Extreme Parametric Sensitivity in the Steady-State Photoisomerization of Two-Dimensional Model Rhodopsin

Chern Chuang and Paul Brumer

Chemical Physics Theory Group, Department of Chemistry, and Center for Quantum Information and Quantum Control, University of Toronto, ON, Email: chern.chuang@utoronto.ca

We computationally studied the photoisomerization reaction of the retinal chromophore in rhodopsin using a two-state two-mode model coupled to thermal baths. Reaction quantum yields at the steady state (10 ps and beyond) were found to be considerably different than their transient values, suggesting a weak correlation between transient and steady-state dynamics in these systems. Significantly, the steady-state quantum yield was highly sensitive to minute changes in system parameters, while transient dynamics was nearly unaffected. Correlation of such sensitivity with standard level spacing statistics of the nonadiabatic vibronic system suggests a possible origin in quantum chaos. The significance of this observation of quantum yield parametric sensitivity in biological models of vision has profound conceptual and fundamental implications. Similar observations in exciton energy transfer and charge separation in the context of light-harvesting are also discussed.