The primary objective of the project is to obtain and study a new class of nanomaterials, luminescent in the near-infrared region, that combine two phenomena: (1) so-called persistent luminescence, originating from pre-irradiation of the material and occurring upon thermal and/or optical stimulation, and (2) quantum-cutting – light emission of two photons in a place of one excitation photon.

The phenomenon of persistent luminescence (often referred to as delayed and long-lasting luminescence or, confusingly, simply phosphorescence) is controlled by the slow, release of trapped charge carriers induced by thermal deexcitation, which leads to population of the excited states of the luminescent dopants. The resulting emission from the dopants is usually in the visible or near-infrared light range. Depending on the type of host material, the dopants, the method of excitation, the use (or not) of photostimulation and the temperature changes, it can last from a few minutes to several hours after removal of the excitation source. In such materials, with the combined persistent luminescence and quantum-cutting, the quantum efficiency thus could theoretically reach even 200%, while in classical phosphors exhibiting persistent luminescence it is well below 100%.

This high efficiency in combination with possibility of producing photons in the near infrared range (in the biological window where most of the biological substances are transparent) is a promising approach to improve the performance of optical bio-imaging. Such materials must, of course, be tested for their biocompatibility and be surface-modified with the appropriate specific substances to achieve adequate selectivity in the chosen biological environment. The luminescent probes proposed in the project will allow working in the biological window, thus enabling deep tissue imaging, reducing phototoxicity and increasing contrast by circumventing autofluorescence, which is one of the main problems in analyzing specific emission signals from luminescent probes in the biological environment. Nanomaterials obtained in this project with such promising luminescent properties, are highly desirable for future applications not only in biotechnology, but also potentially in other fields, such as security, for authenticating valuable objects or as luminescent solar concentrators in photovoltaic cells.