Valley dependent optics in transition metal dichalcogenides

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Transition metal dichalcogenides (TMDs) are strong contenders to optoelectronic applications. Thanks to spin-valley coupling, it is possible to use circularly polarized laser fields to create populations of excited electrons and holes with well-defined spin. These carrier densities can be tracked by optical measurements, such as time-dependent Kerr amplitude signal. However, such populations do not last long in pristine samples, due to scattering by phonons[1]. Here the energy splitting between the K and Q valleys plays a fundamental role in electron scattering mechanisms at higher temperatures[2,3]. This Q-K energy splitting is highly sensitive to thickness of the TMD sample, and can be changed even by encapsulation. Unfortunately, the changes in thickness of the TMD are hard to track once the device is built.
In this work we present a comprehensive study of the effects of Q-K valley energy splitting in the quenching of the Kerr signal. By setting up different valley alignments and excited configurations, we show how the different levels of density of excited carriers lead to a quenching of the Kerr signal amplitude. We relate these changes to the different levels of spin-orbit induced splitting in the band structure and show how the Kerr amplitude signal can be used to track the changes in layer thickness that are introduced in the TMD layer.

References

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Figures

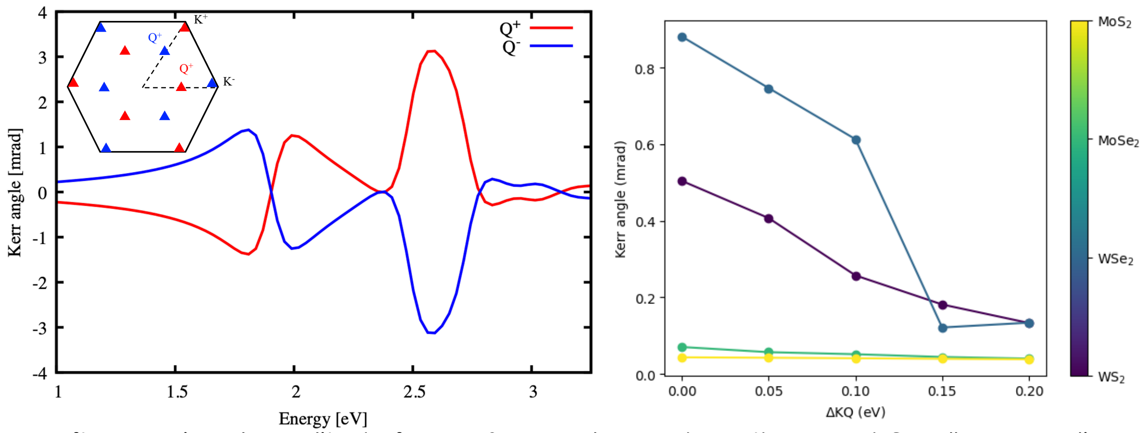

Figure 1: Left – Kerr signal amplitude for a WS_2 monolayer where the K and Q valleys are aligned. The inset marks the regions in the Brillouin zone where excited electrons are placed. Right – change in the Kerr amplitude for the A exciton of each TMD as a function of the energy splitting between the K and Q points.