Revealing Fingerprints of a Charge Density Wave in 2H-$NbSe_2$ via Ultrafast Broadband Optical Spectroscopy

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The family of quasi-2D transition metal dichalcogenides has received renewed interest recently, since these materials can play host to various complex and coexisting collective electronic phenomena. Pertaining to this intriguing class of materials, 2H-$NbSe_2$ undergoes a charge density wave (CDW) transition at T_{CDW} = 33 K and a superconducting transition at T_{SC} = 7 K, below which temperature the two orders coexist [1]. The similar energy scales of these two collective orders makes 2H-$NbSe_2$ an ideal compound in which to employ an out-of-equilibrium approach to reveal the relationship between such exotic phases of matter.

The CDW phase transition is believed to be driven by momentum-dependent electron-phonon coupling [2] and has been shown to persist down to the monolayer limit [3]. An increased understanding of this phase is desirable due to the unusual co-existence of CDW order and superconductivity in $NbSe_2$. Below T_{SC}, the CDW soft phonon mode couples to the spectroscopically '*dark*' superconducting collective excitation, referred to as a Higgs mode, and hence may provide insight to otherwise inaccessible physics [4].

Time-resolved spectroscopies are an important tool for unveiling the properties of collective electronic phenomena, due to their ability to photo-induce transient non-thermal phases. We present time-resolved optical spectroscopic measurements of 2H-$NbSe_2$ around the CDW critical temperature, performed with a ~50 *f*s broadband (400-1400 nm) probe beam. First, the spectral fingerprint of the CDW phase and its associated dynamics are revealed, characterising the manner in which these signals evolve as the sample temperature is varied across T_{CDW} and the phase transition is induced thermally. Secondly, the CDW-to-normal state phase transition was photo-induced, following a non-thermal pathway, by melting the CDW order with a stronger perturbation level. Our results provide new insights regarding CDW order in this prototypical dichalcogenide material.

References

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