N°20: Photon-magnon coupling using superconducting resonators

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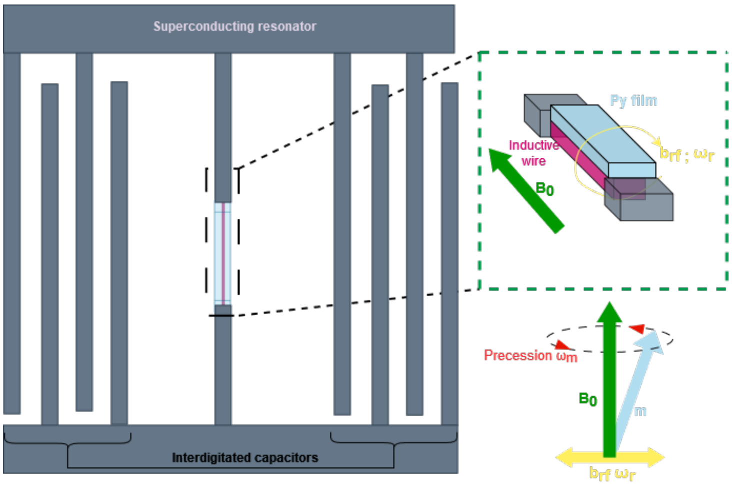
Light-matter interactions play a vital role in the burgeoning fields of quantum information and quantum sensing. In this practical, you will discover a hybrid quantum system consisting of a superconducting microwave resonator and a ferromagnet. Strong light-matter interaction is realized when a magnon, the collective excitation of spins in the ferromagnet, and a photon are in resonance. The coupling strength depends on multiple factors related to both systems, namely their decay rates, the distance between them and the number of spins participating in the process. We will be using lithographically defined planar superconducting resonators, with Permalloy (NiFe, Py) thin film stripes deposited on top of them, and cooled down to mK temperatures in a dilution cryostat.

The practical is thus divided in 3 parts:

1. Introduction to cryogenics and the experimental setup.
2. The theory behind magnon excitation and probing using microwave photons.
3. Performing RF measurements and analyzing the data to extract the coupling strength and other significant parameters to characterize the system.



A schematic of the system is shown where the Permalloy (Py) film is deposited on the thin inductive element of the superconducting resonator. The magnetization of the film precesses around the static magnetic field B_0. This can be also described as a magnon mode. The RF magnetic field b_{rf} is generated by a radiofrequency current going through the wire. Near resonance, the two modes can be coupled.