OPTICAL FORCES ON SMALL MAGNETODIELECTRIC PARTICLES IN THE FOCAL VOLUME OF HIGH NUMERICAL APERTURE MICROSCOPES

Ignacio Iglesias[1] and Juan José Sáenz[2,3]

[1]Departamento de Física, Universidad de Murcia, Campus de Espinardo (CIOyN Bldg.), E-30100, Murcia, Spain
[2]Departameno de Física de la Materia Condensada, Universidad Autónoma de Madrid, E-28049 Madrid, Spain
[3]Donostia International Physics Center (DIPC), Paseo Manuel Lardizabal 4, E-20018 Donostia-San Sebastian, Spain
iic@um.es

A small dielectric particle experiences an optical field gradient and scattering forces caused by the electric-dipolar response. The scattering forces can be modeled as radiation pressure and a non-conservative force term that emerges from the spin curl [1]. In the focal region field generated by a microscope objective, the curl term is a fundamental contribution to the total force when using high numerical apertures [2]. Its presence explains the asymmetry of the trapping potential, which, for linear polarization, has been observed using focused beams (see Fig.1). Additionally, when other polarization structures in the microscope pupil plane are considered, the curl term becomes fundamental for explaining the force field the particle experiences even for moderate numerical apertures.

Recently it has been shown [3] that there are additional force terms when magnetodielectric particles are considered. These correspond to the magnetic-dipolar response, a counterpart to the aforementioned forces, together with additional components emerging from the electric-magnetic dipolar interaction. These new forces should also apply to pure dielectric particles like submicron silicon spheres which present strong magnetic and electric dipolar response in the near infrared [4,5].

Centered on these particles, this presentation will show the characteristics of the force field in the important particular case of tight focused beams generated by microscope objectives, which are frequently used in optical trapping and manipulation experiments.

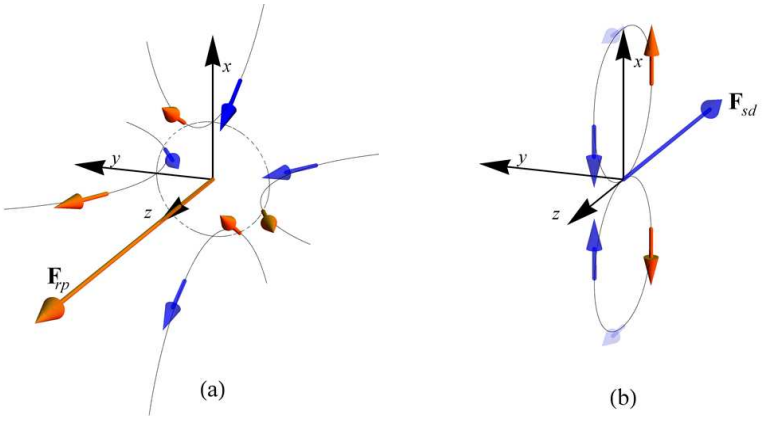

Figure 1.- Scattering forces that a small dielectric particle can experience in the focal region of a high numerical aperture microscope objective. In panel (a) the radiation pressure, in panel (b) the force of the curl term for a linear polarized light beam along the x-axis.

References

1. S. Albaladejo, M. I. Marques, M. Laroche, and J. J. Saenz, "Scattering Forces from the Curl of the Spin Angular Momentum of a Light Field," Phys. Rev. Lett. **102**, 113602-113604 (2009).
2. I. Iglesias and J. J. Saenz, "Non conservative scattering forces in the focal volume of high numerical aperture microscope objectives," Opt. Comm. **(in press)**(2010).
3. M. Nieto-Vesperinas, J. J. Sáenz, R. Gómez-Medina, and L. Chantada, "Optical forces on small magnetodielectric particles," Opt. Express **18**, 11428-11443 (2010).

4. A. García-Etxarri, R. Gómez-Medina, L. S. Froufe-Perez, C. Lopez, L. Chantada, F. Scheffold, J. Aizpurua, M. Nieto- Vesperinas, and J. J. Saenz, “Strong magnetic response of silicon nanoparticles in the infrared,” ArXiv:1005.5446v1 (submitted 2010).
5. M Nieto-Vesperinas, R. Gómez-Medina, and J.J. Sáenz, "Angle-suppressed scattering and optical forces on submicrometer dielectric particles," J. Opt. Soc. A 2011 **28**, 54-60 (2011).