Imaging the interactions of optically trapped particles

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An optically trapped sphere with a diameter between 100 and 500 nm fluctuates in its position as a function of the trapping parameters and the sphere's local environment. The position can be tracked interferometrically in the MHz range with a precision of 1 - 5 nm in three dimensions. The fluctuations are altered by external enthalpic or entropic forces acting on the sphere. This interaction can be visualized by recording the particle's three-dimensional trajectories. In contrast to optical tweezers, which are only able to measure small forces in one direction, a photonic force microscope will also scan the complete interaction potential, from which the force in any direction can be derived. This trapping and tracking technique is applied in various experiments for example: single molecule fluctuations of the protein Myosin II to determine its micro-mechanics, interaction of phagosomes with their local environment, interaction of single microtubules with functionalized trapped probes, and thermally induced transitions between adjacent potentials.

1. A.Rohrbach and E.H.K.Stelzer, "Trapping forces, force constants and potential depths for dielectric spheres in the presence of spherical aberrations", Applied Optics **41** (13): 2494-2507 (2002).

2. A. Rohrbach and E. H. K. Stelzer, "Three-dimensional position detection of optically trapped dielectric particles", J. Appl. Phys. **91** (8): 5474-548 (2002).

3. A. Rohrbach, H. Kress, and E. H. K. Stelzer, "Three-dimensional tracking of small spheres in focused laser beams: influence of the detection angular aperture", Optics Letters **28**: 411-413 (2003).

4. A. Rohrbach, H. Kress and E. H. K. Stelzer, "Reply to comment on: Trapping forces, force constants and potential depths for dielectric spheres in the presence of spherical aberrations", Appl. Opt., **43** (9) (2004).

5. A. Rohrbach, C. Tischer, D. Neumayer, E. L. Florin, and E. H. K. Stelzer, "Trapping and tracking a local probe with a Photonic Force Microscope", submitted.

6. H. Kress, E. H. K. Stelzer, and A. Rohrbach "Tilt angle dependent 3D-position detection of a cylindrical particle in a focused laser beam", submitted.

7. N. Becker, S. Altmann, T. Scholz, H. Hörber, E. H. K. Stelzer, and A. Rohrbach "Single-molecule bending stiffnesses determined by three-dimensional bead position histograms", submitted.