Integration of Magnons into Superconducting Circuits for Sensing Applications

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Circuit Quantum Electrodynamics (QED) is enormously powerful, allowing, e.g., the manipulation and interrogation of superconducting or magnetic qubits and quantum sensing of individual spins. All these interesting applications are built upon the condition of strong coupling between the qubit and a quantized field of excitations. Besides photons, the solid state offers a wide variety of bosonic excitations that can be emitted or absorbed such as, e.g., magnons, the quantum version of spin waves. Magnonic cavities are expected to play an important role since they shall allow building coherent qubit-qubit interactions between distant spin qubits, a challenge difficult to overcome with conventional electromagnetic cavities. One fundamental step towards achieving this goal is the integration of magnonic cavities into superconducting circuits, commonly employed for qubit manipulation and readout.

In this context, we present our progress in integrating patterned magnetic nanostructures into superconducting devices and their coupling to spin qubits. We perform broadband ferromagnetic resonance measurements and cavity experiments that demonstrate that the magnon-photon coupling strength can be estimated using either open superconducting transmission lines or resonant cavities, yielding very good agreement [1]. Finally, we investigate the coupling between topologically protected magnons and spin qubits (see Figure). The former are extremely stable magnetic textures exhibiting a very rich dynamical behavior in the sub-GHz to tens of GHz range. We focus on the coupling of individual spin qubits to vortex cavities for sensing and quantum computing applications [2].

References

[1] Sergio Martinez-Losa del Rincon, Ignacio Gimeno, Jorge Perez-Bailon, Victor Rollano, Fernando Luis, David Zueco, Maria Jose Martinez-Perez Phys. Rev. Applied, 19 (2023) 014002

[2] Carlos A. González-Gutiérrez, David García-Pons, David Zueco, María José Martínez-Pérez ACS Nano (2024) https://arxiv.org/abs/2401.06549

Figures

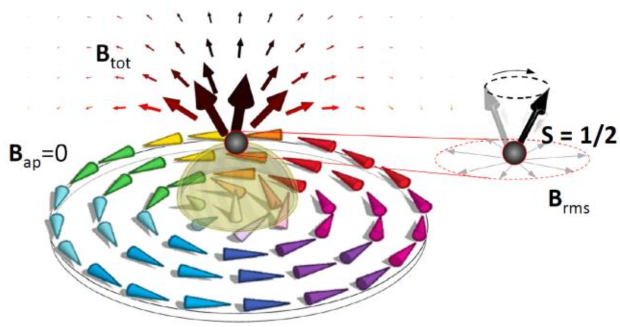

Figure: Spin qubit coupled to a magnetic vortex