Optomechanics with Mie-resonant dielectric particles

Ivan Toftul and Yuri Kivshar
Nonlinear Physics Center, Research School of Physics, Australia National University
Canberra ACT 2601, Australia

The study of dielectric Mie resonances in high-index dielectric nanoparticles open many opportunities for a design of compact devices based on metaphotonics and metasurfaces [1]. This talk will discuss the effects of Mie resonances and their hybridisation on optical manipulation.

Figure 1: Pressure and gradient forces, spin torque on a cylinder in evanescent field with non-zero transverse spin angular momentum. Modes are labeled as qXX{	extsuperscript{mpf}}, where m is the azimuthal number, p is the radial number, and f is the number of maxima along the cylinder axis (Fabry-Perot number). One can note very bright resonances in the torque once the azimuthal number of the mode is non-zero. Cylinder with $\varepsilon = 80 + i0.4$ is placed in vacuum.

We consider a dielectric cylinder with permittivity $\varepsilon = 80 + i0.4$ in the field of an evanescent field given by $E = A(1,0,-ik/kz)T e^{ikz-k\kappa z}$ (Fig. 1 (a)). The wave produces linear momentum along z axis, spin angular momentum along y axis, and non-zero gradients along x axis. We calculate the force $F$ and torque $T$ by using the Maxwell stress tensor approach [2, see SM] while varying the aspect ratio (AS) of the cylindrical particle. One can see very distinct resonance enhancement on different mode lines (Fig. 1 (c)). We name modes as qXX{	extsuperscript{mpf}}, where XX based on the well-known convention in fiber optics, i.e. described in [3, see § 9.2.3], also due to the finite length the Fabry-Perot pattern also involved, that is why the 3rd index $f$ is present. Importantly, the resonant response of torque strongly depends on the azimuthal mode number $m$: for mode with zero angular momenta (AM), i.e. $m = 0$, spin torque is almost absent however, pressure and gradient forces are very evident; for modes with higher AM, e.g. $m = 2$, the spin torque resonances are very sharp, while force components are almost negligible. Finally, torque resonances are symmetric, while gradient and pressure force have classic asymmetric shape (Fig. 1 (b)) which common for two coupled modes.