Upconverted electroluminescence in van der Waals heterostructures

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In this work we present optoelectronic measurements of electrically-driven light emitting vdW heterostructures based on MoS_2 and WSe_2. These structures allowed us to unveil the electroluminescence signal of K-K MoS_2/WSe_2 interlayer excitons (IX), for which the electron is located in MoS_2 and the hole in WSe_2. Surprisingly, an emission at energies of around 1.9 eV can be observed at bias voltages as low as 1.3 V (Fig.1a). Normally, one would expect that the applied voltage roughly corresponds to the energy of the emitted photons. The difference of about 0.6 eV constitutes hence a remarkable energetic upconversion. This effect was explained with an excitonic Auger effect (Fig.1b). In this picture one interlayer exciton (which is indirect in real and momentum space) recombines non-radiatively and transfers the energy and momentum to another interlayer exciton that can then give rise to the characteristic observed intralayer emission of MoS_2 and WSe_2 [1].

The findings of this work are of crucial importance for future light emitting device engineering as well as for attempts towards the observation of fundamental phenomena like superfluidity or Bose-Einstein condensation of interlayer excitons in van der Waals heterostructures.

References

[1] J. Binder et al., Nature Communications, 10:2335 (2019)

Figures

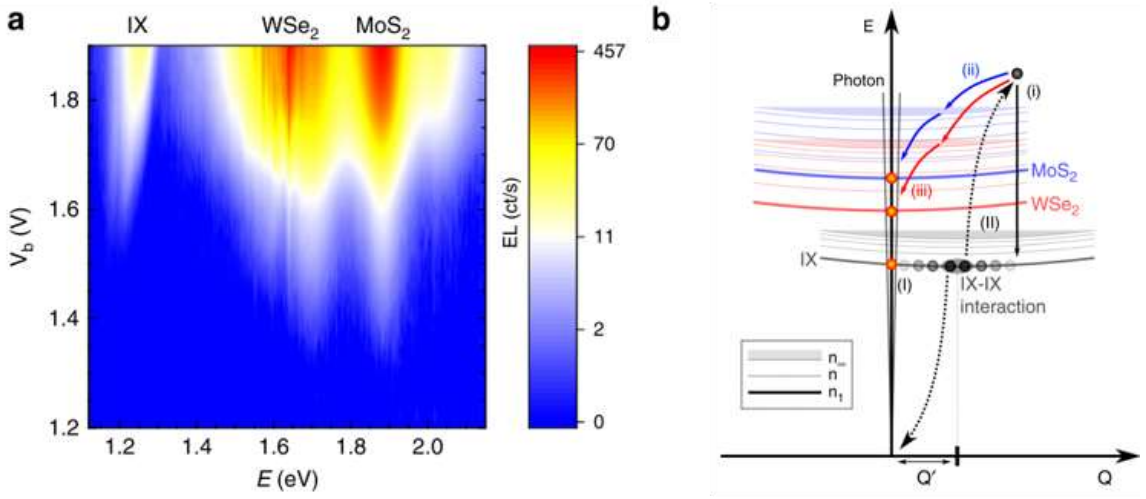

Figure 1: (a)False colour plot of the EL spectra as a function of bias voltage. (b) Mechanism of upconverted emission [1].