Nanoparticle Dynamics in Non-Conservative Optical Fields

Juan José Sáenz

Moving Light and Electrons (Mole) Group, Depart. Física de la Materia Condensada,
Univ. Autónoma de Madrid, Spain

juanjo.saenz@uam.es

Light forces on small (Rayleigh) particles 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 illustrate the relevance of the spin force in the particular simple case of a 2D field geometry arising in the intersection region of two standing waves [2]. The unusual properties of the optical forces acting on particles with both electric and magnetic response will also be analyzed [3].

We will also discuss the peculiar particle dynamics in the non-conservative force field of an optical vortex lattice [4]. Radiation pressure in the whirl-light field (arising in the intersection region of two crossed optical standing waves [2]) 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 [4] that represents a novel concept in dynamics with considerable potential for fundamental and practical implications.

References

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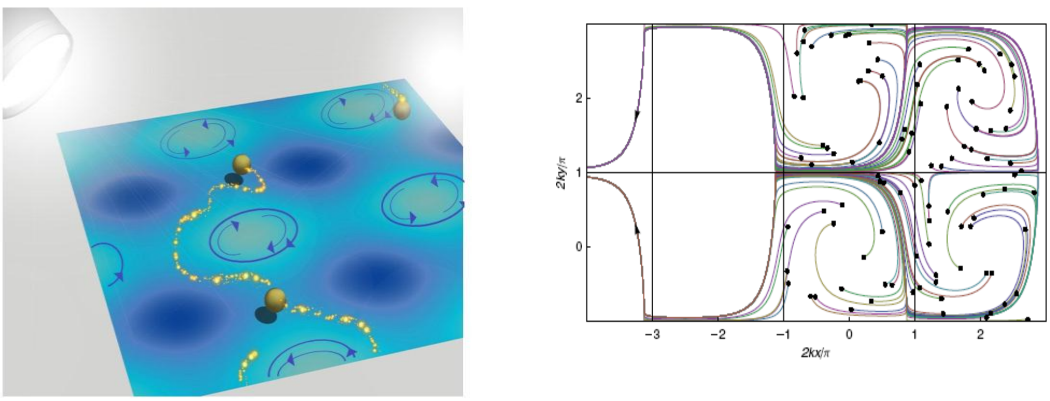

Left: *Sketch of a nanoparticle enhanced diffusion path in an optical vortex lattice [4].* ***Right:*** *Particle trajectories in a “deterministic”optical ratchet. Initial positions are random within the chosen unit cell. All paths converge to two limit periodic trajectories which flow to the left [5].*