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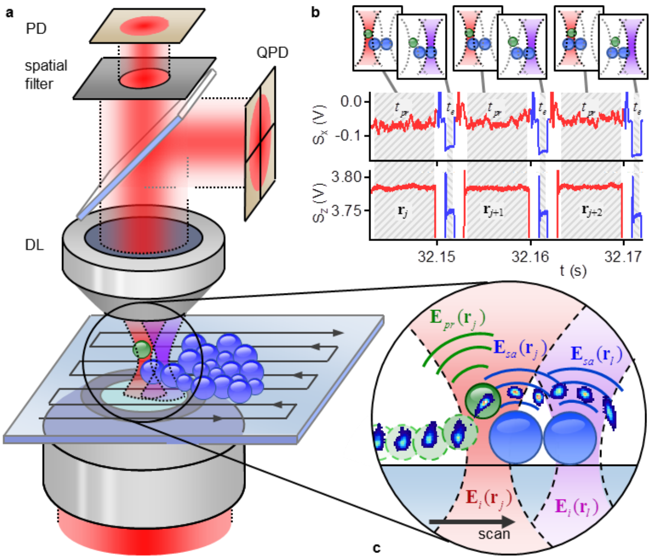
Master thesis

Surface height profile imaging with Optically Trapped Spheres

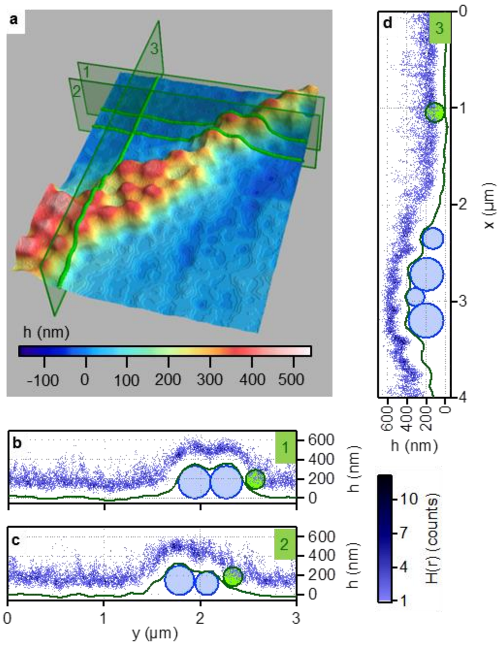
Background: Optical traps play an increasing role in the bio-nano-sciences due to their ability to flexibly apply forces on tiny structures in fluid environments. Combined with particle tracking techniques they allow sensing miniscule forces exerted on these structures. Similar to atomic force microscopy (AFM), but much more sensitive, an optically trapped probe can be scanned across a structured surface to measure the height profile from the displacements of the probe.



We use a combination of a time-shared twin-optical trap and nanometer-precise 3D interferometric particle tracking reliable height-profiling and surface imaging, with a spatial resolution below the diffraction limit. The technique exploits the high energy thermal position fluctuations of the trapped probe, leading to a sampling of the surface 5000 times softer than in AFM. The measured height and force profiles from test structures and helicobacter cells illustrate the potential to uncover specific properties of hard and soft surfaces. (see Friedrich & Rohrbach in Nature Nanotechn., 2015).

Research goal: Further increasing the spatial resolution

The smaller the size of the trapped sphere, the smaller the structures at the surface that can be probed. The achievable spatial resolution depends in a first approximation linearly on the probe diameter and its polarizability. We want to use probes with diameters below 100 nm and with a high polarizability, such as small metal or semiconductor beads. At the same time, the trap stiffness must be increased and the diffusion volume of the probe decreased. Here, the right laser wavelength plays must be found for both trapping stability and tracking sensitivity. In addition, other characteristics of the probe's thermal motion such as 3D fluctuation widths or temporal correlations shall be explored to uncover further structural information of the sample.



Research project

The project parts requires experimental and construction work, as well as computer simulations and theory to work out the principles and to find the best research strategy for solving the above questions.
We are looking forward to answering your questions!