

Statics and Dynamics of laser-illuminated ellipsoidal particles

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We report on the mechanical effects of light on dielectric non-spherical particles. The particles are micrometer-sized and have an ellipsoidal shape. Previous optical levitation experiments using a single laser beam showed that such particles undergo sustained oscillations driven by laser radiation pressure forces and torques [1, 2] (Fig. 1a). Here, we focus on the main findings when adding a second counter-propagating beam. New static and dynamic behaviours have been unveiled that depend on the power ratio of the two beams and the aspect ratio of the ellipsoid (Fig. 1b). We present state diagrams and offer a consistent interpretation of the observations thanks to numerical simulations based on a simple two-dimensional (2d) ray-optics (RO) model.

These experiments are done in the context of gathering data to support theoretical models of light scattering with force and torque calculations.

The findings here are useful to know, as there are numerous practical applications that use optical manipulation techniques in both biology and physics [3, 4, and 5].

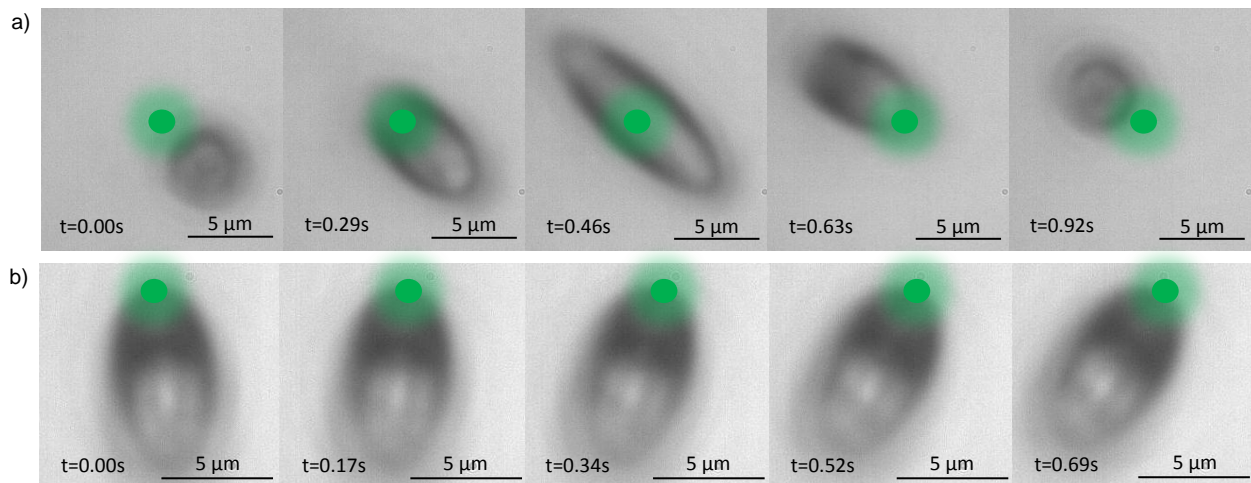


Figure 1: This figure is a series of top-down optical microscopy images showing different dynamical states of laser-illuminated ellipsoidal particles. (a) First kind of oscillations called "primary oscillations". This sequence is only half of the oscillation, as the other half is a mirror of the first. The particle passes through the single beam illuminating it (the green spot) and repeats that motion back and forth until the power is changed. The aspect ratio of this ellipsoid is 4.55, the power of the single up beam is 5.83 mW ($\lambda=514$ nm) and the beam waist radius is 1.8 μm . (b) Another kind of oscillation named "secondary oscillation". Again, this is just the first half of the oscillation, whereby the second half is a mirror of the first. The particle pivots around the beam axis of the two beams illuminating it (the green spot). The aspect ratio of this ellipsoid is 4.23, the power of the up and down beams is 15.50 mW and 4.98 mW ($\lambda=514$ nm) respectively and the beam waist radius is 1.8 μm .

References

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