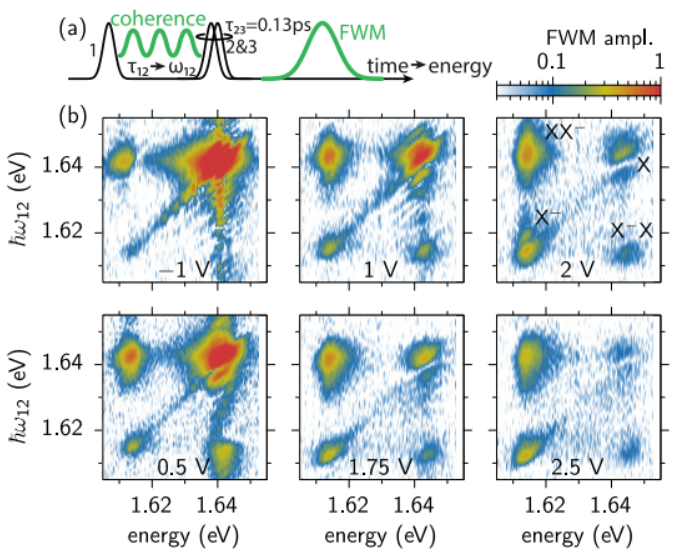
Controlled coherent-coupling and dynamics of exciton complexes in a $MoSe_2$ monolayer

A. Rodek[1] J. Howarth[2] , T. Hahn[3], T. Taniguchi[4], K. Watanabe[5], M. Potemski[1,6,7], P. Kossacki[1], D. Wigger[8] and J. Kasprzak[1,9,10]

[1] *Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warszawa, Poland*
[2] *National Graphene Institute, University of Manchester, Booth St E, M13 9PL UK*
[3] *Institute of Solid State Theory, University of Münster, 48149 Münster, Germany*
[4] *International Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*
[5] *Research Center for Functional Materials, National Institute for Materials Science, 1-1 Namiki, Tsukuba 305-0044, Japan*
[6] *Laboratoire National des Champs Magnétiques Intenses, CNRS-UGA-UPS-INSA-EMFL, 25 Av. des Martyrs, 38042 Grenoble, France*
[7] *CENTERA Labs, Institute of High Pressure Physics, PAS, 01- 142 Warsaw, Poland*
[8] *School of Physics, Trinity College Dublin, Dublin 2, Ireland*
[9] *Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France*
[10] *Walter Schottky Institut and TUM School of Natural Sciences, Technische Universität München, 85748 Garching, Germany*

Quantifying and controlling the coherent dynamics and coupling of optical transitions in solids is of paramount importance in fundamental considerations in condensed matter optics and for their prospective optoelectronics applications in quantum technologies. Here we perform Four-Wave-Mixing microspectroscopy of a charge-tunable $MoSe_2$ monolayer. The experiments show that the homogeneous linewidth and the population decay of exciton complexes hosted by this material can be directly tuned by an applied gate voltage, which governs the free carrier density.



By performing two-dimensional spectroscopy, we also show that the same bias tuning approach permits us to control the coherent coupling strength between different exciton species.

Our findings yield exciting prospects for forthcoming investigations of coherence phenomena in the context of recent discoveries of strongly correlated exciton phases in solids, optically probed quantum Hall states, Moiré superlatices, and magnetic two-dimensional materials.

Figure 1: Phase-referenced two-dimensional FWM spectroscopy of X and X^- (a) The pulse sequence used in the 2D FWM experiment. (b) Examples of 2D FWM spectra for different gate biases as given in the plots.

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