Charge density waves in van der Waals materials

Low dimensional van der Waals materials, such as graphene and transition metal dichalcogenides display many interesting properties, among them the **charge density wave (CDW)** is one of the great interests for researchers. A CDW is an ordered quantum fluid of conduction electrons in a linear chain compound or layered crystals accompanied by periodic distortion of the crystal lattice. The electrons within a **CDW form a macroscopic standing wave pattern**. Periodic lattice distortion changes the lattice periodicity which can lower the total energy of the system. The occurring energy of distortion is compensated by reducing the electronic energy. A Fermi level decreases and a new band gap appear. CDW materials show many interesting properties such as nonlinear transport, resulting an application as a memristive phase switching nano-tool. Moreover, it is known that many CDW materials exhibit superconductivity after applying a pressure.

In this project, we plan to study **1D and 2D van der Waals materials**, which are characterized by the CDW phases. For this group belongs, e.g. NbTe4 and Ta2NiSe7 as 1D materials, and the exemplary 2D material is 2H TaSe2. As the crystal lattice distortions are apparent in CDW materials, the Raman scattering (RS) spectroscopy is an excellent technique to probe the lattice parameters evolution. However, due to electron phonon coupling, it is necessary to excite the materials with particular excitation energies to achieve the resonant conditions of RS. RS spectroscopy with linear-polarization resolution will allow us to recognize apparent phonon modes in the RS spectrum. **The innovative aspect of this project is an investigation of the chirality of CDW materials by the resonant RS technique.** We will use circularly polarized light to investigate chirality as proposed in the literature. Moreover, a CDW phase is responsible for changing the thermoelectric properties of a material. By attaching electrical contacts to the sample it is possible to probe the electrical current induced by laser illumination, which can also be spatially mapped on macroscopic scale.

The main experimental technique in this project will be **Raman scattering**, which will be employed to investigate the vibrational properties of the investigated materials **in a wide range of temperature and polarization resolution.** A major part of high-quality crystals will be obtained from our collaborator who is experienced in crystal growth. **Electrical investigation** of the samples examined previously by optical methods will be implemented to examine the electric response induced by thermoelectric effects due to laser illumination.