Demonstrating Quantum Enhancement in Light-Harvesting Systems

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The most promising quantum enhancement of light harvesting is supertransfer [1,2], a collective quantum effect related to superradiance that enhances the rate of energy transfer between delocalised states. Despite its proposed significance in photosynthesis, there has been no direct experimental demonstration of supertransfer, as delocalisation of states cannot be turned on or off in a molecular system. Here, we demonstrate that this elusive quantum effect could be directly observed using a quantum device based on a superconducting circuit. The device's control over the system and its environment would give full tunability over supertransfer. Additionally, we present design guidelines for optimised energy transfer whose rate scales quadratically with the number of donors and linearly with the number of acceptors. These enhanced rates could inform the design of future, quantum-enhanced light-harvesters.

References

[1] S. Baghbanzadeh and I. Kassal, *J. Phys. Chem. Lett.*, **7** (2016) 3804.

[2] S. Tomasi and I. Kassal, *J. Phys. Chem. Lett.*, **11** (2020) 2348.

Figure

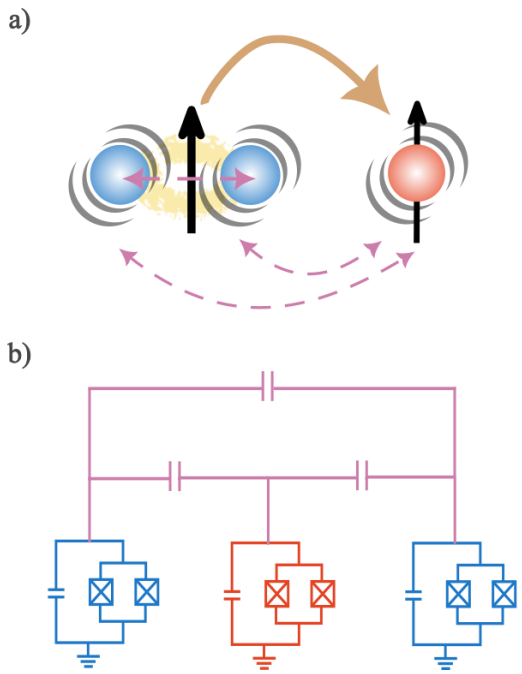

Figure 1: Experimental demonstration of supertransfer using a superconducting circuit. **A)** Supertransfer leads to enhanced transfer from delocalised donors (blue) to an acceptor (red). **B)** A circuit that demonstrates supertransfer by mapping the donor-acceptor system and that can tune the delocalisation using controllable noise.