Bio-inspired Nanoscale Stacked Ring Geometry for Efficient Excitation Transfer

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In photosynthesis, nature relies on light-harvesting (LH) complexes to capture and transport solar energy to the reaction center with supreme efficiency. We took inspiration from the oligomeric geometry of biological LH2 complexes (roughly 6 nm in diameter) and utilized the quantum optical Lindblad master equation approach to theoretically propose and predict highly efficient asymmetric interlayer excitation energy transfer in a bio-inspired, larger ninefold (C_9) stacked concentric ring geometry [1]. This three-dimensional C_9 stacked configuration of two-level atoms (diameter of 400 nm) enables a maximum of 100% excitation transfer via the darkest collective eigenmode, in particular from the sparse to dense ring layer, for certain choices of dipole orientations. Our approach importantly provides a blueprint for proposing similar stacked geometries with different rotational symmetries, such as C_n $(n \geq 3)$. The proposed ring geometry is potentially accessible by nanofabrication and could be realized in diverse physical platforms, especially those operated at cryogenic temperatures, where weak or controllable system-environment interactions are possible to achieve.

References

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