Project name, IRN	AP26100001 - Study of the physical principles of obtaining scintillation crystals with specified physical, chemical and luminescent properties based on alkali halide and oxide compounds doped with isoelectronic impurities.
Completion date	02.09.2025-31.12.2027
Project supervisor	Shynar Sagimbayeva, c.ph.-m.s., associated professor
Report	***The aim of the project*** is to create exciton-like formations (ELF) in the field of isoelectronic impurities to generate luminescent centers with high quantum yield in matrices of alkali halide compounds (AHC) doped with sodium ions and oxide compounds (OC) doped with scandium, lanthanum, and yttrium ions. ***The project will develop a fundamental physical platform*** that will enable the growth of: (i) potassium and rubidium chloride single crystals, doped with Na ions over a wide concentration range, from solution in an inert gas atmosphere (or in a vacuum); (ii) single-crystal garnet films $A_3B_5O_{12}$ (A=Y, Lu, La; B=Al, Ga), doped with $R^{3+}=Sc^{3+}$, La^{3+}, Lu^{3+}, Y^{3+} over a wide range of activator concentrations, from melt (crystals) and by liquid-phase epitaxy (films). ***The novelty and distinguishing feature*** of this project is the growth of AHC and OC single crystals doped with isoelectronic impurities, which exhibit a high efficiency of high-temperature recombination assembly of electron-hole pairs with maximal radiative relaxation (luminescence) yield, which is essential for identifying potential scintillation crystals. A fundamentally ***new*** approach to converting the energy of ionizing particles into light (unlike the classical exciton mechanism) is proposed, which involves an increased probability of recombination assembly of electron excitations in the field of isoelectronic ions (Na), due to the high mobility of unrelaxed holes, leading to enhanced scintillation in AHC and OC. This project also enables an ***interdisciplinary*** approach to the research topic, combining condensed matter physics, nuclear physics, materials science, crystallography, inorganic chemistry related to crystal growth, as well as experimental instrumentation that requires modern technological innovations for light signal detection. The implementation of this project aligns with the State Program for the Development of Education and Science of the Republic of Kazakhstan for 2020–2025 (№988 dated 27.12.2019), the "Kazakhstan-2050" Strategy (2012), and the President's Address (16.06.2022). The President's Address of September 2, 2024, is particularly significant, emphasizing the importance of constructing a nuclear power plant as part of Kazakhstan's strategic development plan. The results of the national referendum held on October 6, 2024, confirmed the soundness of Kazakhstan's development strategy, moving toward high-tech and stable energy production. In light of this, the development of fundamental physical science related to nuclear energy, detection of ionizing radiation in the nuclear industry using scintillation and thermoluminescent

	dosimeters for environmental radiation safety monitoring, as well as the training of highly qualified scientific personnel, is of paramount importance.
Purpose	The aim of the project is to create exciton-like formations (ELF) in the field of isoelectronic impurities to generate luminescent centers with high quantum yield in matrices of alkali halide compounds (AHC) doped with sodium ions and oxide compounds (OC) doped with scandium, lanthanum, and yttrium ions.
Expected results	1. Based on comprehensive studies of XRL, CL, PL, TL, and OSL spectra and their temperature dependences, a selection of crystalline matrices within AHC and OC crystalline matrices where radiative recombination of ELF, facilitated by isoelectronic impurities, is most efficient will be identified. This process will select matrices that yield high scintillation output. 2. Single crystals of potassium and rubidium chlorides, both undoped and doped with varying concentrations of sodium ions, will be grown from solution. Subsequently, the luminescent characteristics of these crystals, particularly their light yield under excitation by various types of ionizing radiation, will be investigated to understand their scintillation properties. 3. Samples of garnet crystals and monocrystalline garnet films, doped with the specified isoelectronic impurities, will be grown from both melt and solution-melt, respectively, with studies following to investigate the formation of luminescent centers induced by these impurities. These studies will further consider variations in growth method, growth temperature, and the composition of the ambient gas to understand optimal conditions. 4. Foundational principles regarding the formation of luminescent centers by isoelectronic impurities in AHC and OC matrices will be established, depending on the crystallographic position of the impurity, differences in ionic radii, atomic masses, the structure of the ionic core, and outer electron shells. Based on this, the selection of matrix types (AHC, OC) and isoelectronic impurities with the highest light yield efficiency will be justified.
Research group	<u>*Supervisor:*</u> Shynar Sagimbayeva, physics-informatics, c.ph.-m.s., associated professor, h-index: 9 (Researcher ID ABC-4687-2021; ORCID 0000-0002-1234-3030; Scopus Author ID 6602130267) https://www.scopus.com/authid/detail.uri?authorId=6602130267 Kuanyshbek Shunkeyev, physics d.ph.-m.s., professor, h-index: 14 (Researcher ID O-8849-2017; ORCID 0000-0002-3860-397X; Scopus Author ID 57211063006). https://www.scopus.com/authid/detail.uri?authorId=57211063006 Yuriy Zorenko, dr.hab., professor, h-index: 36 (Researcher ID AAH-3046-2020; ORCID 0000- 0001-6641-3172; Scopus Author ID 6701307998) https://www.scopus.com/authid/detail.uri?authorId=6701307998 Daulet Sergeyev, c.ph.-m.s., professor, h-index: 12 (Researcher ID O-3783-2017; ORCID 0000-0001-7426-3039; Scopus Author ID 55237792800). https://www.scopus.com/authid/detail.uri?authorId=55237792800

	Ainur Duisenova, PhD, h-index: 2 (Researcher ID CNL-5127-2022: ORCID 0000-0003-4868-1944; Scopus Author ID 57221375049) https://www.scopus.com/authid/detail.uri?authorId=57221375049 Adelya Kenzhebayeva, master, h-index: 1 (Researcher ID DAI-0449-2022; ORCID 0000-0002-0214-9517; Scopus Author ID 57358022800) https://www.scopus.com/authid/detail.uri?authorId=59249718200 Assel Istlyaup, master, h-index: 2 (Researcher ID GDL-1881-2022; ORCID 0000-0003-3423-5126; Scopus Author ID 57211115630). https://www.scopus.com/authid/detail.uri?authorId=57211115630 Sholpan Krambayeva, Laboratory assistant, Scientific center "Radiation Physics of Materials"
List of published works	1. K. Shunkeyev, A. Kenzhebayeva, Sh. Sagimbayeva, Y. Syrotych, Yu. Zorenko. **Journal of Luminescence, 2025**, Vol. 281, 213208. https://doi.org/10.1016/j.jlumin.2025.213208 *Web of Science – **Q1.** Scopus – **83 %.*** 2. K. Shunkeyev, Sh. Sagimbayeva, A. Kenzhebayeva, D. Sergeyev. **Journal of Optics, 2025**, Vol. 29 (7), 104864. https://doi.org/10.1088/2040-8986/ad8404 *Web of Science – **Q2.** Scopus – **57 %.*** 3. K. Shunkeyev, Sh. Sagimbayeva, A. Kenzhebayeva, Yu. Zorenko. **Eurasian Journal of Physics and Functional Materials, 2025**, Vol. 9 (2), pp. 32–42. https://doi.org/10.29317/ejpfm.2025.9.2.1240 *Scopus – **38 %.*** 4. Sh. Sagimbayeva, A. Kenzhebayeva, A. Istlyaup, K. Shunkeyev. **Eurasian Journal of Physics and Functional Materials, 2025**, Vol. 9 (3), pp. 224–234. https://doi.org/10.69912/2616-8537.1257 *Scopus – **38 %.***