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# Luminescence efficiency of a hygroscopic Cerium-doped Lanthanum Bromide ($LaBr_3$:Ce) single crystal scintillator: Temperature dependence

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## INTRODUCTION & AIM

- Scintillators are used in a variety of applications, including modalities for extreme temperature or radiation flux environmental conditions.
- Thus, knowledge of their luminescence performance, under the influence of temperature or radiation flux, is of paramount importance.
- In this framework, the aim of this study was to examine the influence of temperature on the luminescence efficiency of a hygroscopic cerium-doped lanthanum bromide ($LaBr_3$:Ce) single-crystal scintillator.
- The crystal output was compared with a cerium-doped lanthanum chloride ($LaCl_3$:Ce) crystal scintillators of equal dimensions, in similar experimental conditions [1].

## METHOD

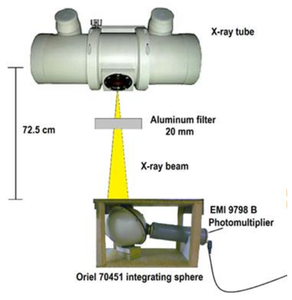
- The experimental setup comprised of a CPI series CMP 200 DR medical X-ray source, set to a fixed high voltage (90kVp), to expose the sample to X-ray radiation, under temperature conditions in the range 23-154 °C.

- $LaBr_3$:Ce is an extremely efficient crystal with high light yield of 63,000 photons/MeV and fast decay time (25ns) [2].
- The crystal was removed from the protective aluminum encapsulation (thickness 0.7 mm).


- Heating was performed by using a Perel 3700-9 2000W heating gun. The temperature on the crystal surface was monitored using an Agilent Technologies U1253A digital multimeter, coupled to a U1185A thermocouple (J-Type) with temperature probe adapter.
- The ratio of the light energy flux emitted by the examined sample, normalized by the X-ray exposure rate can be expressed as the absolute luminescence efficiency (ALE)[3,4]:

$$AE = \eta_A = \frac{\dot{\Psi}_\lambda}{\dot{X}} = \left(\frac{i_{elec}}{S\eta_p\alpha_s c_g}\right)\dot{X}^{-1}$$

- In equation (1) $\dot{\Psi}_\lambda$ is the light energy flux (output signal) in units of μW $m^{-2}$. $\dot{X}$ is the exposure rate (mR $s^{-1}$).
- $i_{elec}$ is the current produced by the electrometer in pA and S denotes the surface of the crystal, excited by X-rays ($mm^2$).




- The peak sensitivity of the photocathode ($\eta_p$) is expressed in units of pA/W. $\alpha_s$ is the spectral matching between the light source to the spectral response of the optical sensor.
- The geometric light collection efficiency ($c_g$) has a value of 15.6. The units of the ALE is EU=(μW $m^{-2}$)/(mR $s^{-1}$).

## RESULTS & DISCUSSION

- The luminescence efficiency of $LaBr_3$:Ce decreases with increasing temperature, between 69.58 EU at 23.0°C to 18.27 EU at 154°C. (EU is the S.I. equivalent μW$m^{-2}$/(mGy/s).
- The corresponding values for $LaCl_3$:Ce were 33.14 to 17.96 EU in the temperature range from 29 to 162 °C.
- The room temperature absolute efficiency of $LaBr_3$:Ce, with the protective aluminum encapsulation, was 50.02 EU.

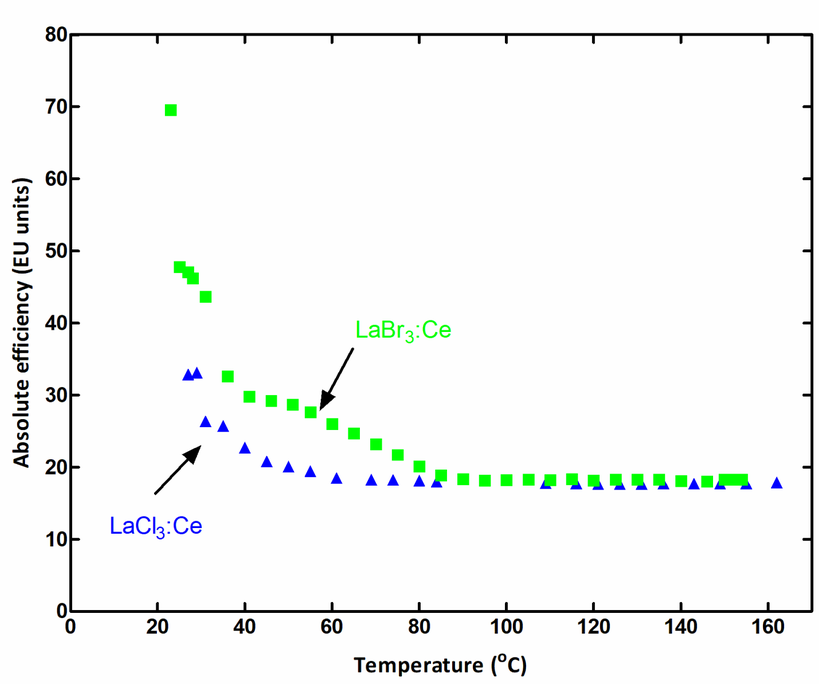



**Figure 1**. Absolute luminescence efficiency of $LaBr_3$:Ce and $LaCl_3$:Ce single crystals.

## CONCLUSION

$LaBr_3$:Ce is an extremely efficient crystal scintillator and knowledge upon its performance in various temperatures, could be useful for various applications, from medical imaging up to detectors for extreme environments.

## FUTURE WORK / REFERENCES

1. Tseremoglou, S.; Ntoupis, V.; Linardatos, D.; Valais, I.; Michail, C.; Bakas, A.; Ninos, K.; Lavdas, E.; Kandarakis, I.; Fountos, G.; et al. Temperature Dependence of the Luminescence Output of $LaCl_3$:Ce Single Crystal Scintillator. *Procedia Structural Integrity* **2023**, *47*, 119–124, doi:10.1016/j.prostr.2023.07.002
2. Tseremoglou, S.; Michail, C.; Valais, I.; Ninos, K.; Bakas, A.; Kandarakis, I.; Fountos, G.; Kalyvas, N. Evaluation of Cerium-Doped Lanthanum Bromide ($LaBr_3$:Ce) Single-Crystal Scintillator's Luminescence Properties under X-Ray Radiographic Conditions. *Applied Sciences* **2023**, *13*, 419, doi:10.3390/app13010419.
3. Tseremoglou, S.; Michail, C.; Valais, I.; Ninos, K.; Bakas, A.; Kandarakis, I.; Fountos, G.; Kalyvas, N. Efficiency Properties of Cerium-Doped Lanthanum Chloride ($LaCl_3$:Ce) Single Crystal Scintillator under Radiographic X-Ray Excitation. *Crystals* **2022**, *12*, doi:10.3390/cryst12050655.
4. Tseremoglou, S.; Michail, C.; Valais, I.; Ninos, K.; Bakas, A.; Kandarakis, I.; Fountos, G.; Kalyvas, N. Optical Photon Propagation Characteristics and Thickness Optimization of $LaCl_3$:Ce and $LaBr_3$:Ce Crystal Scintillators for Nuclear Medicine Imaging. *Crystals* **2024**, *14*, 24, doi:10.3390/cryst14010024.