Right- and left-handed optical torques acting on vanadium oxide particles

RIES, Hokkaido Univ.[1], ○Christophe Pin[1], Keiji Sasaki[1]

E-mail: christophe.pin@es.hokudai.ac.jp

Because of the fast insulator-to-metal phase transition of vanadium dioxide (VO_2) and the resulting nonlinear change of optical properties, [1] VO_2 nanoparticles in water solution are optically trapped in orbit around a focused IR laser beam. [2-3] For particles large enough (typically larger than 200 nm in diameter) that are optically trapped using a circularly polarized Gaussian beam, the simultaneous excitation of several Mie resonances induces spin-to-orbital angular momentum conversion and results in the light spin-induced orbital rotation of the trapped particle. It was shown in previous work that this phenomenon enables controlling the rotation direction of the trapped particle. [2-3]

In this work, we conduct a more detailed investigation of the optical torque acting on trapped VO_2 particles. First, we numerically and experimentally demonstrate that the insulator-to-metal phase transition causes a flip of the optical torque handedness for a given range of particle sizes. Second, we show that under similar trapping conditions, particles with different size, shape and/or material composition may experience optical torques with opposite handedness. We numerically study how the heterogeneous material composition of vanadium oxide particles and particle clusters influences the handedness of the optical torque and describe the conditions under which left-handed orbital rotation occurs.

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