Energy transfer (ET) is a non-radiative process in which energy gets transferred from an excited material (donor) to an unexcited material (acceptor). In the last several decades, the ET process has been proven as an essential ingredient of many biological and chemical applications. However, the ET exploration is still ongoing, because the biggest roadblock in fully utilizing the ET process is that many of the predicted ET applications are based on the idea of placing donor and acceptor in sub-nanometer proximity. In the case of 2D materials, sub-nanometer spacing in heterostructures (HSs) has already been proven by several studies. Thus, 2D HSs are ideal candidates to study the ET process.

In HSs, interlayer processes such as charge, and energy transfer compete, and fast charge transfer dominates over the ET process. Charge transfer can be suppressed by placing a thin charge-blocking interlayer, however the long-distance dipole-dipole coupling ET process is difficult to stop, unless the materials are placed relatively far away from each other, which is not ideal for any real device application. Thus, understanding the ET process is crucial to design any practical application. To date, studies have shown the presence of ET process in type-II 2D HSs by placing a charge-blocking layer to completely suppress the charge transfer process. PI's latest work shows in a type-II 2D HS made by one-atomic layer thick rhenium disulfide (ReS_2) as donor and molybdenum diselenide ($MoSe_2$) as acceptor, without any charge-blocking interlayer material in-between interlayer ET process dominates. This work has opened a new door to simultaneously study the charge and energy transfer process at ultrafast timescale. In this proposed work, we plan to extend the ET study in the newly emerging layered quantum materials and understand the role of Moiré superlattice, effect of stress/strain and defect densities in the ET process.