Surface Plasmon Enhanced Optical Torque between Twisted Nanorods

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Plasmon coupling between two metal nanoparticles depends on their interparticle separation and enhances the electromagnetic (EM) field in the nanogap, resulting in the enhancement of their interaction optical force [1,2]. In general, optical force is induced by the linear momentum transfer between light and matter. Meanwhile, the light-matter interaction also can produce optical torque due to the transfer of angular momentum [3]. Here, we have studied, for the first time, an interaction optical torque between twisted metal nanorods using electromagnetic simulation and revealed that the optical torque can be strongly enhanced by plasmon coupling.

Figure 1 shows the simulation model of a twisted nanorod dimer. We used gold nanorods with the same size (length: 120nm, diameter: 40nm). The two nanorods were separated by a distance of *d*. In our calculation, rod 2 was twisted by an angle of θ from rod 1 fixed along y-axis. The twisted nanorods were illuminated by y-polarized light to propagate along the -*z*-axis, with the intensity of 10MW/cm^2. We calculated optical torque on each rod using Maxwell stress tensor method.

As shown in Figure 2 (a), we found that our structure can induce plasmon coupling modes at shorter and longer wavelength than an isolated rod, that is, the so-called "plasmon hybridization". The plasmon coupling between twisted nanorods depends not only on the gap size *d* but also on the twisted angle θ. Each rod experiences optical torque of the same strength but opposite direction with another rod, i.e., interaction optical torque. In Figure 2 (b), the interaction optical torque is enhanced strongly by the plasmon coupling and its peak wavelength is corresponding to the plasmon coupling mode at long wavelength. It should be noted that the optical torque at long wavelength mode is much larger than that at short wavelength, even though its extinction cross section is smaller than that at short wavelength.

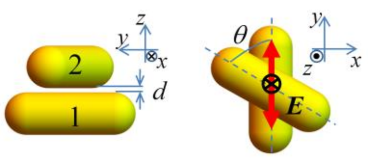

Fig. 1 Twisted nanorods

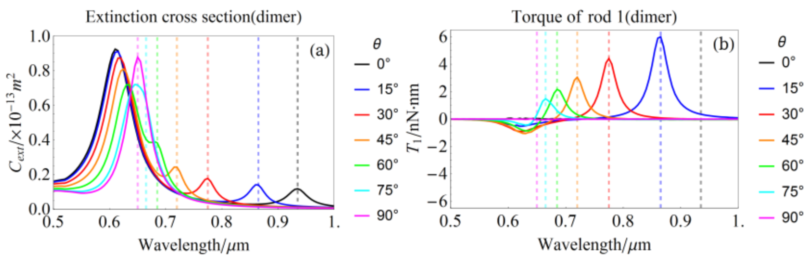

Fig. 2 Twisted angle dependence for (a) extinction cross section and (b) optical torque spectra

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[3] Philip H. Jones *et.al.*, Optical tweezers: principles and applications (Cambridge University Press, 2015).