M2 internship / PhD proposal

Study of the optomechanical coupling on glass microtubes: transfer of electromagnetic momentum to transparent objects

Optomechanics refers to the coupling of a mechanical degree of freedom and an electromagnetic field. The radiation pressure, which comes from the momentum carried by the photons, is one of the mechanisms [1]. It obvious that, the smaller the size of the objects, the more sensitive they are to this pressure. However, a frontier appears when the dimensions reach the size of the wavelength, since, then, diffraction, interferences, scattering and surface waves co-exist and equally contribute to the optical behavior of the system. The mechanical reaction of such objects to a light beam is therefore hardly deterministic, and antagonistic responses have been observed with close experimental configurations.

To study these different optical regimes, we are more specifically interested in glass microtubes [fig. (a)] since they present mechanical modes at low frequencies (close to the acoustic domain) and are therefore "easily" observable, and also have applications in biomedicine. Nevertheless, the apparent conceptual simplicity of this system hides two major modeling difficulties: their transparency and their cylindrical shape, which breaks several symmetries. In order to predict their optomechanical behavior, we have developed a numerical code by finite differences in the time domain [fig. (b) and (c)] which has allowed to highlight a large variety of different effects. Our team also has a historical know-how in the ultra-sensitive measurement of displacements of micro- and nano-systems with, currently, a resolution of 10^{-12} m [2,3].

The aim of the present internship is thus to observe and characterize the different regimes of the optomechanical coupling in microtubes. The different tasks in this direction will be:

- the assembly of an ultrasensitive bench for measuring displacements under illumination;
- the development of a formalism to describe the dynamics of the system;
- the electromagnetic simulation on a computing mesocenter.

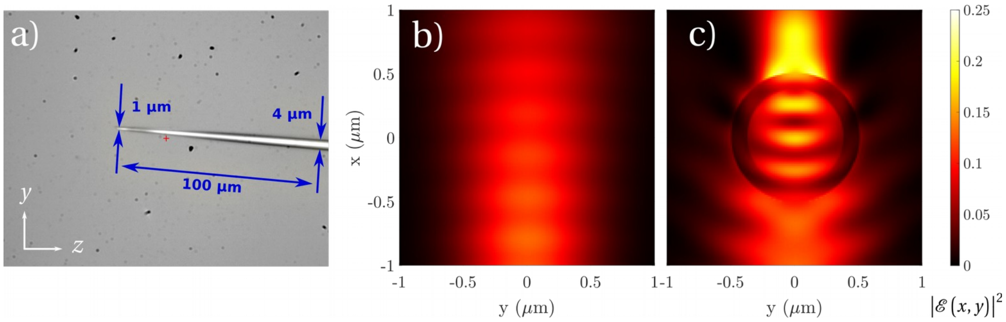

Figure: a) microscope view of a microtube; FDTD simulation of the propagation of a focused laser beam: b) in vacuum, c) across a microtube.

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[1] P. Verlot et al., Comptes rendus - Physique, Vol. 12, Issue 9, p. 826-836 (2011)
[2] T. Antoni et al., Optics Letters, Vol. 36, Issue 17, pp. 3434-3436 (2011)
[3] K. Makles et al., Optics Letters, Vol. 40, Issue 2, pp. 174-177 (2015)