The history of solid state science shows a number of critical moments usually closely related to new material discoveries and significant progress of the technology of the electronic devices. An example of such a turning point took place two decades ago with the identification of atomically thin (two-dimensional) crystals and discovery of easy fabrication techniques by means of mechanical exfoliation. The first member of the 2D materials family was graphene, shortly followed by semiconductor compounds such as transition metal dichalcogenides (TMDs). Despite great hopes and huge efforts devoted to progress with those new materials, the mainstream electronics remains dominated by silicon. However, even if mass products will be based on silicon for the decades to come, there are important niche applications in which new materials could emerge. One of them are optoelectronic devices profiting from such extraordinary properties as robust room-temperature photoluminescence.

Several years of intensive studies resulted in deep understanding of basic physical properties of several monolayer TMD materials such as MoS_2or WSe_2. Advancements in fabrication technology allowed for obtaining very complex structures containing several different and precisely aligned monolayers. However, even the simplest structures still hide some secrets. One of them is the reason for relatively low efficiency of photoluminescence. Even the best quality structures at the best experimental conditions (*e.g.* at cryogenic temperatures) rarely exceed 50% quantum efficiency.

The goal of the proposed project is to reveal the mechanisms limiting the photoluminescence efficiency. We propose a thorough study of the relaxation of the optical excitation just after short pulse of light. We will develop experimental tools necessary to record and analyze the optical properties (reflectivity and photoluminescence) of TMD materials with temporal resolution below 50 fs, which is million times shorter than the duration of the typical lightening. Application of such unique tools will shed light on the details of the mechanisms governing energetic relaxation of photo-created carriers (electrons and holes), their thermalisation and radiative recombination competing with different non-radiative processes. We expect that the gained knowledge will have significant impact on the further development of advanced optoelectronic devices.