Enhancing Radiation Force at Solution Interface: the Role of Optical Resonance Effect

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Since Prof. Ashkin discovered the optical trapping phenomena, laser trapping has been used as optical tweezers to trap and manipulate nanoparticles in three dimensions. Recently, one of the interests in this field has been to develop novel strategies to enhance the radiation forces that are induced to the objects. Among them, we believe that taking advantage of optical resonance effect is one of the most promising strategies. Optical resonance effect is based that we can induce a change in polarizability (and consequently a change in the induced force) when the particle absorbs photons that have similar energy than their transition levels.

Different works have been published either from experimental and/or theoretical perspectives. Although, to our best knowledge any work has been published studying the optical resonance effect at interfaces. Recently, optical trapping at interfaces has gained interest in this field due to the discovery of the formation of optically evolving assemblies by us. Thus, optical resonance effect could have an impact on the formation and behavior of such assemblies if dye-doped particles are used.

Herein, we demonstrate the effect of 488 nm widefield illumination on the trapping behavior of single dye-doped polystyrene bead (continuous wave, 1064 nm wavelength laser) at glass/solution interface. To track the movement of the trapped bead, we have used our recently developed multiplane widefield microscope, which allows to track the movement of the particle in a volume of 40x40x4 μm with subpixel accuracy (< 20 nm for x,y-, and < 30 nm for z-directions). The trapping stiffness is calculated from the traces obtained from each single particle experiment. We observe that the trapping stiffness is enhanced for x,y- directions when the dye-doped particles are excited with 488 nm laser. Instead, the extent of this phenomenon in z- direction is much more reduced. To gain further confidence in our results, we photobleached the dye-doped trapped particle and then no trapping stiffness enhancement is observed in any case. The photobleached dye-doped particle is the best possible control because it reduces the uncertainty due to the intrinsic physical, chemical and mechanical parameters of each individual particle. Thus, from the analysis of the trapping stiffness of the beads at different experimental conditions (e.g. excited state concentration, trapping laser power or particle size among others), we have been able to demonstrate and elucidate the main parameters that have a key role on the optical resonance effect at an interface.