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Circuit Quantum Electrodynamics with two-dimensional materials-based devices

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Hybrid superconductor-semiconductor systems are platforms where superconducting cavities are coherently coupled to semiconductor devices. Lately, they have become promising platforms for quantum information processing since they have shown compatibility with high magnetic fields and have opened the possibility of realizing noise-protected qubits. In the above framework, devices composed of graphene combined with superconductors, such as the so-called graphene Josephson junction, embedded in nanocircuits have shown exciting potential applications in quantum technologies due to the possibility of tuning resonant frequencies and couplings in situ by exploiting the gate voltage tunability and the peculiar low energy characteristics of 2D materials. In this work, we studied the inductive interaction between a superconducting loop with an embedded short ballistic graphene Josephson junction and a quantum LC resonator. Specifically, within a mean-field approach, we analyzed how the properties of the global system ground state are affected by the light-matter coupling strength. Furthermore, we computed the hybridized light-matter excitations spectrum by calculating the retarded linear response function of the quantum LC resonator flux.