Optical spectroscopy of excited exciton states in MoS_2 monolayers in van der Waals heterostructures

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The optical properties of MoS_2 monolayers are dominated by excitons, but for spectrally broad optical transitions in monolayers exfoliated directly onto SiO_2 substrates detailed information on excited exciton states is inaccessible.

Encapsulation in hexagonal boron nitride (hBN) allows approaching the homogenous exciton linewidth [1,2], but interferences in the van der Waals heterostructures make direct comparison between transitions in optical spectra with different oscillator strength more challenging. We have performed reflectivity and photoluminescence excitation experiments which reveal the presence of excited states of the A exciton in MoS_2 monolayers encapsulated in hBN layers of calibrated thickness, allowing us to extrapolate an exciton binding energy of ≈220 meV [3].

We theoretically reproduce the energy separations and oscillator strengths measured in reflectivity by combining the exciton resonances calculated for a screened two-dimensional Coulomb potential with transfer matrix calculations of the reflectivity for the van der Waals structure.

Our analysis shows a very different evolution of the exciton oscillator strength with principal quantum number for the screened Coulomb potential as compared to the ideal two-dimensional hydrogen model.

[1] F. Cadiz et al, Physical Review X **7**, 021026 (2017).
[2] E. Courtade, Physical Review B **96**, 085302 (2017)
[3] C. Robert *et al*, Phys. Rev. Mat. **2**, 011001(R) (2018)

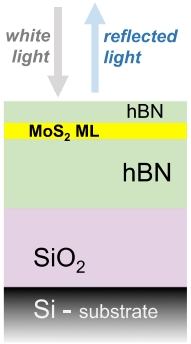

Figure 1 : Schematic of the investigated Van der Waals heterostructure