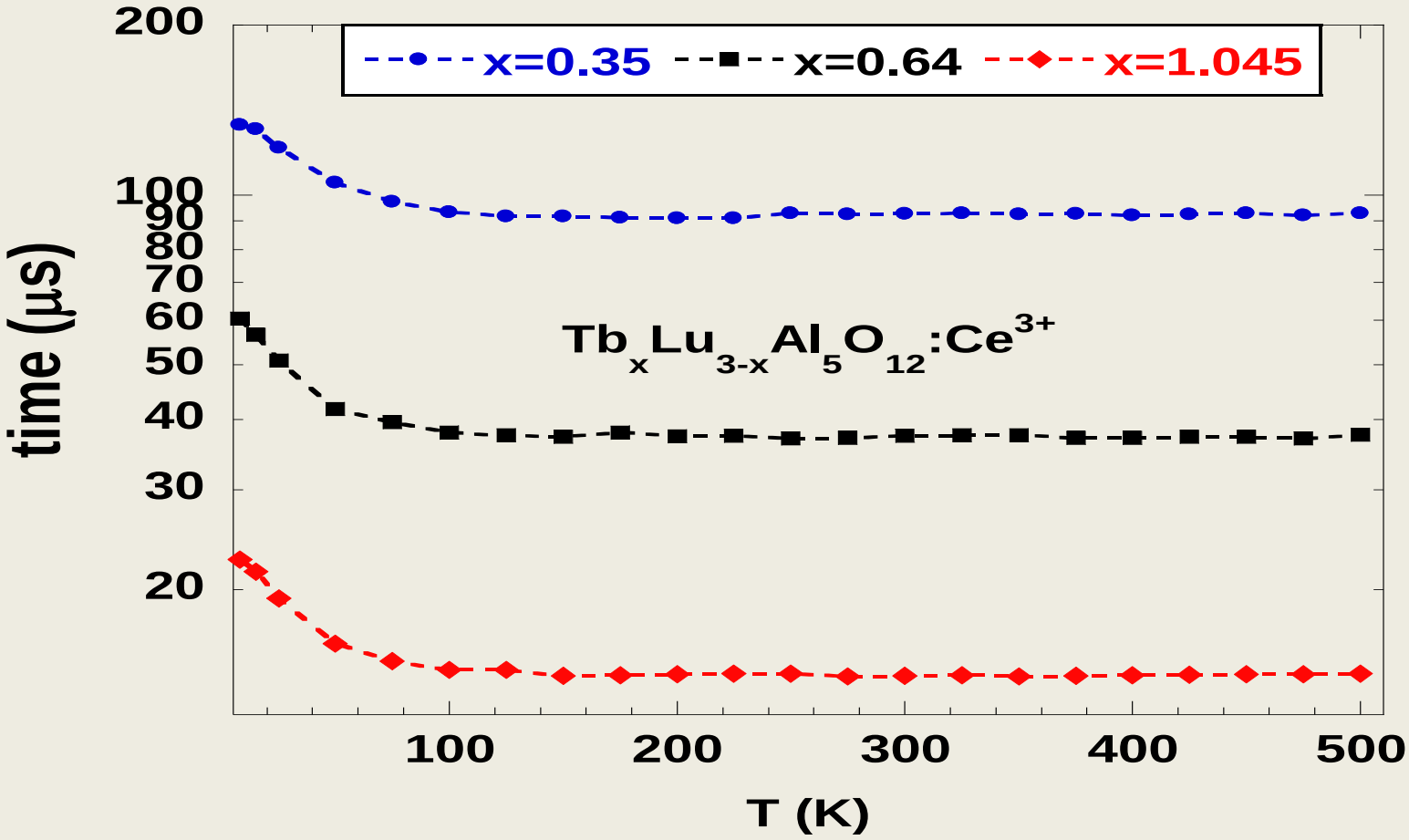
Excitation and emission characteristic



Low temperature (8 K) excitation and emission spectra of the Ce-doped $Tb_{0.35}Lu_{2.65}Al_5O_{12}$ single crystalline film for emission at 520 nm and excitation at 262 nm, respectively

