Studying the Functional Quantum Biology of Light-Harvesting Processes with Superconducting Circuits

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The process of photosynthesis is despite almost a century long investigation still not fully understood. With recent observations of quantum coherent effects in light harvesting protein complexes the interesting question whether an interplay of quantum and classical effects can play an important functional role in biological processes emerged. In particular, the high efficiency of the energy transport has been theoretically shown to result from such an interplay. Testing these ideas in biological systems is extremely challenging due to an immense molecular complexity and the lack of precise control of system parameters. Comprehensive model systems are therefore needed to verify the models and gain an experimental insight into the basic concepts behind energy transfer in disordered systems. To address this problem we employ an analog quantum simulator based on superconducting circuits to study energy transport in a system of three qubits exposed to Markovian and non-Markovian environments. Our results show the existence of an optimal noise power that maximizes the energy transport, which is in good agreement with the theoretical models of noise-assisted transport. Furthermore we show that highly structured non-Markovian environments can lead to higher transfer efficiencies where transport is highly sensitive to the features of the noise spectrum. These observations are also relevant for understanding olfactory processes giving rise to the sense of smell.