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Understanding Radiative Recombination in Two Dimensional Semiconductors

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Abstract: Two-dimensional (2D) materials have shown exceptional promise in various electronic and optoelectronic applications with prospects of improved performance compared to traditional technologies. Some unique advantages include the ability to create van der Waals (vdW) heterostructures, many-body physics, and various approaches to band structure engineering. Unlike the free-carrier characteristics of conventional semiconductors, the photophysics of 2D materials is governed by excitons, which are the primary format of photogenerated carriers at room temperature due to their strong binding energies. In this talk I will show that because of this excitonic nature the carrier recombination can be entirely radiative in monolayer transition metal dichalcogenides, as long as the photogenerated carriers are in the form of neutral excitons. As a result, the photoluminescence (PL) quantum yield (QY), defined as the ratio of photons emitted to photons absorbed, can approach unity at all generation rates even in the presence of a high native defect density. I will then talk about the excitonic to free-carrier transition in black phosphorus and show that the PL QY is highest at the monolayer limit when it is excitonic. This uniquely robust tolerance to defects presents a key advantage of 2D semiconductors over conventional semiconductors toward developing highly efficient optoelectronics, as stringent growth and fabrication requirements for high-quality crystals can be lowered.

Bio: Shiekh Zia Uddin is a Ph.D. candidate in Prof. Ali Javey's group. His research is focused on carrier recombination in low-dimensional semiconductors. He received his Bachelors in Science degree in Electrical and Electronics Engineering from Bangladesh University of Engineering and Technology (BUET), where he worked on both biomedical signal processing and nanophotonics.