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Title of the lecture:
Mechanics with Levitated Objects

Format:
TBA

Contents & Summary

1. Optical Forces

We discuss the forces experienced by a polarizable object in an optical field. Starting with the conservation law for linear momentum we derive the conservative and non-conservative forces acting on a nanoparticle and discuss their use for controlling the nanoparticle's dynamics.
Reference: *L. Novotny and B. Becht "Principles of Nano-Optics," (2nd ed.) Cambridge 2012.*

2. Levitodynamics

Levitodynamics is the trapping and control of nano- and micro-objects in vacuum.
It offers the possibility to study the motional and rotational dynamics of levitated objects, their internal properties, and the interplay between them. In this lecture we will review recent advancements and applications.
Reference: *C. Gonzalez-Ballestero et al. ``Levitodynamics: Levitation and control of microscopic objects in vacuum," Science 374, eabg3027 (2021).*

3. Stochastic Electrodynamics

In stochastic electrodynamics one assumes that all excitations (matter and field) are composed of a deterministic part and a stochastic part. The stochastic part accounts for both thermal and zero-point fluctuations. In the past, stochastic electrodynamics has been applied to various phenomena, including van der Waals and Casimir forces, blackbody radiation, heat transfer, the ground state of the hydrogen atom and the absence of atomic collapse, and to vacuum friction. In this lecture we will use stochastic electrodynamics to discuss quantum ground state cooling of a levitated nanoparticle.
References: *T. W. Marshall, ``Random electrodynamics," Proc. R. Soc. A 276, 475-491 (1963); T. H. Boyer, ``Stochastic electrodynamics: The closest classical approximation to quantum theory," Am. J. Phys. 7, 29-39 (2019).*

4. Coupled Mode Theory

Coupled mode theory is a theoretical framework that underlies many physical phenomena, such as coupled optical cavities, the interaction between optical waveguides, coupled electronic resonators, optomechanical systems, interacting nanoparticles, or the coupling between an atom and a cavity. Coupled mode theory also forms the basis for quantization of open systems under the framework of input-output theory. In this lecture we review the basic elements of coupled mode theory and apply it to a mechanical system coupled to an optical resonator.

Reference*: H. Haus, Waves and Fields in Optoelectronics, Prentice Hall, Englewood Cliffs, NJ (1984).*

References:

1. L. Novotny and B. Becht "Principles of Nano-Optics," (2nd ed.) Cambridge 2012.
2. C. Gonzalez-Ballestero et al. ``Levitodynamics: Levitation and control of microscopic objects in vacuum," Science 374, eabg3027 (2021).
3. T. W. Marshall, ``Random electrodynamics," Proc. R. Soc. A 276, 475-491 (1963)
4. T. H. Boyer, ``Stochastic electrodynamics: The closest classical approximation to quantum theory," Am. J. Phys. 7, 29-39 (2019).
5. H. Haus, Waves and Fields in Optoelectronics, Prentice Hall, Englewood Cliffs, NJ (1984).