Electronic Coherence Effects in Photosynthetic Light Harvesting

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Highly efficient energy harvesting and trapping performed by photosynthetic systems are critical to the success of photosynthesis; however, the physical mechanisms that are responsible for the remarkable efficiency remain largely unclear. Recent experimental and theoretical investigations into the mechanisms of excitation energy transfer in photosynthetic complexes have provided evidences that quantum coherence effects can contribute to optimize the efficiency of photosynthetic light harvesting. In this work, we investigate quantum coherence effects in photosynthetic complexes, including electronic coherences manifested in delocalized electronic exciton states and excitonic coherences manifested in superposition between electronic excitons. We show how quantum mechanical rules play important roles in the speedup of excitation energy transfer, the stabilization of electronic excitations, and the robustness of light harvesting. In addition, we present the results of our recent work using a simple model to investigate quantum coherence effects in inter-complex excitation energy transfer in natural photosynthesis, with a focus on the likelihoods of generating excitonic coherences during the process. Finally, the implications of all these combined experimental and theoretical works to important open questions that remain to be answered will be discussed in this work.