Fakultät für Mathematik und Physik
Albert-Ludwigs-Universität Freiburg
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Quantum Efficiency
Seminar und Colloquium

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Quantum coherence and its interplay with protein environments in photosynthetic electronic energy transfer

ABSTRACT: 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. A longstanding question in photosynthesis has been the following: How does light harvesting deliver such high efficiency in the presence of disordered and fluctuating dissipative environments? The precise molecular mechanisms of these initial steps of photosynthesis are not yet fully elucidated.

Recently, the technique of two-dimensional electronic spectroscopy has been applied to explore photosynthetic light harvesting complexes. The observation of long-lived electronic quantum coherence in the complexes stimulated a huge burst of activity among experimentalists and theorists. Much of the interest arose because the finding of electronic quantum coherence in a “warm, wet, and noisy” biological system was considered very surprising. In order to elucidate the origin of the long-lived electronic quantum coherence and its interplay with the protein environment, we tackled the development of an appropriate theoretical framework. The developed theory predicts several times longer-lived quantum coherence between electronic excited states of pigments than the conventional Redfield equation, which is widely used in the literature of photosynthetic light harvesting, does. Furthermore, our results reproduce the experimental data at 77K and 300K.

In this talk, we illustrate the present state of understanding of electronic quantum coherence in photosynthetic light harvesting with the aim of shedding light on the physical mechanisms underlying the long-lived coherence and the potential functions such coherence could facilitate.

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