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TÉMA

Low dimensionality effects in single layers of transition metal dichalcogenides

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Transition metal dichalcogenides (TMDs) are subject to effects of reduced dimensionality when thinned down from bulk to the single-layer limit, which may impact their fundamental properties and overall response. In this talk I will illustrate the influence of such effects on the electronic and optoelectronic properties of MBE-grown 2D TMD semiconductors and metals. I will first discuss the direct experimental observation of extraordinarily high exciton binding energy and band structure renormalization in a single layer of semiconducting TMD [1] due to reduced screening by using a combination of STS and photoluminescence spectroscopy. We have also studied the role of interlayer coupling and layer dependent carrier screening on the electronic structure of few layer $MoSe_2$ [2]. We find that the electronic quasiparticle bandgap decreases by nearly 1 eV when going from one layer to three. Finally, I will describe the fate of the collective electronic phases, i.e. charge density wave order and superconductivity, of $NbSe_2$ in the single layer limit [3]. We demonstrate that - in striking contrast to recent theoretical predictions - 3 x 3 CDW order remains intact in 2D. Superconductivity also still remains but its onset temperature is depressed to 1.9 K. Our STS measurements at 5 K reveal a CDW gap of $\Delta = 4$ meV at the Fermi energy, which is accessible via STS due to the removal of bands crossing the Fermi level in the 2D limit. These findings enable to experimentally rule out two well-known mechanisms proposed to explain the origin of the CDW in $NbSe_2$, and our results impose stringent constraints on any future theory of CDW formation in $NbSe_2$.

References:

[1] M. M. Ugeda, et al., Nature Materials 13, 1091 (2014).
[2] A. J. Bradley, M. M. Ugeda, et al., Nano Letters 15, 2594 (2015).
[3] M. M. Ugeda, et al., Nature Physics 12, 92 (2016).

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