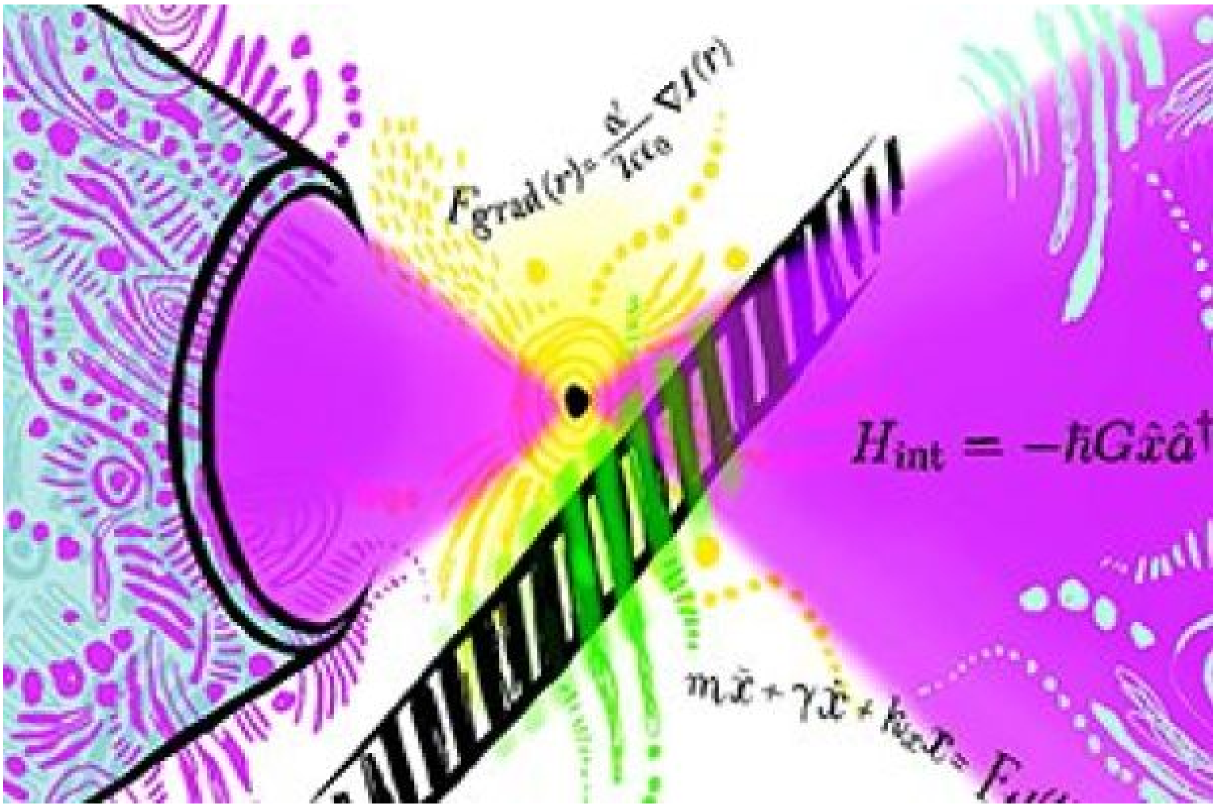

PhD THESIS DEFENSE: Levitodynamics on-a-Chip: From Planar Paul Traps to Near-Field Optical Nanocavities

IRENE ALDA

July 09, 2020

11:00

ICFO Auditorium and Online (Teams)

PhD Thesis Defense, July 9, 2020, 11:00. Online

IRENE ALDA

Plasmon Nano-Optics

ICFO-The Institute of Photonic Sciences

The field of levitation optomechanics---or levitodynamics---studies the manipulation and control of small trapped objects in an isolated environment, providing a gateway to answer fundamental questions in physics and expanding the range of applications at the nanoscale.

Levitation of particles can be achieved through different tools and techniques such as Paul traps and optical tweezers. Paul traps are created by alternating electric fields to levitate charged particles, while optical traps are based on optical forces that confine and manipulate nano-objects with high polarizability and low absorption.

Both have the potential to be reduced to on-a-chip systems, enabling the miniaturization of the experiment, its interface with other photonic devices, and the expansion of trapping tools to on-a-chip technologies. In particular, a nanocavity coupled with a levitated particle is a promising platform to attain higher per-photon sensitivities than far-field detection schemes. The further study of on-a-chip levitated optomechanics systems will allow for new applications that enable sub-wavelength control and near-field detection in vacuum conditions.

In this thesis, we describe our work with two on-a-chip levitodynamics experiments. Firstly, we have designed and built a planar Paul trap to levitate nanoparticles. This integrated device allows to manipulate and interrogate the trapped specimen, even over long periods of time. We optimized the geometry of the trap to a confinement of 4 microns in each direction. This on-a-chip levitation tool has potential to become a clean loading mechanism to trap particles in vacuum, avoiding current techniques that are unsuitable for contamination-sensitive experiments.

Secondly, we have also designed, fabricated and tested a 1D photonic crystal nanocavity suspended on a silicon nitride membrane to study near-field levitodynamics. We have approached a levitated nanoparticle by an optical tweezer to the near-field of the nanocavity and measured the dynamics of the nanoparticle through the nanocavity. From the output signal of the nanocavity, we have estimated the single-photon optomechanical strength g_0 along each axis. We have also characterized the thermal dynamics of the nanocavity. The power circulating inside the cavity increases the temperature of the device, inducing rich and tunable behavior in the transmission, such as bistability and self-induced oscillations.

Control over these thermal effects is fundamental to create all-optical integrated circuits. This technology, exploited alongside the miniaturization of Paul traps and near-field schemes, could enable on-a-chip levitodynamical devices that are able to trap, manipulate, and detect nano-objects with unprecedented precision.

Thursday, July 9, 2020, 11:00. Online

Thesis Advisor: Prof Dr Romain Quidant
Hosted by: Prof Dr Romain Quidant

Irene Alda's Thesi Cover