The increasing energetic demand of a society where a continuous population and industrialization growth occurs questions the current energy chain supply model, which heavily relies on non-renewable fossil fuels. One of the most prominent sources of renewable energy is solar energy, which can directly be converted to electricity in photovoltaic devices. This technology is currently dominated by traditional semiconductor materials, such as crystalline silicon (Si) or gallium arsenide (GaAs). While Si solar cells have reached conversion efficiencies as high as 20% only after several decades of research efforts, the huge fabrication costs, related mostly to the high cost of the semiconductor material, hamper significantly its widespread diffusion and, in a long-term vision, the replacement of the current non-renewable based energetic model. In response to this situation, significant research efforts have been undertaken to identify a viable alternative as efficient, cheap and reliable photovoltaic active material to replace Si in solar cell devices. Recently, metal halide perovskites have been proposed as light harvester in solar cells. The unprecedented rate of increase in performance of perovskite solar cells has led to a dramatic increase of the photovoltaic efficiency from $\sim 4\%$ of the first demonstration to a $\sim 25\%$ efficiency demonstrated in the latest reports, reaching the Si solar cell efficiency in only a few years' time. This makes perovskites the most promising material for photovoltaic applications.

However, metal halide perovksites are not only excellent light absorbers but also outstanding light emitters. In particular atomically thin nanocrystals, referred to as nanoplatelets, have been found to be highly efficient light emitters in spectral regions which can be extremely interesting for applications in light emitting devices, such as displays, LEDs and similar, with a minimized energy and carbon footprint – a feature of high importance in view of the increasing awareness of the environmental challenge which we are facing in the coming years. At the moment their excellent emission properties are not sufficiently backed by a deep understanding of the physical mechanisms which governs them. Metal halide perovskites are known to be ionic semiconductors. This means that the atoms which compose the crystal tend to attract electrons with a considerably different strength. This property is currently suspected to be intimately related to many of the outstanding optical properties of metal halide perovskites. The strong motivation that drives our research project is to achieve a deeper understanding of the physical mechanisms that lead to the light emission in metal halide perovskite nanoplatelets. We expect that this will initiate a positive feedback loop, which will ultimately lead to an even further improvement of their optical properties. To reach our goal, we have devised a set of optical spectroscopy experiments to understand the behavior of charge carriers in this materials: how strongly they interact with one another and how strong the interaction with the lattice of the metal halide perovskite is. This aspect, which is unusually prominent in metal halide perovskites, singles them out with respect to more conventional semiconductors. Preliminary studies suggest that the perovskite crystal lattice reacts to the presence of a charge carrier by surrounding it with a polarization cloud. This is conceptually similar to the working principle of soap, which is made of molecules that surround fatty particles, making their dissolution in water possible via a process known as solvation and ultimately enabling the cleaning of cloths or of our body.

Our research will consist in a series of optical experiments at different conditions of excitation levels, temperature and magnetic field to study how the optical properties of these materials are influenced. We will make use of ultrashort laser pulses and monitor the time-dependence of the emission of metal halide perovskite nanoplatelets to reveal how the presence of the solvation effects changes their emission over time. The magnetic fields we will use are among the largest available to experimentalists and will enable us to understand the dynamical behaviour of charge carriers in these materials. These experiments will allow us to evaluate quantitatively the strength of the carrier-carrier correlation and how important the influence of the lattice solvation effect is on the optical properties of metal halide perovskites.