

Poster-1-28

Tuning a CDW Phase Through Intrinsic Doping in Bulk ZrSe₂

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Using low-temperature scanning tunnelling microscopy and spectroscopy (STM/STS), we investigated bulk ZrSe₂, a layered transition metal dichalcogenide (TMD). We show that intrinsic impurities dope the system and shift the Fermi level into the conduction band, causing a semiconductor-to-metal transition accompanied by the appearance of charge density wave (CDW) phases. The CDW phase is a collective phenomenon in which the electrons in a material arrange themselves in a periodic pattern, leading to a modulation in the charge density. Due to the local nature of the doping impurities, we successfully correlate the presence of impurities with shifts in the Fermi level and finite CDW modulation amplitudes, highlighting the tunability of correlated electronic phases through doping in TMDs. Furthermore, due to the nature of the electronic bands and their crossing with the Fermi level, our investigation also highlights the k-dependence of STM, inciting increased attention to systems with similar electronic structures.