Excitonic Linewidth Approaching the Homogeneous Limit in MoS_2 based Van der Waals Heterostructures

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Transition metal dichalcogenides such as MoS_2 and WSe_2 are layered materials that are semiconductors with a direct bandgap when thinned down to one monolayer (ML). The strong light matter interaction and the valley selective optical selection rules make these monolayers an exciting 2D material for fundamental physics and optoelectronics applications. But so far optical transition linewidths even at low temperature are typically as large as a few tens of meV and contain large inhomogeneous contributions [1].
In this work we show that encapsulation of ML MoS_2 in hexagonal boron nitride can efficiently suppress the inhomogeneous contribution to the exciton linewidth, as we measure in photoluminescence and reflectivity a FWHM down to 2 meV at T = 4 K [2]. Similar results are obtained with encapsulated $MoSe_2$, WSe_2 and WS_2 monolayers [3,4]. This indicates that surface protection and substrate flatness are key ingredients for obtaining stable, high quality samples. These encapsulated monolayerss allow accessing the optical and spin properties of these materials with unprecedented detail for neutral and charged excitons (trions).
Among the new possibilities offered by the well-defined optical transitions we evidence the optical selection rules for in-plane propagation of light. These studies yield a direct determination of the bright-dark exciton splitting, for which we measure 40 meV and 55 meV for WSe_2 and WS_2 monolayer, respectively [5]. The dark exciton fine structure is also revealed [6]. We also uncover new information on spin and valley physics and present the rotation of valley coherence in applied magnetic fields perpendicular to the ML [7].

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