Ultrastrong magnetic field-tunable excitonic transitions in a 2D magnet

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The discovery of 2D layered materials paved the way for investigating new quantum phenomena emerging from lower dimensions. The first exfoliation of these materials gave rise to the concept of “nano-lego”, with a number of classes of 2D materials to be combined into heterostructures. In particular, in recent years, there has been a considerable focus on such a special class exhibiting a magnetic ordering.

One prominent material in this class of 2D magnetic semiconductors is CrSBr. In recent years, it has gained popularity for its quasi-1D excitons in the infrared energy range ([3]) with remarkable magnetic tunability. With an external magnetic field, the magnetic structure in the material can be tuned from a-type AFM to FM, which affects the exciton’s interlayer delocalization and, thus, induces a quadratic energy shift in the external magnetic field ([2]). However, a range of different excitons in a higher energy range, which were expected by theory ([3]), remained largely unexplored.

In our work, we present the most prominent transitions expected by theory and examine their exceptional properties in the magnetic field[1]. While the two infrared excitons are susceptible to a total energy redshift of around 20 meV in the magnetic fields up to 2 T, transitions in the higher energies provide an order-of-magnitude higher tunability, reaching remarkable 85-110 meV shifts (Fig. a). Striking qualitative differences are apparent in the higher-energy range there is a state that is polarized orthogonally and experiences a blueshift. Interestingly, a coupling-like energy dependence can be observed between pairs of orthogonally polarized excitons (Fig. b).

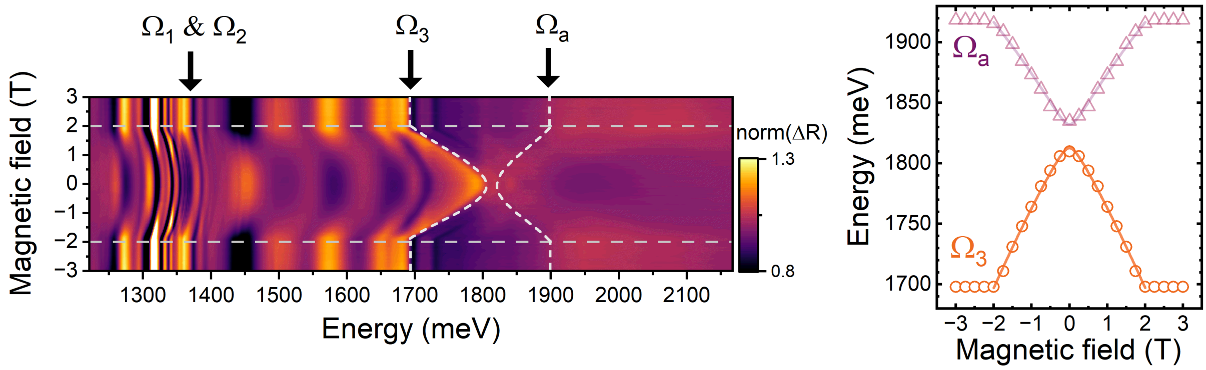

Figure 1: a) Contour-plot of differential magneto-reflectance normalized along magnetic fields in range [-2 T, 2 T] vs magnetic field (y-axis) and energy (x-axis). Most prominent transitions were marked with arrows around their energy in ±3 T. b) Approximate exciton energy of Ω_3 and Ω_a (a-polarized transition), showing opposite sign of energy shifts in magnetic field and magnetic-field-mediated coupling-like dependence.

References

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