Inorganic materials containing the Cr^{3+} dopant, exhibiting efficient luminescence, have found application in optoelectronics as laser materials, temperature and pressure sensors, and as red phosphors in light-emitting diodes LEDs.

Recently, Cr^{3+} activated phosphors, characterized by efficient broadband emission in the near-infrared (i.e., radiation invisible to the human eye), have become a worldwide hotspot. This type of radiation can penetrate the skin to a certain depth, making it possible use in medical diagnostics. One of the main applications of near-infrared phosphors is the marking and imaging of substances introduced into the living body, using the persistent luminescence phenomena, i.e., luminescence, which can last up to several hours after excitation. Another important application of Cr^{3+}-activated materials is in miniature near-infrared LED sources that can be used to analyze the food freshness, quality, and composition. The near-infrared Cr^{3+} activated phosphors also found application in optical thermometry. It is a non-invasive method that can be used to determine the temperature inside living bodies.

An in-depth understanding of the physical properties of luminescent materials makes it possible to predict their characteristics and thus gives the ability to design materials with appropriate luminescent properties, which is desirable from the point of view of commercial applications. In the context of future applications, it is important to understand the radiative (light emission) processes and the competing non-radiative processes responsible for reducing luminescence efficiency. While the radiative processes in Cr^{3+} doped materials are well known, the non-radiative processes still need a satisfactory explanation.

The luminescence of atoms or ions is related to the transitions of their electrons between different energy levels, where the energy difference between these levels is emitted as light (radiative process). However, the electron may find another non-radiative path to relax to the ground state (the lowest energy state), and the energy can be converted into heat. In this case, the luminescence will be significantly diminished. The non-radiative transitions can occur directly between the Cr^{3+} or by thermally induced promotion of electrons from the dopant into the conduction band (autoionization). Then electrons can be captured by non-radiative relaxation centers, for example, defects in the crystal structure. Notably, the ionized free electrons in the conduction band can be detected by measuring photoconductivity, i.e., electric current resulting from the illumination of the material.

The project's aim is to investigate and explain the processes responsible for the temperature quenching of luminescence in materials doped with Cr^{3+} ions. Experimental methods utilized in the project include: measurement of the temperature dependence of emission spectra (wavelength dependence of luminescence intensity) and temperature dependence of photoconductivity (wavelength dependence of current intensity). The conclusions obtained thanks to the research will allow determining the mechanism responsible for the processes of non-radiation quenching of luminescence in the Cr^{3+} ion. Another goal will be to generalize the obtained results to materials doped with ions of other elements.

Apart from the methods mentioned above, the unique technique used in the project is measurements of optical properties at high pressures generated in diamond anvils cells (DACs). In DAC, pressures up to 300,000 times greater than atmospheric pressure can be obtained. Although solids are considered incompressible, the pressure generated in the high-pressure chambers is sufficient to reduce the distances between atoms in solids. Such high pressure influences the surroundings of the luminescence ion, so the physical properties of the material may change, revealing some of its properties that are not revealed by standard measurement techniques under normal conditions. These high-pressure studies will allow us to understand the phenomena occurring in the material.