Corso di dottorato in Fisica / PhD in Physics
Ciclo 37 / Cycle 37
A.Y. 2021-2022

Borse a tematica vincolata / *Reserved scholarships*

(for detailed information visit: **https://www.unitn.it/drphys/en/12/doctoral-programme-physics**)

Scholarship title	**Theory and experiments on levitated microparticles approaching the quantum regime**
Research group link	BEC group: https://bec.science.unitn.it/BEC/0_Home.html CNR-IFN: http://www.tn.ifn.cnr.it/
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Synthetic description of the activity and expected research outcome	Nanomechanical resonators are highly versatile elements with widespread technological applications. For instance, they can be as sensors with ultralow noise or as interface to/between a variety of quantum systems. Levitated microparticles have recently emerged as a very promising class of extremely isolated mechanical systems, which can potentially achieve very low dissipation. This ingredient, together with low temperature, is key in order to suppress thermal decoherence and bring a mechanical system deeply in the quantum regime. In particular, micromagnets suspended in a superconducting trap by Meissner effect appear as the perfect systems for operation at very low temperature. A pioneering experimental activity on levitated micromagnets is ongoing in the CNR-IFN group in Trento with some promising initial results **[1]**. We plan to complement these experiments with a theory/modeling activity in order to study the nonlinear and quantum dynamics of these systems. In particular, the PhD activity will be initially related with the modelling and analysis of nonlinear experiments in the classical regime. Then we will explore several strategies in order to achieve active cooling of the microparticle to push it in the quantum domain. For instance, we will investigate how to include an optical/microwave cavity or another quantum system, in order to generate and control quantum states of the levitated microparticle **[2]**. We have the ambitious goal of experimentally realizing quantum superposition states of massive levitated microparticles. Experimental confirmations of macroscopic quantum superpositions started using electrons, and have today reached the size of organic molecules containing thousands of atoms. Preparing macroscopic quantum superpositions of objects containing billions of atoms will bring macroscopic quantum physics to an entirely new level, which will give the opportunity to attack some of the biggest open questions of modern physics: is quantum mechanics valid all the way up to the macroscopic world, together with its interpretation issues and paradoxes, or may it break down? **[1]** “*Ultralow mechanical damping with Meissner-levitated ferromagnetic microparticles”*, A. Vinante et al., Phys. Rev. Appl. vol. **13**, page 064027 (2020). **[2]** *“Cooling of a levitated nanoparticle to the motional quantum ground state”*, U. Delić et al., Science vol. **367**, page 892 (2020).
Ideal candidate skills	Basic of quantum physics, condensed matter physics, quantum optics and many-body physics