Superconducting on-chip spectrometer for mesoscopic quantum systems

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We propose a sensitive on-chip absorption spectrometer for mesoscopic systems functioning well into the millimeter wave band, which is based on a voltage-biased superconducting quantum interference device. At its core, the Josephson effect locally converts the DC bias voltage into microwave oscillations used for the spectroscopy, with the resulting absorption spectrum conveniently measured in the device DC current-voltage characteristic. Josephson spectrometers fabricated in aluminium have a bandwidth spanning from 1 GHz up to 180 GHz, with an optimal emission linewidth of 100 MHz and an intrinsic sensitivity of 20 kHz (NEP=1.3 x10^{18} W/√Hz) at 100 GHz. We demonstrate the capabilities of the spectrometer by coupling it to a variety of superconducting systems probing quantum phenomena such as quasiparticle and plasma excitations [1]. Additionally, the spectrometer emission power can be tuned in-situ with an applied magnetic field, which allows exploring the linear and non-linear spectroscopy regimes. This enabled to investigate transitions to highly excited states, containing hundreds of photons, in a microscopic tuneable non-linear resonator in the 40-50 GHz range, constituted by an rf-squid fabricated in a separated chip [1,2]. Moreover, recently fabricated devices using niobium have their bandwidth extended up to 1.2 THz, allowing the detection of absorption peaks of superconducting circuits at frequencies as high as 310 GHz, surpassing aluminium based devices capabilities.

References

[1] J. Griesmar *et al.*, Phys. Rev. Research, 3 (2021) 043078.
[2] O. Dmytruk *et al.*, Phys. Rev. B, 104 (2021) 214508

Figures

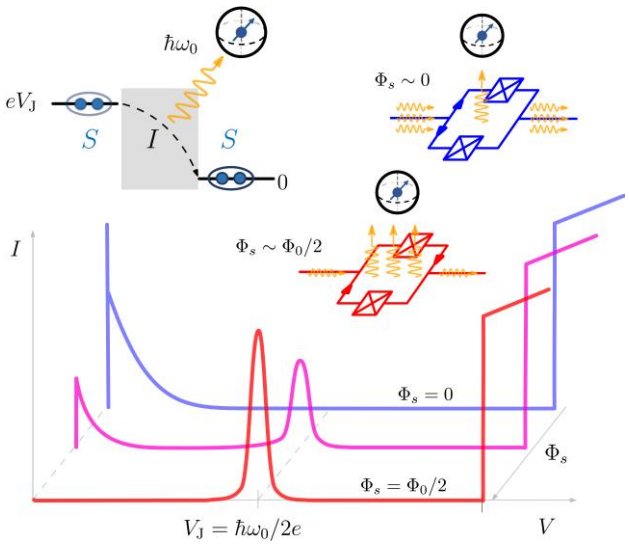

Figure 1: Principle of Josephson spectrometer.

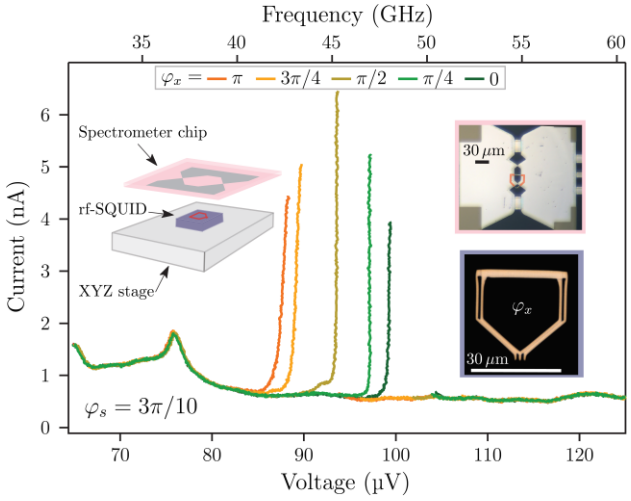

Figure 2: Linear spectroscopy of an off-chip tuneable rf-squid inductively coupled to the spectrometer