Exploring cells and bacterial molecular motors with a multimodal workstation combining microscopy, holography and optical tweezers

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Optical tweezers are an exciting technology with increasing impact across a variety of different fields, with most important applications in biomedical sciences. By tightly focusing a laser beam, optical tweezers enable to confine, move and rotate near the focus spot precisely transparent microscopic particles. The trapped particles, which must have a higher refractive index than the surrounding environment, as it is the case for cells and bacteria cultures, are thus manipulated in a contact-less and aseptic way. Most common application of optical tweezers are found in molecular and cell biology to manipulate and control cell organelles as well as to measure smallest forces of cell interactions.

The implementation of liquid crystal spatial light modulators (SLM) in holographic optical tweezers (HOT) enables to modulate the phase-front of a laser light field spatially by means of computer generated holograms. This allows for the dynamic optical control of a multitude of particles by tailoring the light field in several single tweezers or even more complex optical traps as e.g. non-diffracting and self-similar light fields, and thus extending the applications of conventional optical tweezers.

In this contribution, we present our experimental HOT workstation and show exciting applications on investigations at single cell level, as e.g. the study of synchronization in bacteria and the assembly of bio-hybrid machines, as well as the combination of HOT with different microscopy techniques, as digital holographic microscopy (DHM) in order to analyze the inner structure of eukaryotic cells and to model the parasitic-host interaction during an infection processes.