Optical Response of Two-Dimensional Crystals

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Abstract

Since the mechanical isolation of graphene – a single atomic layer of carbon atoms arranged in a chicken-wire pattern – in 2004, studies of atomically-thin two-dimensional (2D) crystals have evolved into a vibrant field with many interesting discoveries and surprises. At UMass Amherst, we probe the optical response of these fascinating 2D materials using a variety of light sources and techniques. The electrical outputs of graphene under electromagnetic wave excitation provide a basis for developing high performance sensors, especially in the mid- and far-infrared frequency ranges. These detectors are highly sensitive, fast and have very large bandwidth [1–4]. The optical outputs of 2D crystals under laser excitation provide fundamental optical fingerprints[5–7] and offer an appealing venue for investigating many-body physics[8–10]. In monolayer transition metal dichalcogenide (TMDC) semiconductors, the inherent Coulomb interaction of the high-quality samples we fabricate enables us to observe light emission due to two-, three-, four- and five-particle bound states. We unambiguously determine the spin and valley composition of these states. The luminescence further reveals 2s, 3s and 4s excited Rydberg states in high magnetic fields up to 31 Tesla. These studies pave way for new opportunities to build valleytronic quantum devices, and quantum communication platforms harnessing unique TMDC properties.

References:

1.Yan, J. *et al.* Dual-gated bilayer graphene hot-electron bolometer. *Nat. Nanotechnol.* **7**, 472–478 (2012).
2.Cai, X. *et al.* Sensitive room-temperature terahertz detection via the photothermoelectric effect in graphene. *Nat. Nanotechnol.* **9**, 814–819 (2014).
3.Tong, J., Muthee, M., Chen, S.-Y., Yngvesson, S. K. & Yan, J. Antenna Enhanced Graphene THz Emitter and Detector. *Nano Lett.* **15**, 5295–5301 (2015).
4.Tong, J. *et al.* Asymmetric Two-Terminal Graphene Detector for Broadband Radiofrequency Heterodyne- and Self-Mixing. *Nano Lett.* **18**, 3516–3522 (2018).
5.Chen, S.-Y., Goldstein, T., Venkataraman, D., Ramasubramaniam, A. & Yan, J. Activation of New Raman Modes by Inversion Symmetry Breaking in Type II Weyl Semimetal Candidate T ′-MoTe2. *Nano Lett.* **16**, 5852–5860 (2016).
6.Chen, S.-Y., Zheng, C., Fuhrer, M. S. & Yan, J. Helicity resolved Raman scattering of MoS2, MoSe2, WS2 and WSe2 atomic layers. *Nano Lett.* **15**, 2526–2532 (2015).
7.Chen, S.-Y., Naylor, C. H., Goldstein, T., Johnson, A. T. C. & Yan, J. Intrinsic Phonon Bands in High-Quality Monolayer T′ Molybdenum Ditelluride. *ACS Nano* **11**, 814–820 (2017).
8.Chen, S.-Y. *et al.* Superior Valley Polarization and Coherence of 2s Excitons in Monolayer WSe2. *Phys. Rev. Lett.* **120**, 046402 (2018).
9.Chen, S.-Y. *et al.* Luminescent Emission of Excited Rydberg Excitons from Monolayer WSe_2. *Nano Lett.* **19**, 2464–2471 (2019).
10.Chen, S.-Y., Goldstein, T., Taniguchi, T., Watanabe, K. & Yan, J. Coulomb-bound four- and five-particle intervalley states in an atomically-thin semiconductor. *Nat. Commun.* **9**, 3717 (2018).

About the Speaker

Jun Yan is currently an Associate Professor of Physics at the University of Massachusetts Amherst, USA. He did his undergraduate study at Nanjing University, China, and his PhD at Columbia University in New York, USA. He held a postdoc position from 2009 at the University of Maryland, College Park before joining UMass Amherst in 2012. His research interests are mainly on the optical and optoelectronic properties of atomically thin crystals.