EPR in the high-cooperativity regime: a playground for microwave quantum electronics

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Quantum electronics operating in the microwave domain, e.g. quantum amplifiers/oscillators, are becoming essential building blocks of quantum computers, sensors and communication devices due to their ultralow (i.e. quantum-limited) noise performance. However, to maintain the delicate quantum coherence and non-equilibrium quantum states, microwave quantum electronics have long been imprisoned in refrigerators. The last decade has seen the dawn of solving the dilemma by the EPR-assisted discovery[1,2] of the optically pumped electron spins in solids that possess long spin relaxation times and high polarization at room temperature. By coupling the spins to microwave cavities with high cooperativity, several works[3,4,5] have demonstrated the feasibility of such hybrid quantum systems to be configured as room-temperature microwave quantum electronics while the functionalities and controllability are still lacking of exploration.

In this talk, we will report on a solid-state hybrid quantum system, constituted by the optically polarized pentacene triplet spins coupled to a high-*Q* sapphire cavity, that for the first time serve for quantum amplification and oscillation at X band (~9.4 GHz) via the masing process at room temperature. In particularly, the performance of the device and the constituent parts can all be evaluated and optimized by the EPR techniques. Our work[6] demonstrates the powerfulness and full compatibility of EPR spectroscopy for facilitating the development of microwave quantum electronics at room temperature.

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