## 7th International Workshop on 2D Materials

**Title of the Presentation:** Detecting photoelectrons from spontaneously formed excitons


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**Short Biography:**

I have received the Ph.D. degree from University of Nebraska-Lincoln in the USA. I have served as an assistant professor at Tohoku University in Japan, and currently work as a senior researcher at Center for Artificial Low-Dimensional Electronic Systems (CALDES), Institute for Basic Science (IBS) and also serve as an endstation manager of BL-4A2 (SARPES) at Pohang Light Source in Korea. My profession is in experimental condensed matter physics, with particular emphasis in the investigations of electronic structures of low-dimensional and strongly correlated materials by means of angle-resolved photoemission spectroscopy (ARPES).

**Abstract:**


Excitons, quasiparticles of electrons and holes bound by Coulombic attraction, can be created transiently by light and play an important role in optoelectronics [1], photovoltaics [2] and photosynthesis [3]. In contrast, they are also predicted to form spontaneously in a small-gap semiconductor or a semimetal, leading to a Bose-Einstein condensate at low temperature. However, despite the growing number of evidences for the existence of such material, called excitonic insulator [4], the presence of the spontaneously formed excitons has been elusive without any direct evidence.

Here we detect the direct photoemission signal from such spontaneously formed excitons in a debated excitonic insulator candidate $Ta_2NiSe_5$. Our symmetry-selective angle-resolved photoemission spectroscopy reveals a characteristic excitonic feature above the transition temperature, which provides the direct estimates for the properties of excitons such as their Bohr radii and their anisotropy (see Fig. 1). The present result evidences the existence of so-called preformed excitons and guarantees the excitonic insulator nature of $Ta_2NiSe_5$ at low temperature. Direct photoemission can be an important tool to characterize steady-state excitons.


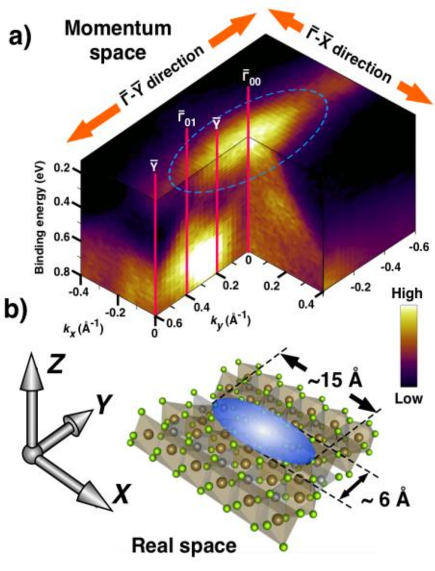


Fig. 1. **(a)** The photoemission signature of spontaneously formed excitons in $Ta_2NiSe_5$, as revealed by ARPES at the temperature of 380 K, and **(b)** the schematic illustration of the corresponding excitons in real space, constructed from the experimentally extracted anisotropic Bohr radius.


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[2] M.M. Furchi *et al.*, Nano Lett. **14**, 4785 (2014).
[3] H. Lee *et al.*, Science **316**, 1462 (2007).
[4] Y. Wakisaka *et al.*, Phys. Rev. Lett. **103**, 026402 (2009); Y. F. Lu *et al.*, Nat. Commun. **8**, 14408 (2017); K. Sugimoto *et al.*, Phys. Rev. Lett. **120**, 247602 (2018).