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Quantum Coherence in Biomolecular Exciton Systems

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Abstract:

We show that quantum coherence of biomolecular excitons can be maintained over exceedingly long times due to the constructive role of their non-Markovian protein-solvent environment. Using a numerically exact approach, we demonstrate that a slow quantum bath helps to sustain quantum entanglement of two pairs of dipole coupled excitons, in contrast to a Markovian environment. We consider the crossover from a fast to a slow bath and from weak to strong dissipation and show that a slow bath can generate robust entanglement. This persists to surprisingly high temperatures, even higher than the excitonic gap and is absent for a Markovian bath. In addition, we consider the role of spatially correlated environmental fluctuations, which are due either to propagating environmental modes or to local fluctuations with a finite localization length. The sound velocity of the solvent determines the wavelength of the environmental modes, which, in turn, has to be compared to the spatial distance of the chromophore sites. When the wavelength exceeds the distance between donor and acceptor sites, we find a strong suppression of decoherence. In addition, we consider two spatially separated donor-acceptor pairs under the influence of propagating environmental modes. Depending on their wavelengths fixed by the sound velocity of the solvent material, the spatial range of correlations may extend over typical interpair distances, which can lead to an increase in the decohering influence of the solvent. Surprisingly, this effect is counteracted by increasing temperature.

[1] M. Thorwart, J. Eckel, J.H. Reina, P. Nalbach, and S. Weiss
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[2] P. Nalbach, J. Eckel, and M. Thorwart
Quantum coherent biomolecular energy transfer with spatially correlated fluctuations
New J. Phys. Focus Issue on "Quantum Effects and Noise in Biomolecules" (invited) **12**, 065043 (2010)