DESCRIPTION FOR THE GENERAL PUBLIC

Functional materials based on trivalent lanthanide ions arouse broad scientific interest thanks to their **luminescent and magnetic properties**. The ability of the material to exhibit luminescence, defined as light emission caused by external stimuli (irradiation by other light, chemical reaction, electric current, etc.), was fruitfully explored among lanthanide-based materials. This is related to the characteristic photoluminescent properties of lanthanide ions, for instance, upon UV light irradiation Eu^{3+} ions exhibit red emission, Tb^{3+} ions show green emission, while Yb^{3+} ions reveal emission in the near-infrared (NIR) range. The emission of lanthanide ions can be enhanced by their bonding to organic or inorganic molecules that can absorb light and transfer the energy to the lanthanide center. Some time ago other luminescent phenomena were discovered in lanthanide-based materials, such as up-conversion luminescence which is a two-photon process enabling the conversion of the NIR into visible light. All these effects opened the application horizon for luminescent lanthanide-based materials in display devices, light-emitting diodes, optical communication, bioimaging, and energy conversion. Recently, photoluminescent materials based on lanthanide-containing molecules, so-called **molecular materials**, gained considerable attention as they can be designed at the molecular level, being also sensitive to external stimuli. This was utilized for applications in **luminescent molecular thermometers** offering contactless temperature sensing at the nanoscale in electronic devices, medical diagnostic tools, or chemical reactors, as well as in **chemical sensors** exploring optical sensitivity to chemical stimuli, such as solvent vapors or gases, which are attractive for analytical and biomedical tools.

Molecular materials based on **lanthanide ions** are also investigated due to the attractive magnetic properties. When embedded in the specific molecular environment, the lanthanide ion can exhibit such strong magnetic anisotropy that it behaves as an independent tiny magnet. Below blocking temperature, the resulting **single-molecule magnet** (SMM) shows extremely slow relaxation of magnetization giving rise to the magnetic hysteresis, similar to observed in permanent magnets. Due to the memory effect at the molecular level, SMMs are great candidates for high-density data storage. Very recently, the new concept of further functionalization of SMM-based materials appeared, which was realized by constructing luminescent molecular nanomagnets. Lanthanide ions are the best choice for such **multifunctional molecular materials**.

In this regard, the project goal is to design, synthesize, and characterize **novel luminescent lanthanide-based molecular nanomagnets** combining strong magnetic anisotropy and attractive photoluminescence phenomena with **high sensitivity to chemical stimuli and temperature**. We plan to achieve such multifunctional materials by the **molecular-level functionalization of lanthanide ions realized by linking cyanido metalloligands** (see Scheme below). We will employ a diverse set of transition metal complexes involving cyanide ions (CN^-). Starting from classical hexa- and tetracyanidometallates, we will use the special type of complexes built of metal ions surrounded by cyanido ligands and additional non-innocent organic ligands. We plan to obtain novel coordination systems in the form of crystalline materials that will exhibit a pronounced SMM effect and a variety of photoluminescence effects, from sensitized visible-to-near-infrared emission to up-conversion luminescence and quantum cutting effects. These optical effects will be designed to induce high sensitivity to temperature and chemical stimuli related to solvent vapor sorption properties. We will show the **extraordinary level of multifunctionality** achieving the unprecedented families of **luminescent molecular thermometers and chemical sensors based on lanthanide molecular nanomagnets**. The project will result in a novel class of functional materials that may exhibit unique physical effects arising from the conjunction of optical and magnetic functionalities. We will contribute to the increase of the general knowledge on the interaction between light and matter with the impact of magnetic properties and external stimuli. The project will give efficient synthetic pathways towards the new generation of opto-magnetic stimuli-responsive molecular materials for multiple applications in magnetic, optical, and electronic devices, as well as high-performance sensors.