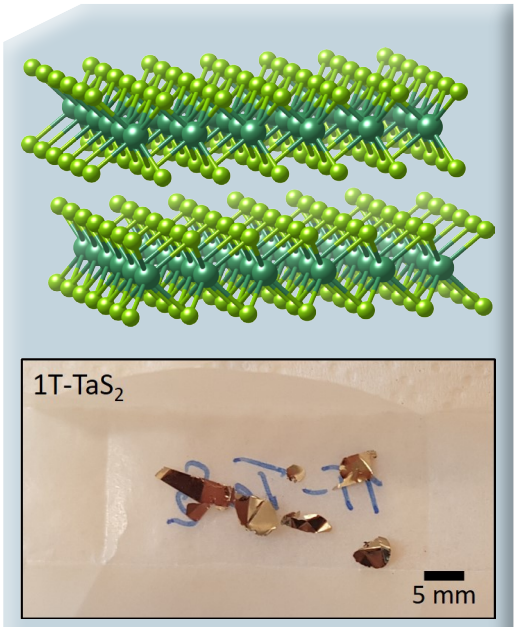
Master's project

Studying phase transitions with helium scattering

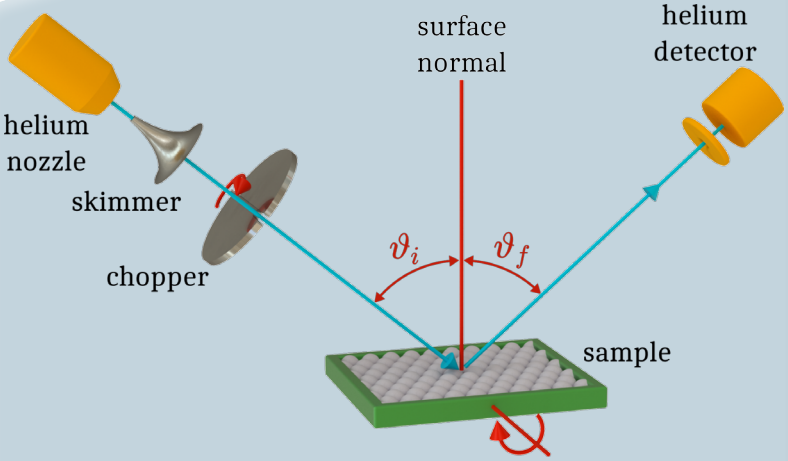
The aim of this project is to study the surface structure of the transition-metal dichalcogenide (TMDC) TaS_2 with helium atom scattering. The 1T polytype of TaS_2 has a particularly rich phase diagram involving several charge-density wave (CDW) transitions driven by strong electronic correlations and electron-phonon coupling upon changes of the surface temperature.

He atom scattering is ideally suited to study these phases since the neutral He beam is directly scattered by the surface electrons. Elastic scattering measurements at different sample temperatures should allow to follow the phase transitions and changes upon the surface structure / charge density with temperature.

Moreover, as recently shown by our group, inelastic He atom scattering can be used to extract information upon the electron-phonon coupling strength – which may further help to draw conclusions about the "driving force" of the phase transitions in 1T-TaS_2.



Drawing of the TaS_2 crystal structure (top panel), showing the layered (2D) arrangement of the atoms and a photo of the grown samples (bottom).



A helium beam is produced in a source chamber, before being scattered from the sample. The scattered beam is monitored with a mass-spectrometer detector. Momentum transfer occurs due to scattering of the He beam from the crystal, at a certain incident angle ϑ_i. Energy resolution is optionally added by chopping the He beam with a chopper and measuring the time-of-flight.

While the research on CDWs in layered TMDCs is more than 40 years old, renewed interest has recently been driven by the experimental accessibility of metallic TMDCs as single layers and the possibility to observe metastable "hidden states".

No final agreement about the electronic ground state of the material or the role of correlations has been reached up to date. It has even been suggested that the existing experimental evidence for 1T-TaS2 is consistent with the ground state being a quantum spin liquid.
The measurements within the course of this master's project should help to elucidate these peculiar effects.

Compensation: € 2640 (for the whole project)

For more information:
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