Master 2 Internship

Title: A mechanical oscillators coupled to a two-level system

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Project:

Detecting and manipulating nanomechanical oscillators in the quantum regime is a current and significant challenge with implications for quantum sensing and quantum state manipulation. In our research group, we have demonstrated the feasibility of coupling a mechanical oscillator to single molecules and leveraging the spectroscopic signal to detect the displacement of the mechanical oscillator [1]. More recently, we have explored methods for cooling the oscillator and performing topological operations on its mechanical state by driving the oscillator around an exceptional point in the mechanical spectrum [2]. Our group has also illustrated how a carbon nanotube coupled to a double quantum dot two-level system can serve as a nanomechanical qubit [3]. Notably, the experimentally observed non-linearity predicted in this context has been reported [4].

During this internship, we will delve into the study of mechanical systems coupled to two-level systems, investigating their dynamics, and the way they can be manipulated and detected. Funding is available for a PhD fellowship focused on this subject.

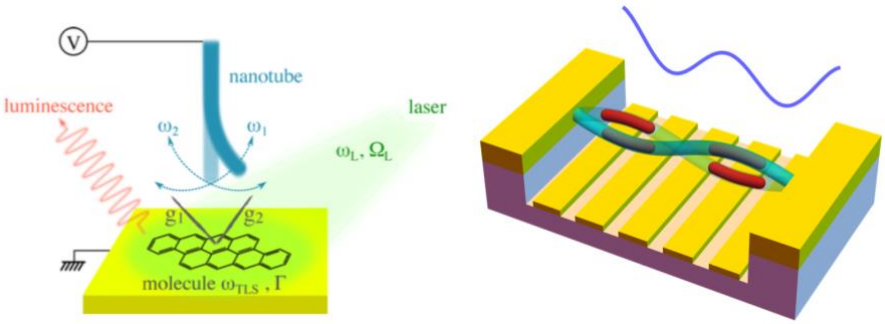

Figure: *Left*: A singly clamped suspended carbon nanotube oscillates modulating the electric field on a single molecule [1,2]. The single molecule is embedded in a solid-state matrix and irradiated by a laser beam. *Right*: suspended carbon nanotube coupled to a double-dot and forming a nanomechanical qubit [3].

References:

[1] V. Puller, B. Lounis, and F. Pistolesi, Phys. Rev. Lett. 110, 125501 (2013).
[2] C. Dutreix , R. Avriller , B. Lounis , and F. Pistolesi, Phys. Rev. Res. 2, 023268 (2020).
[3] Proposal for a nanomechanical qubit, F. Pistolesi, A. Cleland, A. Bachtold, Phys. Rev. X 11, 031027 (2021).
[4] Nonlinear nanomechanical resonators approaching the quantum ground state, C. Samanta, S. L. De Bonis, C. B. Møller, R. Tormo-Queralt, W. Yang, C. Urgell, B. Stamenic, B. Thibeault, Y. Jin, D. A. Czaplewski, F. Pistolesi and A. Bachtold, Nature Physics, **19**, 1340 (2023).