Elements of Quantum Physics involved in Photosynthesis

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Photosynthesis converts light energy into chemical energy. The initial step is light absorption, performed by protein-chromophore assemblies, which act as very efficiency antennas to 1) convert light energy into electronic excitation energy and 2) transport this energy towards the so-called reaction center (RC) where the actual conversion to chemical energy is performed.

Within antennas, the light absorbing molecules, i.e. the chromophores, interact with each other such that the excitation energy may delocalize over several individual chromophores, in a so-called quantum superposition of electronic states, which may have a central role in the efficiency of the excitation energy transfer to the RC. However, these protein-chromophore complexes also have a very large number of vibrational degrees of freedom which constitute a large thermal bath interacting with the (possibly delocalized) electronic states, and resulting in very fast dissipation and loss of the quantum coherence properties.

We will shortly present elements of the physics of molecules in order to introduce the above vocabulary, used in a very active field of today's research trying to address the following question: to what extent do the natural protein-chromophore assemblies exploit electronic coherence properties to improve maximally the overall efficiency of phochemical energy conversion?