Optical Torque from Enhanced Scattering by Multipolar Plasmonic Resonance

Yoonkyung E. Lee¹, Kin Hung Fung¹,², Dafei Jin¹, Nicholas X. Fang¹

¹Department of Mechanical Engineering, MIT, Cambridge, MA 02139, USA
²Department of Applied Physics, the Hong Kong Polytechnic University, Hong Kong

Light can exert force and torque on particles because electromagnetic field carries momentum and angular momentum. Optical excitation has been one of the most useful methods to control particle dynamics on the nanoscale, following the invention of the laser.

Optical torque is produced when a mismatch in the angular momentum carried by the incident and the scattered field is balanced by the mechanical rotation of the particle to conserve total angular momentum. Various setups are known to be capable of providing this angular momentum mismatch, such as when the particle absorbs light, illustrated by the red rotating arrows in Figure 1, or when it changes the azimuthal distribution of the field through birefringence or structural chirality. On the other hand, the blue rotating arrows in Figure 1 represents the torque by resonant scattering. [1]

In this talk, we present the numerical results to demonstrate that torque can be dominantly produced by light scattering at multipolar plasmonic resonance. Scattering can produce up to 80% of the total torque on a resonant gold nanoparticles, and this torque is extremely mode-specific as shown in Figure 2. Our findings suggest that a modified current distribution on a plasmonic surface can lead to a mechanical torque, without the introduction of birefringence or chirality. Major governing factors that determine the quality of the redistribution of angular momentum will be discussed in further detail.