Transfer and Conversion of Optical Linear and Angular Momenta

Hokkaido University, ○Keiji Sasaki

E-mail: sasaki@es.hokudai.ac.jp

Recently, we clarified that multipolar plasmons of metal nano-disks can be selectively excited by circularly-polarized optical vortex beams, i.e., Laguerre-Gaussian (LG) beams [1,2]. The total angular momenta, that is the sum of orbital and spin angular momenta, are transferred from chiral photons to localized surface plasmons. Unfortunately, the mode volume of this plasmonic nanodisk resonator is sub-micrometer dimension that is restricted by the diffraction limit of the surface plasmon wave. In order to realize single-nanometer-sized cavities, we design the tailored plasmonic structure consisting of metal multimer surrounding a nano-gap. We showed with numerical simulation that this metal structure makes it possible to localize the optical vortex fields into the gap space with conserving the total angular momenta. However, the orbital and spin angular momenta of the vortex field can be converted to each other in accordance with the boundary conditions at the metal surfaces. Therefore, the nano-vortex field is formed as interference of LG-modes having different angular momenta even when the single LG-mode beam is incident on the plasmonic multimer structure.

The transfer of the angular momenta from this interference nano-field to molecules or nanoparticles induces rotational radiation pressure, i.e., optical torque, and gradient force directed to the center [3,4], which causes nano-vortex flow of molecules/particles and may lead to chiral structuring of molecule/particle assemblies. We succeeded in rotational manipulation of a polymer nano-bead with a gold triangle trimer structure. The plasmonic nano-structure was illuminated with a circularly polarized beam of a near-infrared laser, so that the nano-sized field with the orbital angular momentum as well as the spin is formed within the gap. We will explain detailed analyses of the rotational motions and their relations to the chirality of the plasmonic fields.

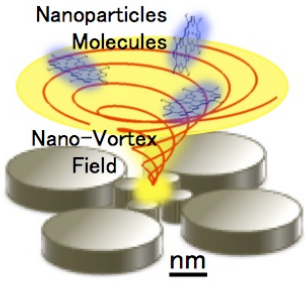

Fig.1 Nano-Manipulation with Angular Momentum Control

In the presentation, we also introduce the theoretical and experimental analyses of transfer, conversion, and inversion of linear and angular momenta in the case of focused laser beam manipulation.

References

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