Reversal of optical binding force between uniaxial anisotropic heterodimer based on the forced breaking of symmetry

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This study theoretically investigates the optical binding force exerted on uniaxial anisotropic heterodimer induced by an arbitrarily polarized high-order Bessel beam (HOBB). Such non-diffracting light suppressed the influence of the axial intensity profile of the illuminating beams on the self-organization process which then depended critically upon the inter-particles interactions. Using the generalized multi-particle Mie equation (GMM) [1,2], we analyzed the lateral binding force in terms of Maxwell's stress tensor for various inter-particle distance at some specific wavelengths. The stimulating connection between the reversal of near-field binding force of uniaxial anisotropic heterodimer and the role of symmetry-breaking has not been investigated comprehensively in the literature. In this work, the symmetry of spherical uniaxial anisotropic heterodimer-setup is broken forcefully by shining the light from a specific side of the set-up instead of impinging it from the top. We demonstrate that for the forced symmetry-broken spherical heterodimer-configurations: reversal of lateral and longitudinal near-field binding force follow completely distinct mechanisms. Interestingly, the reversal of lateral binding force can be easily controlled changing the direction of light propagation or by varying their relative orientation. Besides, the polarizations of incident HOBB considerably influence the optical binding force of uniaxial anisotropic nanoparticles. In binding uniaxial anisotropic nanoparticles, the polarization of incident beams should be chosen in accordance with the anisotropic permittivity tensor elements. This simple process of controlling binding force may open a novel generic way of optical manipulation even with the anisotropic heterodimers of other shapes. Though it is commonly believed that the reversal of near-field binding force should naturally occur for the presence of bonding and anti-bonding modes, our study based on Lorentz-force dynamics suggests notably opposite proposals for the aforementioned cases. Observations in this article can be very useful for improved sensors, particle clustering and aggregation.

References

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