Control of Plasmonic Collective Phenomena in Metallic Nanoparticles by External Fields under Thermal Fluctuations

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In my research group, we are aiming at the construction of guiding principles to control dynamics and functions of nano-composites by changing the balance between the thermal fluctuations and the inter-object interaction with optical manner. Since light-induced force (LIF) depends on a variety of properties of excitation light such as wavelength, angular momentum, polarization and intensity distributions, we can greatly enhance the degree-of-freedom of nanodynamics. Our future goal is the construction of a group of technologies "Light-induced-force Nano Engineering" for '*Fabrication*', '*Observation*', and '*Manipulation*' of nano-composite materials based on the obtained principles. Through such a research activity, we are trying to open the way to high-performance light-energy conversion system, which can be used for highly-efficient solar cell [1], single molecule detection [2], optical sensors [3], photo-thermal therapy [4] and so on.

In order to realize the construction of such an engineering, we pay attention to metallic nanoparticles (NPs) that show strong optical response even at room temperature due to localized surface plasmon (LSP). Also, controlling arrangement and functions of metallic nanoparticles (NPs) is crucial for various applications of LSP. Paying attention to the technique of optical tweezers, a stable trapping of metallic NPs was successfully demonstrated [5-7]. In addition, attractive and repulsive inter-object light-induced force (LIF) between closely spaced small objects [8] would be a promising mechanism for the arrangement control of metallic NPs reflecting the various properties of irradiated light fields. Recently, based on our developed general theory of LIF, I have developed '*Light-induced Force Nano Dynamics method* (LNDM)' for the evaluation of dynamics of NPs under the LIF and spontaneous inter-object force between NPs in the presence of thermal fluctuations [9]. By using LNDM, we have clarified that we can simultaneously control the spatial configuration of an assembly of metallic NPs and their radiative relaxation rate. Especially, the light-scattering can be greatly enhanced with increasing of NPs since the large dipole moment can be generated via light electromagnetic field, i.e. "*plasmonic superradiance*". Furthermore, we have clarified that we can realize the wavelength tunable optical energy transfer along a one-dimensional array of metallic NPs on a flexible nanoscale chain under the external field resonant with its vibration mode [10]. Also, if I have a time, the noise reduction of SPM cantilever by cavity-induced radiation force will be introduced, which is called macroscopic laser cooling [11].

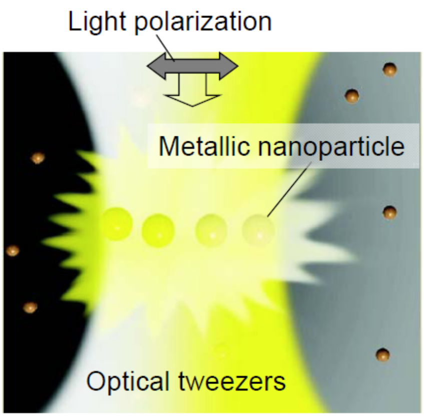

Fig.1 Schematic image of strong light scattering by super-radiance phenomenon in metallic nanoparticles arranged by optical tweezers.

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