Optimizing optical tweezing with directional scattering in composite microspheres

Instituto de Fisica, Universidade Federal do Rio de Janeiro

In effective medium approximation, directional light scattering by spherical nanosphere made up of composite material is demonstrated in the optical regime. Effective optical properties of composite media are described by the Extended Maxwell-Garnett theory (EMG). By varying the extra degree of freedom generated by EMG theory (i.e. filling fraction and size of inclusion), the zero backscattering efficiency or so-called 2nd kerker condition is achieved in composite media. Composite is made up of high refractive index dielectric particles that exhibit strong surface reflection, so that it usually cannot be applied to optical tweezers. At the kerker condition, we numerically investigate and optimise the optical trapping force on a composite particle in optical tweezers, using a highly focused laser beam with high numerical aperture. Moreover, the connection between optical trapping force and the directional scattering is unveiled, and we show that optical trapping force can be optimised at second kerker condition. The results for the stability of optical tweezing shows that the strength and position of the trapped particle is strongly affected by spherical aberration. Spherical aberration is caused by refractive index mismatch between the objective mirror and medium around the particle (water in this case). Furthermore, we present an interpretation of our results in terms of the oscillations of axial force at focus and backscattering efficiency. Our findings indicate that a correlation between the minima of backscattering efficiency and oscillations existing in interferometer picture leads to a stable trapping condition. This analysis provides a detailed and systematic strategy to optical tweezing which not only allows for high refractive index material trapping but also optimize optical pulling force.