Quantum Rabi Model in the slow Oscillator Regime

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The quantum Rabi model is a fundamental building block in quantum optics and, more broadly, in qubit manipulation and detection. In the resonant case, where the oscillator frequency ω_m is close to the two-level system (TLS) splitting Δ, the model reduces to the celebrated Jaynes-Cummings model. A less explored regime occurs when $\omega_m \ll \Delta$, and the coupling constant is sufficiently large to induce a sizable anharmonic behavior in the oscillator, since this implies a coupling constant of the order of the oscillator frequency.

We investigated this regime by studying a TLS formed by a double-quantum dot embedded in a carbon nanotube, coupled to the second flexural mode of the nanotube [1]. In this talk, I will discuss the dynamics of this system in the presence of environmental coupling to both the oscillator and the TLS, and I will outline the different regimes that emerge depending on the physical parameters [2]. This study is primarily motivated by ongoing experiments in the ICFO group [3] where this regime of strong coupling has been achieved.

[1] F. Pistolesi, A. Cleland, A. Bachtold, Phys. Rev. X 11, 031027 (2021).

[2] J. Franz, F. Pistolesi (in preparation).

[3] C. B. Møller, R. Tormo-Queralt, V. Román-Rodríguez, E. Vázquez-Rodríguez, M. Cagetti, E. Mateos-Madinabeitia, J. Franz, S. Forstner, L. Ornago, M. El Abbassi, S. Jung, A. N. Cleland, D. A. Czaplewski, F. Pistolesi, and A. Bachtold, (under review).