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Ultrafast dynamics of structural and orbital order in TiSe2

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Charge density waves (CDWs) comprise a class of collective phenomena that find their roots in the interplay of (i) a materials electron density and (ii) its underlying atomic lattice. In the prominent reference system TiSe¬2, numerous experimental and theoretical studies have looked at the emergence of the CDW phase –yet until today the microscopic mechanisms remain elusive.[1,2] Based on our previous research [3], we performed ultrafast resonant X-Ray diffraction experiments at the Se K edge, tracking the structural and orbital order of TiSe2 after optical excitation. We observe similar transient dynamics of structural and orbital response, yet the dependency on pump fluence appears remarkably different. Furthermore, we find a strong oscillatory lattice deformation in the high fluence regime –likely the result of a coherently driven L1 phonon mode. Current efforts are directed towards theoretical considerations and calculations, which will put the experimental findings into context with existing hypotheses. Here, we hope that our findings will help to understand if (i) electron-phonon interactions or (ii) exciton correlations are the main driving mechanism for the formation of the CDW in TiSe2.

[1] M.Porer, U.Leierseder, et al.; Non-thermal separation of electronic and structural orders in a persisting charge density wave. Nature Materials 13, 857-861 (2014).
https://doi.org/10.1038/nmat4042
[2] E.Möhr-Vorobeva, S.L.Johnson, et al.; Nonthermal Melting of a Charge Density Wave in TiSe2. Physical Review Letters 107, 036403 (2011).
http://doi.org/10.1103/PhysRevLett.107.036403
[3] P.Beaud, A.Caviezel, et al.; A time-dependent order parameter for ultrafast photoinduced phase transitions. Nature Materials 13, 923-927 (2014).
https://doi.org/10.1038/nmat4046

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