The capability of modifying at will the intrinsic properties of semiconductors with a variety of tuning knobs represents one of the reasons for their successful use in many practical devices. These approaches include alloying (solid state solutions between two different materials), crystal doping (controlled introduction of a very small quantity of impurities in the host lattice of a material), and strain, which indicates the relative displacement of ions with respect to their equilibrium positions in the absence of external mechanical stress. In conventional semiconductors, the amount of strain that can be introduced is generally fixed by the fabrication process. While there has recently been significant progress in the development of methods to apply reconfigurable stresses to these materials, the maximal amount of strain that can be introduced in conventional semiconductors is typically capped at ~1% by their elastic limit.

The application of stresses is a particularly attractive tuning knob for two-dimensional (2D) semiconductors. These materials feature a layered crystal structure, in which atoms are held together by strong in-plane bonds, while the layers are connected only via weak van der Waals interactions. This peculiar crystal structure allows to mechanically cleave bulk crystals to obtain flakes of a few to a few tens of nanometre thickness. Their ultra-small thickness allows for the application of large strains before reaching their fracture point. Moreover, 2D materials have demonstrated an excellent mechanical robustness and flexibility, which allows them to sustain very large deformations. The properties of these materials can therefore be profoundly affected by the application of external stresses. Strain, in particular, induces reversible changes in the materials' vibrational, electronic and optical properties.

Lead halide perovskites are considered an emerging class of semiconductors. These materials have a crystal structure which consists of a three-dimensional network of interconnected lead-halide octahedra. They have been initially investigated for their excellent optoelectronic properties and their outstanding performance as light harvester in photovoltaic devices. However, metal halide perovskites are not only very good light absorbers, but they also very strong light emitters, as demonstrated by their use in light emitting devices such as displays, LEDs, and lasers. One of the drawbacks of lead halide perovskites is their limited stability under atmospheric conditions. By incorporating large organic cations in the crystal structure, it is possible to synthesize samples in which layers of lead halide octahedra are separated by organic spacers. These materials, usually referred to as layered or 2D perovskites, display a very large exciton binding energy and a rich and not fully understood physics. Recently, the synthesis of other layered materials, referred to as silver chalcogenolates, has been demonstrated. These materials are also semiconductor with emission properties in the blue region of the visible spectrum and are characterized by a greatly improved stability as compared with 2D perovskites.

Surprisingly, in spite of their success as materials for energy and lighting applications, strain has not been one of the tuning knobs of choice to control the properties of layered perovskites. Due to the recent synthesis of silver chalcogenolates, experiments in which silver chalcogenolates are strained have not been attempted yet. In this project, we wish to investigate the effect of uniaxial mechanical deformations on the optoelectronic properties of these materials. We propose in particular to induce mechanical deformations and to study how this strain can help us tune controllably the emission energy, the frequency of the vibrational modes, the coupling between lattice and electronic degrees of freedom and finally how exciton transport is affected by strain. To reach these goals, we devised a set of optical spectroscopy experiments to be performed in combination with the use of different devices for the application of external stresses to very thin flakes of layered perovskites. We will study how the optical spectra and the exciton recombination dynamics will be affected by the presence of strain. The results acquired in this project will represent the first demonstration of how the optoelectronic properties of layered perovskites can be controlled at will by making use of mechanical deformations.