Magnetooptics of Exciton Rydberg states in Monolayer Semiconductors

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In bulk and quantum-confined semiconductors, optical spectroscopy in high magnetic fields has historically played an essential role in determining the fundamental properties of excitons such as their mass, size, binding energy and spin.
In conventional semiconductors such as GaAs, which have light carrier masses and small exciton binding energies E_B, magnetic fields of order 10T are typically sufficient to achieve the regime where magnetic (cyclotron) energies exceed E_B. In marked contrast, in the family of monolayer semiconductors such as MoS_2 or WSe_2, carrier masses are heavier and E_B is huge (hundreds of meV), requiring much larger magnetic fields of order 100 T to approach a similar regime [1,2].

In this talk, I will review our progress on optical transmission spectroscopy of laterally small (~μm) and atomically thin semiconductors in large magnetic fields to 65 Tesla.

The first part of my talk will show how different dielectric encapsulation directly influences the exciton binding energy in monolayer WSe_2 as observed through the changed diamagnetic shift of the fundamental exciton [3].

In the second part of my talk, I will present high field absorption data from a hBN encapsulated monolayer of WSe_2. We observe the diamagnetic shifts of the 1s – 4s Rydberg states of the neutral exciton [2], which enabled the unambiguous identification of those states, and a quantitative and detailed comparison with leading theoretical models (Keldysh potential) resulted in the first experimental measure of the exciton's reduced mass in a monolayer semiconductor.

[1] A.V. Stier et al., Nature Commun. **7**, 10643 (2016)
[2] A.V. Stier et al., Phys. Rev. Lett **120**, 057405 (2018)
[3] A.V. Stier et al., Nano Lett. **16**, 7054 (2016)