



PhD THESIS DEFENSE: Levitation and Control of Particles with Internal Degrees of Freedom

GERARD PLANES

June 30, 2020

11:00

ICFO Auditorium and Online (Teams)

PhD Thesis Defense, June 30, 2020, 11:00. Online

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Plasmon Nano-Optics

ICFO-The Institute of Photonic Sciences

Levitodynamics is a fast growing field that studies the levitation and manipulation of micro- and nanoobjects, fuelled by both fundamental physics questions and technological applications. Due to the isolated nature of trapped particles, levitated systems are highly decoupled from the environment, and offer experimental possibilities that are absent in clamped nanomechanical oscillators. In particular, a central question in quantum physics is how the transition between the classical and quantum world materializes, and levitated

objects represent a promising avenue to study this intermediate regime.

In the last years, most levitation experiments have been restricted to optically trapped silica nanoparticles in vacuum, controlling the particle's position with intensity modulated laser beams. However, the use of optical traps severely constrains the experiments that can be performed, because few particle materials can withstand the optical absorption and resulting heating in vacuum. This completely prevents the use of objects with internal degrees of freedom, which---coupled to mechanical variables---offer a clear path towards the study of quantum phenomena at the macroscale.

In this thesis, we address these issues by considering other types of trap and feedback schemes, achieving excellent control on the dynamics of optically active nanoparticles. With stochastic calculus, simulations and experiments, we study the dynamics of trapped particles in different regimes, considering also a hybrid quadrupole-optical trapping scheme. Then, using a Paul trap of our own design, we demonstrate the trapping, interrogation and feedback cooling of a nanodiamond hosting a single NV center in vacuum, a clear candidate to perform quantum physics experiments at the single spin level. Finally, we discuss and implement an optimal controller to cool the center of mass motion of an optically levitated nanoparticle. The feedback is realized by exerting a Coulomb force on a charged particle with a pair of electrodes, and thus requires no optics.

Tuesday, June 30, 2020, 11:00. Online

Thesis Advisor: Prof Dr Romain Quidant

Thesis Co-advisor: Dr Andreas Schell

Hosted by: Prof Dr Romain Quidant



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