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Excitons at Interfaces

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Solar photovoltaics based on molecular and nano materials commonly involve excitons. This results from strong Coulomb attraction between an electron and a hole due to the low dielectric constants of molecules or quantum confinement of nano materials. In this lecture, I will address the question of how excitons dissociate at donor/acceptor interfaces. The first example deals with charge separation in organic photovoltaics. Due to the low dielectric constant of organic materials, an electron-hole pair across an organic donor/acceptor interface is bound by the Coulomb potential. This gives rise to a set of H-atom like states called charge-transfer excitons, as observed experimentally. The lowest energy charge transfer exciton state has a binding energy much higher than kT at room temperature. This leads to the conclusion that hot charge transfer exciton states must be involved in charge separation in organic photovoltaics. The second example deals with hot exciton dissociation due to electron transfer from photo-excited semiconductor nanocrystals (PbSe) to an electron acceptor (TiO2), an issue of particular interest to hot carrier solar cells with theoretical solar conversion efficiency surpassing the Shockley-Queisser limit. We show that, with appropriate chemical treatment of the nanocrystal surface, ultrafast transfer of a hot electron can be competitive with hot exciton relaxation due to phonon scattering. The last example will show recent development on hot carrier scattering and multiple exciton generation (MEG) in semiconductor nanorystals.