Optical Tweezers – Instruction Notes

Keywords: radiation pressure, optical trapping, Rayleigh scattering, Mie scattering, diffusion, random walk

I. GOALS OF THE EXPERIMENT

In a typical optical tweezers configuration, the incoming light originates from a focused laser beam through a microscope objective of high numerical aperture and focuses on a spot in the sample. The intensity or field distribution in the focus causes micron-sized beads with a higher index of refraction than the liquid (usually water) to be trapped. For a realistic simulation of a small particle in a trap, it is necessary to consider the Brownian motion. The amplitude of these fluctuations is a measure of the trap strength

Since their development in the 1980s, optical tweezers have have become a versatile tool in many fields. In particular, the capability of optical tweezers to measure forces on particles offers a unique and valuable tool for studying cell components such as biological proteins and molecular motors.

II. LEARNING CONTENT

- theory of trapping
- setup of optical tweezers and microscope
- methods for position detection and required setup (Quadrant Diode and Camera)
- different calibration techniques (statistical, equipartition, viscous, PSD)
- diffusion and random walk (Ficks' law, Einsteins' law, viscosity).
- laser safety

III. PROCEDURE

FIRST LAB SESSION

- prepare a sample chamber
- set and calibrate the CCD camera
- by drawing a line on a microscope slide, try to determine the location of the focus in water.
- prepare a dilute solution of 3 μm polystyrene beads in water.
- fill a sample chamber with a drop of this solution. Try to catch a particle.
- calibrate the trap by moving the sample chamber at a known speed relative to the focus.
- use the calibrated trap to measure the viscosity of the bead solution in water

SECOND LAB SESSION

- set and calibrate the trap with different techniques
- measure the trapping strength of the optical tweezer

IV. REFERENCES:

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(4) Sischaka, A. (2002), *Aufbau einer Optischen Pinzette*, Diplomarbeit, Universität Bielefeld