Scattering Asymmetry and Non-conservative Optical Forces on Nanoparticles

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We will address some basic questions related to the light forces on small (Rayleigh) particles, which are usually described as the sum of two terms: the dipolar or gradient force and the scattering or radiation pressure force. The scattering force is traditionally considered proportional to the Poynting vector, which gives the direction and magnitude of the momentum flow. However, as we will show, when the light field has a non-uniform spatial distribution of spin angular momentum, an additional scattering force arises as a reaction of the particle against the rotation of the spin. This non-conservative force term is proportional to the curl of the spin angular momentum of the light field [1].
We will discuss the peculiar dynamics of gold and silver nanoparticles in the non-conservative force field of an optical vortex lattice [2]. Radiation pressure in the vortex field (arising in the intersection region of two crossed optical standing waves) plays an active role spinning the particles out of the whirls sites leading to a giant acceleration of free diffusion. Interestingly, we show that a simple combination of null-average conservative and non-conservative steady forces can rectify the flow of damped particles. We propose a "deterministic ratchet" stemming from purely stationary forces [3] that represents a novel concept in dynamics.
The unusual properties of the optical forces acting on particles with both electric and magnetic response will also be analyzed [4]. We will focus on nanometer-sized spheres of conventional semiconductor materials, like Silicon (Si) or Germanium (Ge), which have extraordinary electric and magnetic optical properties in the infrared-telecom range of the electromagnetic spectrum [5-7]. Recent experimental results on microwave scattering on loss-less subwavelength dielectric spheres will be discussed [8]

References

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