D 2.1 Fabrication and operation of a single photon source

We have designed, realized and tested a unit cell of two ferromagnetically coupled superconducting qubits embedded in a coplanar waveguide resonator as briefly described in the progress report of WP 1 (task 1.5). This structure is a basic superconducting building unit for the realization of integrated devices such as *d*ressed state laser (maser) as photon source.

Such a qubit coupled to a resonator strongly driven at the frequency of its third harmonic can emit photons at the fundamental frequency of the resonator. This leads to a lasing effect known in quantum optics as dressed state lasing [1]. The transmission through the resonator is enhanced when the Rabi frequency of the driven qubit is tuned into resonance with one of the resonator modes (**Fig. 1**). Amplification as well as line-width narrowing of a weak probe signal has been observed (**Fig. 2**). The stimulated emission in the resonator has been studied by measuring the emission spectrum. We analyzed our system and found an excellent agreement between the experimental results and the theoretical predictions obtained in the dressed-state model where the superconducting qubit plays the role of a photon source.

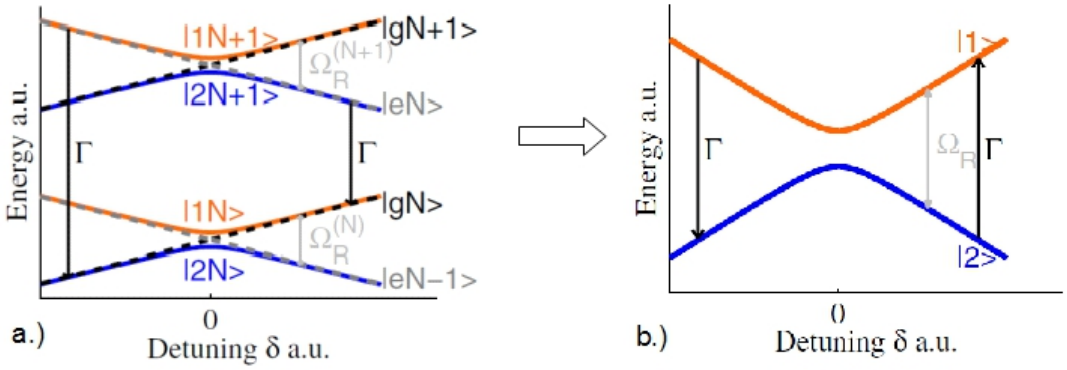

Fig. 1 *After tracing over the photon number N (left panel) an effective two-level system, denoted with states |1> and |2> ,is obtained (right panel). Both the sign and strength of the relaxation (excitation) in this system depend on the detuning [1].*

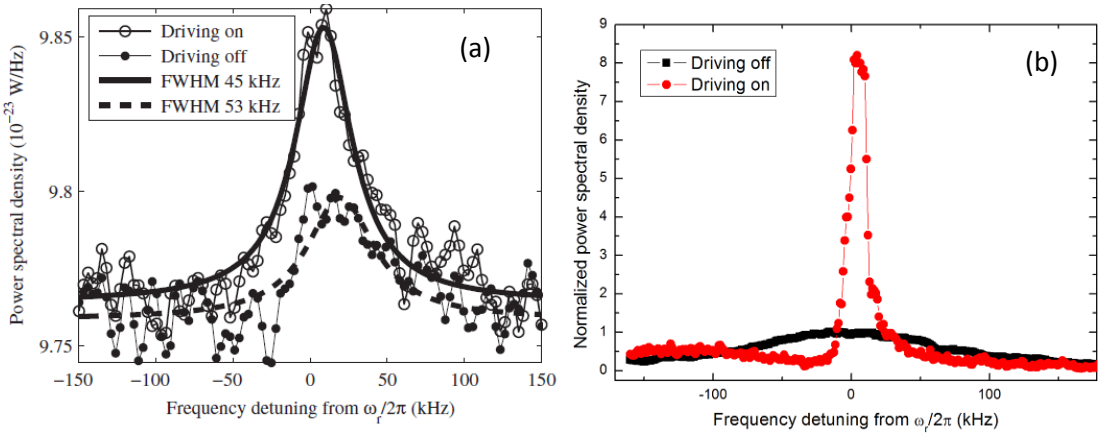

Fig. 2 *Spectral emission from the resonator at 10 mK for design presented in [1] (a) and new optimized design with strong qubit-resonator coupling (b). The solid lines in (a) correspond to the best Lorentzian fits of the measured data and are used to reconstruct the linewidths. (b) The characteristic linewidth narrowing is much more pronounced for the new optimized design. Moreover the curve is not Lorentzian but exhibits a much steeper domain, which is close to bistable bifurcation (Fig 2 of [2]).*