COHERENT MODELS FOR PHOTOSYNTHETIC ENERGY TRANSFER

Richard H. Squire[1], Lou Massa[2], Norman H. March[3]

[1] Department of Natural Sciences, West Virginia University-Institute of Technology, Montgomery, WV 25136

[2] Department of Chemistry, Hunter College, New York, NY

[3] Department of Physics, University of Antwerp, Groenborgerlaan 171, B-2020, Antwerp, Belgium; Oxford University, Oxford, England

ABSTRACT

The transfer of energy in the Fenna-Matthews-Olson (FMO) complex in photosynthesis exhibits nearly perfect transfer of the energy of an absorbed photon to a distant charge separation complex in a process described as coherent (Engle, et al, 2007). The protein environment appears constant from 77K to 277K and efficient quantum transport is a balance between unitary (oscillatory) and dissipative (dephasing) dynamics which seems to be optimized at room temperature, enhancing the process robustness [G. Panitchayangkoon et al, 2010]. Others have independently verified that this interplay between dephasing and quantum coherence results in highly efficient electronic energy transfer that is fast and unidirectional.

We present two related models which may describe this phenomenon. Both are built on the assumption that the initial absorption of light generates bacteriochlorophyll *a* (Bchl-*a*) exciton particles (bosons) that develop extended wave packets comparable to the interparticle distances. The fixed geometry of the Bchl-a molecules allows exchange effects and boson condensation (BEC). Since the condensate chemical potential is zero, a photon can be added at $\vec{r}$ and another removed at $\vec{r}\,'$ with finite amplitude and no dispersion. An alternative possibility is that a combined exciton-photon, a polariton condensation (J. J. Hopfield, 1958) could exist. However, the rates of either process would overwhelm the ability of the reaction center to perform the necessary charge separation and energy would be wasted and the center could be damaged by local heating effects. To achieve the near perfect efficiency each type of condensate could have its own dephasing mechanism whose purpose is to delay energy transfer to the reaction center charge separation function to prevent energy loss and possible damage. We will discuss the various possibilities.

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G. Panitchayangkoon, et al (2010) Proc. Nat. Acad. Sci. **107**, 12766.
Hopfield, J. J., Phys Rev. **112**, 1555 (1958)