

Mechanisms of Enhancing the Light Yield of KCl:Li Crystals under X-ray and VUV-Radiation

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Luminescence spectroscopy methods were used to study the mechanisms of activation by lithium ions (1÷200 ppm) responsible for the enhancement of the light yield of the KCl matrix under X-ray and vacuum ultraviolet (VUV) radiation over a wide temperature range (4.2÷400 K).

Upon exposure to X-ray radiation, an increase in radioluminescence intensity was recorded at 2.8 eV (dominant) and 3.1 eV, depending on lithium ion concentration and sample temperature. This is interpreted as the result of the recombination of correlated electron–hole pairs near lithium ions, whose radiative relaxation originates from an exciton-like state [1, 2].

This experimental finding is further supported by the temperature dependence of the radioluminescence intensity (3.1 eV and 2.8 eV), which increases with temperature and with the enhanced mobility of non-relaxed hole simultaneously.

Under VUV excitation by photons with an energy of 7.6 eV, which directly create single-halogen anionic excitons at 4.2 K in KCl:Li crystals, photoluminescence with a maximum at 2.8 eV was registered, interpreted as luminescence of a localized exciton in the field of a lithium ion $e_S^0(\text{Li}^+)$.

The coincidence of the luminescence maximum at 2.8 eV under both X-ray and VUV-excitation is consistent with the assumption of an exciton-like nature of radioluminescence in KCl:Li crystals.

In KCl:Li crystals, the main difference between X-ray and VUV-excitation manifests itself in the temperature dependence of the luminescence: photoluminescence decreases, whereas radioluminescence increases. In our view, this behavior is associated with mechanisms of radiative relaxation of the exciton $e_S^0(\text{Li}^+)$ and exciton-like $e_{SL}^0(\text{Li}^+)$ excitations.

Thus, the activation mechanism of the enhanced luminescence (2.8 eV and 3.1 eV) by lithium ions in KCl:Li crystals under X-ray and VUV-radiation at high temperatures is attributed to the recombination assembly of electron–hole pairs near lithium ions.

The mechanism of increasing the light yield of KCl, RbCl and CsCl is discussed with the aim of developing the basis for scintillation detectors whose operation is based on the recombination assembly of electron–hole pairs in the field of light cation (Li, Na).

1. K. Shunkeyev, A. Kenzhebayaeva, Sh. Sagimbayeva, Y. Zorenko, “Luminescence of CsI:Na crystal scintillator under synchrotron radiation excitation,” *Journal of Luminescence*, **284**, 121308 (2025).

2. K. Shunkeyev, A. Kenzhebayaeva, A. Krasnikov, V. Nagirnyi, Sh. Sagimbayeva, D. Sergeyev, A. Tilep, Zh. Ubaev, A. Lushchik, “Luminescence of bound excitons created near sodium impurity ions in KCl: Na single crystals,” *Optical Materials: X*, **25**, 100395 (2025).

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