MAR15-2014-001979

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

**Optoelectronics of Transition Metal Dichalcogenide Monolayers and Heterostructures**

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Monolayer transition metal dichalcogenides (TMDs) contain 2D valley excitons which reside in two degenerate momentum space valleys at the edges of the Brillouin zone. It is crucially important to understand fundamental 2D exciton properties in TMD monolayers and van der Waals heterostructures. By performing coherent nonlinear optical spectroscopy with high spectral resolution, we observe nanosecond decay dynamics in single monolayers of $MoSe_2$, implying the presence of a previously unreported long-lived state that appears to trap the exciton population. In $MoSe_2$-$WSe_2$ vertical heterostructures, we observe intralayer excitons, where the electron and hole are confined to different monolayers, and show evidence of strong exciton-exciton interaction effects and long lifetimes. Based on TMD monolayer excitons, we have also investigated a variety of fundamental quantum devices, including a nano-cavity laser and a second-harmonic generation transistor. Finally, we report a new type of single quantum emitter, based on single localized excitons spatially confined to defects in monolayers of $WSe_2$. The photoluminescence from these localized excitons is spectrally narrow and shows strong anti-bunching, demonstrating the single photon nature of the emission.