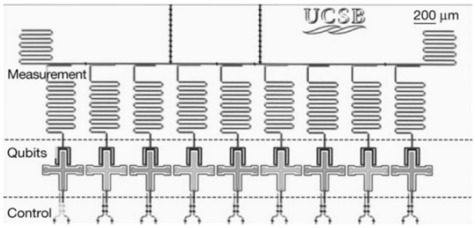
PhD advisor: Dr. Tomás Ramos del Rio

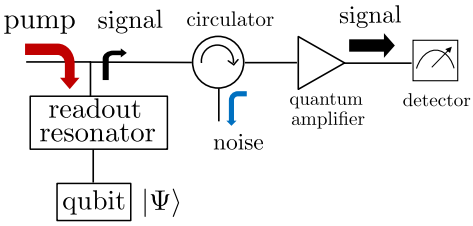
Email: tomas.ramos@csic.es , **Linkedin**

Improving qubit readout and amplification in superconducting quantum circuits

The current generation of quantum machines can perform universal quantum logic operations, but the number of qubits and the number successive operations is limited by imperfections and decoherence. Performing tasks with quantum advantage requires scaling up these systems to $\sim 10^5 - 10^6$ qubits with controlled error, as a long term goal.



In superconducting circuits [1], qubit readout is currently responsable for the largest error per operation (an order of magnitude larger than two-qubit gates), and this accumulates exponentially in succesive operations. Addressing the readout problem involves improving all aspects of the measurement lines including the amplification of quantum microwave signals, which requires to be of high gain, low noise, directional, and large bandwidth to read out many qubits simultaneously.



In this PhD thesis, the student will become expert on the state-of-the-art methods for qubit readout [1,2] and quantum amplification of microwave quantum signals [3,4]. He will delve into theoretical tools like master equations and input-output theory to describe linear and non-linear quantum light-matter interactions involved in these quantum systems [5,6]. Together with the advisor and collaborators, we will push the boundaries by exploring improved schemes for qubit readout and/or parametric amplification, identifying and quantifying the limits and advantanges for their realization in realistic superconducting circuit setups.

You'll gain hands-on experience in doing practical numerical simulations of the dynamics of these quantum systems, equipping you with the skills to contribute to the forefront of quantum technology!

[1] A. Blais et al. “Circuit Quantum Electrodynamics” Rev. Mod. Phys. 93 025005 (2021).
[2] F. Swiadek et al. “Enhancing Dispersive Readout of Superconducting Qubits through Dynamic Control of the Dispersive Shift: Experiment and Theory”, PRX Quantum 5, 040326 (2024).
[3] M. Esposito et al. “Perspective on traveling wave microwave parametric amplifiers”, Appl. Phys. Lett. 119, 120501 (2021).
[4] D. J. Parker et al., Phys. Rev. Applied 17**,** 034064 (2022).
[5] S. Haroche & J.M. Raimond, Exploring the Quantum: Atoms, Cavities, and Photons (2013).
[6] C. Gardiner & P. Zoller “The physics of Quantum-Optical devices” (2015).