Breakdown of dipolar blueshift at low-temperatures indicating quantum correlations in exciton ensembles in WSe_2-$MoSe_2$ hetero-bilayer

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Atomistic van der Waals hetero-bilayers are ideal systems to study the (quantum-) phase diagram of excitons including Bose-Einstein condensation due to large exciton binding energies, an interfacial dipole moment, an in-plane optical dipole and long lifetimes [1-3]. Light emission and electron energy-loss spectroscopy showed first evidence of excitonic many-body states in such two-dimensional materials [4,5]. Pure optical studies, the most obvious way to access the phase diagram of photogenerated excitons have been elusive. We observe several criticalities in photogenerated exciton ensembles hosted in $MoSe_2$–WSe_2 hetero-bilayers with respect to photoluminescence intensity, linewidth, and temporal coherence pointing towards the transition to a coherent many-body quantum state, consistent with the predicted critical degeneracy temperature [6]. Most intriguing, the density dependent dipolar blueshift breaks down at millikelvin temperatures over at least 5 orders of magnitude of the excitation fluence indicating transition to a quantum liquid phase [7]. For this state, the estimated occupation is approximately 100%. The phenomena stay robust till above 10 Kelvin [6,7].

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References

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Figures

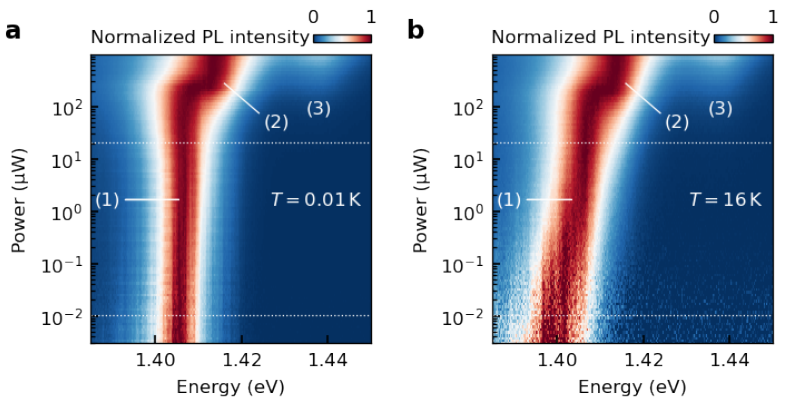

Figure 1: Excitation power dependent photoluminescence (PL) of interlayer excitons (IX) of a $MoSe_2$-$WeSe_2$ hetero bilayer. (a) IX PL obtained under continuous wave (cw) excitation at 1.704 eV as a function of excitation power at 10 mK displaying the breakdown of exciton blue sift of peak (1). (b) IX PL as in (a) for T = 16 K clearly showing a significant dipolar shift for peak (1).