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**Hybrid quantum magnetism in circuit-QED: from spin-photon waves to many-body spectroscopy** ALEJANDRO BERMUDEZ, ANDREAS KURCZ, JUAN JOSE GARCIA-RIPOLL, Spanish Research Council, QUINFOG TEAM — We introduce a model of quantum magnetism induced by the non-perturbative exchange of microwave photons between distant superconducting qubits. By interconnecting qubits and cavities, we obtain a spin-boson lattice model that exhibits a quantum phase transition where both qubits and cavities spontaneously polarise. We present a many-body ansatz that captures this phenomenon all the way, from a the perturbative dispersive regime where photons can be traced out, to the non-perturbative ultra-strong coupling regime where photons must be treated on the same footing as qubits. Our ansatz also reproduces the low-energy excitations, which are described by hybridised spin-photon quasiparticles, and can be probed spectroscopically from transmission experiments in circuit-QED, as shown by simulating a possible experiment by Matrix-Product-State methods.

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