Results and Discussion

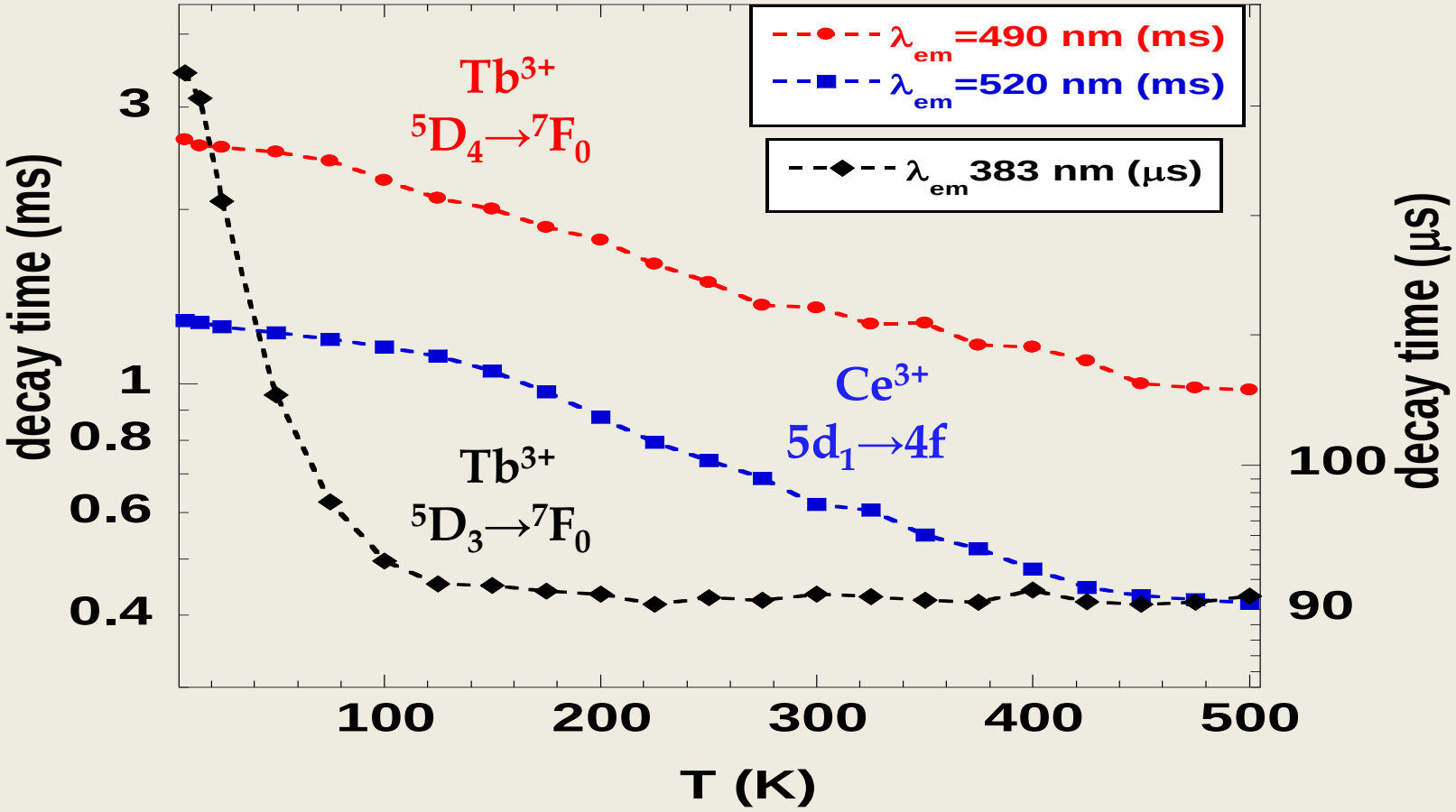
$Tb^{3+} \rightarrow Ce^{3+}$ energy transfer through $^5D_3$ energy level of Tb^{3+}



Temperature and Tb dependence of the photoluminescence decay time for the emission from $^5D_3$ (λ_{em}=383 nm) energy level of the Tb^{3+} in $Tb_xLu_{3-x}Al_5O_{12}:Ce^{3+}$ (SCF) under 262 nm excitation into 4f→5d absorption band of Tb^{3+}

