QUANTUM TECHNOLOGIES

[Enrique Rico, Adolfo del Campo, Jorge Casanova]

Circuits [ER]

- Single-electron effects: single-electron box, Coulomb blockade, single-electron transistor.
- Josephson effect: superconductivity, Josephson equations, corresponding Hamiltonian.
- Quantization of Cooper-pair box.
- Superconducting qubits: charge qubit and mention transmon, flux qubit.
- Superconducting oscillators: LC circuits, quantisation, mention dissipation.
- Transmission line resonators: telegrapher's equation, quantisation.
- Circuit QED: derivation of the Rabi Hamiltonian.

References

M. H. Devoret *et al.*, *Superconducting Qubits: A Short Review*, arxiv:cond-mat/0411174.

S. M. Girvin, *Basic Concepts in Quantum Information,* arxiv:1302.5842.

S. M. Girvin, *Circuit QED: Superconducting Qubits Coupled to Microwave Photons* (Oxford University Press, 2014) - available here.

Trapped ions [AdC]

- Trapped ion qubit.
- Trapped ions in quantum metrology and precision sensing.
- Quantum control of trapped ions; quantum simulation and computation.
- Trapped ions as a test-bed for quantum thermodynamics and statistical mechanics: quantum heat engines and fluctuation theorems; simulation of spin models and critical phenomena.

References

D. Leibfried, R. Blatt, C. Monroe, and D. Wineland, *Quantum dynamics of single trapped ions*, Rev. Mod. Phys. **75**, 281 (2003).

Ch. Schneider, D. Porras, and T. Schaetz, *Experimental quantum simulations of many-body physics with trapped ions*, Rep. Prog. Phys. **75**, 024401 (2012).

M. Orzag, *Quantum Optics* (Springer, 2008).

NV centers [JC]

- Nuclear spin resonance and magnetic resonance imaging.
- Basic mathematical tools for NMR: interaction picture, rotating wave approximation (RWA), programing with MATLAB.
- Electron spin resonance.
- The nitrogen-vacancy (NV) center.
- Dynamical decoupling techniques: pulsed and continuous sequences.
- Nuclear spin detection and control at the nanoscale; hyper-polarization.

References

Malcom H. Levitt, *Spin dynamics: Basics of Nuclear Magnetic Resonance* (Wiley, 2008).