Anomalous interlayer exciton diffusion in WS_2/WSe_2 moiré heterostructure

Antonio Rossi*[1,2,3], Jonas Zipfel[1],, Indrajit Maity[4], Monica Lorenzon[1], Medha Dandu[1], Elyse Barré[1], Luca Francaviglia[1], Emma C. Regan[5], Zuocheng Zhang[5], Jacob H. Nie[5,6], Edward Barnard[1], Kenji Watanabe[7], Takashi Taniguchi[8], Eli Rotenberg2, Feng Wang[5], Johannes Lischner[3], Archana Raja[1]* and Alexander Weber-Bargioni1[1]

1-The Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, USA.
2-Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, USA.
3-Center for Nanotechnology Innovation @ Laboratorio Nest, Pisa, Italy.
4-Imperial College London, South Kensington Campus, London, United Kingdom.
5-Department of Physics, University of California at Berkeley, Berkeley, CA, USA.
6-Department of Physics, University of California at Santa Barbara, Santa Barbara, CA, USA
7-Research Center for Functional Materials, National Institute for Materials Science, 1-1 Namiki, Tsukuba, Japan 8
8-International Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba,Japan

Van der Waals (vdW) heterostructures are often considered key to unlock the full potential of two-dimensional (2D) materials[1,2]. Stacking van der Waals crystals allows for on-demand creation of a periodic potential landscape to tailor the transport of quasiparticle excitations. We investigate the diffusion of photoexcited electron-hole pairs or excitons at the interface of WS_2/WSe_2 Van der Waals heterostructure over a wide range of temperatures. We observe the appearance of distinct interlayer excitons for parallel and anti-parallel stacking, and track their diffusion through spatially and temporally resolved photoluminescence spectroscopy from 30 K to 250 K. While the measured exciton diffusivity decreases with temperature, it surprisingly plateaus below 90 K. Our observations cannot be explained by classical models like hopping in the moiré potential. Using a combination of ab-initio theory and molecular dynamics simulations, we suggest that low energy moiré phonons, also known as phasons[3], may play a key role in describing and understanding this anomalous behavior of exciton diffusion. In particular, we show that the moiré potential landscape is dynamic down to very low temperatures. Our observations show that the phason modes arising from the mismatched lattices of a moiré heterostructures can enable surprisingly efficient transport of energy in the form of excitons, even at low temperatures. The speaker acknowledges the PNRR MUR Project PE0000023-NQSTI.Co-funded by the European Union Next Generation EU.

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