Quantum Efficiency
Seminar und Colloquium

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Photosynthesis Exploits Quantum Coherence for Efficient Solar Energy Conversion

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Photosynthesis is a biological process whereby the energy of the Sun is collected, transformed and stored into biochemical energy needed to power life. Hence, photosynthesis serves as the vital link between the energy of the Sun and all living organisms.

In plants, the conversion of solar energy takes place in the photosystem II reaction center (PSII RC), a pigment-protein complex embedded in the photosynthetic membrane. In the PSII RC the excitation energy (exciton) is converted into a charge-transfer (CT) state on an ultrafast time scale and with near unit quantum efficiency. Hence, the understanding of the molecular mechanisms leading to charge separation is crucial for the design of efficient solar cells.

To investigate the charge separation (CS) process, and the possible role of quantum coherence in driving ultrafast and efficient charge separation, we have performed Two-Dimensional Electronic Spectroscopy (2DES) on the isolated PSII RC from spinach at cryogenic and room temperature. 2DES, a technique with high temporal (16 fs) and spectral (<1 nm) resolution, correlates excitation with emission energies in 2D spectra as a function of population time (T). In the 2D spectra, the signal on the diagonal correspond to populations while the non-diagonal signals (cross-peaks) correspond to coherences and energy transfer between states.

The experimental data (signal amplitude as a function of T) contains oscillatory features which could be assigned to coherences with electronic and/or vibrational origin. The analysis of the frequencies present in the data will shed light on this question.

In addition, the data has been modelled with Redfield theory which allows to examine the effect and function of electronic coherence in single PSII RCs. The results indicate that the direction of electron transfer is related to the degree of electronic coherent mixing between the excited states and between the excited and charge-transfer states present in the PSII RC.

In conclusion, we propose that the interplay between electronic and vibrational coherences and the coherent mixing of electronic states may well be responsible for ultrafast and efficient charge separation.

Date: **Tuesday, November 6th, 2012 3:45 pm**
Location: **Lecture Hall 1, Hermann-Herder-Str. 3, Freiburg**

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