Results and Discussion

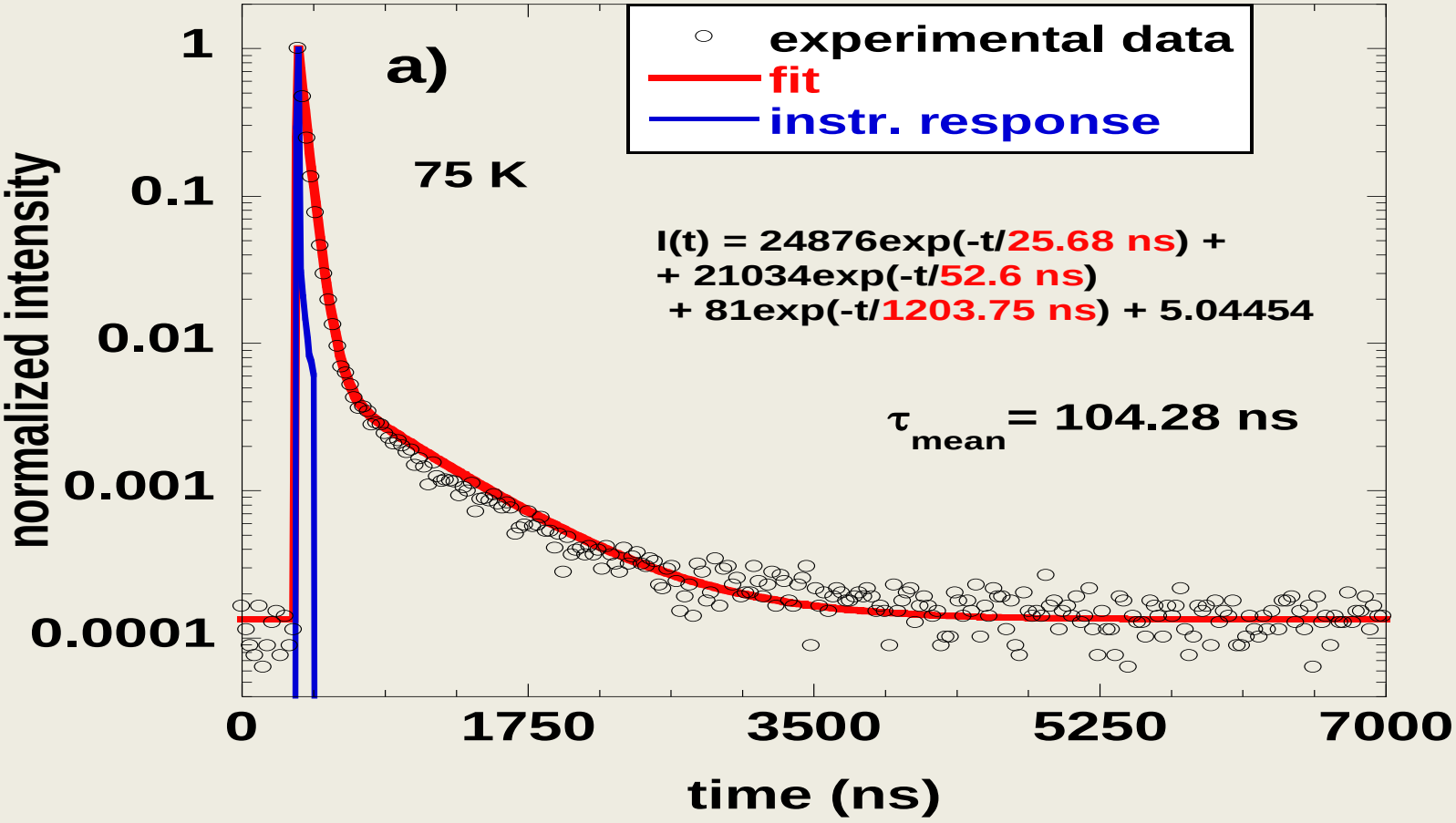
$Tb^{3+} \rightarrow Ce^{3+}$ energy transfer through $^5D_4$ energy level of Tb^{3+}



Temperature dependence of the photoluminescence mean decay time of the Tb^{3+} emission ($^5D_3 \rightarrow {}^7F_0$, λ_{em}=383 nm and $^5D_4 \rightarrow {}^7F_0$, λ_{em}=490 nm) and Ce^{3+} emission ($5d_1 \rightarrow 4f$, λ_{em}=520 nm) under excitation into $4f^8 \rightarrow 4f^7 5d^1$ Tb^{3+} absorption band at 262 nm in $Tb_{0.35}Lu_{2.65}Al_5O_{12}:Ce^{3+}$

Results and Discussion

$Ce^{3+} \rightarrow Tb^{3+}$ energy transfer



Prompt $5d_1$-4f decay curve of the Ce^{3+} luminescence measured at λ_{em}=520 nm and λ_{ex}=452 nm in the $Tb_{0.35}Lu_{2.65}Al_5O_{12}:Ce^{3+}$

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3 Results and Discussion

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- 3b $Gd_xY_{3-x}Al_5O_{12}:Ce^{3+}$
- 3c $Tb_xLu_{3-x}Al_5O_{12}:Ce^{3+}$

4 **Conclusions**

Conclusions

✓ Energy migration among co-activator in garnet lattice is efficient at concentration around ~50 %

✓ Gd^{3+} and Tb^{3+} ions show efficient energy transfer to Ce^{3+} in garnet lattice

✓ Energy transfer from Ce^{3+} ions in perovskite phase to Ce^{3+} in garnet was revealed

✓ $^5D_3$ and $^5D_4$ energy levels of Tb^{3+} are involved in $Tb^{3+} \rightarrow Ce^{3+}$ energy transfer

✓ In diluted and heavily Tb doped $Lu_3Al_5O_{12}:Ce^{3+}$ single crystalline films bidirectional $Ce^{3+} \rightarrow Tb^{3+}$ energy transfer was revealed

Acknowledgment

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Děkuji

Merci

Bedankt

Ευχαριστώ

Thank You

Aitäh

Danke

Dziękuję

Hvala

Grazie

OBRIGADO

Спасибо

Gracias