Photosynthetic Light Harvesting: Recent Advances in Theoretical and Experimental Studies

Akihito Ishizaki

Institute for Molecular Science, Myodaiji, Okazaki 444-8585, Japan

e-mail address: ishizaki@ims.ac.jp

Photosynthesis provides the energy source for essentially all living things on Earth, and its functionality has been one of the most fascinating mysteries of life. Photosynthetic conversion of the energy of sunlight into its chemical form suitable for cellular processes involves a variety of physicochemical mechanisms. The conversion starts with the absorption of a photon of sunlight by one of the light-harvesting pigments, followed by transfer of electronic excitation energy to the reaction center, where charge separation is initiated. At low light intensities, surprisingly, the quantum efficiency of the transfer is near unity. The precise mechanisms of these initial steps of photosynthesis are not yet fully elucidated from the standpoint of molecular science.

Recently, techniques of two-dimensional electronic spectroscopy have been applied to explore photosynthetic light harvesting systems. The observation of long-lived electronic quantum coherence in the complexes [1] stimulated a huge burst of activity among experimentalists and theorists. In order to elucidate the nature of photosynthetic electronic energy transfer dynamics, we have investigated appropriate theoretical frameworks and concepts in cooperation with experiment [2,3].

In this lecture, we begin with a brief discussion of introductory nonequilibrium statistical mechanics as fundamentals of nonlinear laser spectroscopy and condensed phase chemical dynamics. And then, we illustrate the present state of understanding of energy and charge transfer dynamics in photosynthetic light harvesting systems.

[1] Engel G. S. et al., *Nature* **446**, 782 (2007).
[2] Ishizaki, Calhoun, Schlau-Cohen & Fleming, *Phys. Chem. Chem. Phys.* **12**, 7319 (2010).
[3] Schlau-Cohen G. S., A. Ishizaki & G. R. Fleming, *Chem. Phys.* **386**, 1 (2011).