OPTICAL TWEEZERS WITH STRUCTURED LIGHT FOR BIOLOGY

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Shortly after Ashkin demonstrated the 3D trapping of polystyrene beads using optical tweezers in 1986 [1] he used this method for studies of biological and biomedical systems. Already in 1987 Ashkin showed optical trapping of viruses and bacteria [2]. Since then the field has been developing extremely fast and found tremendously broad range applications in biology and biomedicine. This incredibly rich field is still finding new and exciting directions. Trapping is done in liquids and in vacuum.

In optical trapping we use light to apply forces to matter. The way light can apply forces to a nano- or micro-sized object is easily understood as an exchange of momentum between the light beam and the object. This applies to the exchange of both linear momentum and angular momentum. Methods based on these phenomena promise high flexibility and an opportunity for trapping and driving a large variety of objects.

Optical drive of micron scale devices promises the ability to carry out measurements and operations on microscopic systems in a flexible way. The energy that is needed can be transmitted without harm through many materials including a membrane of a cell. Optical tweezers have been already used in atom optics as well as to measure mechanical properties of cells and their components, and also for studies of molecular motors. The stimulation of cells by forces and torques applied to them has allowed studies of cell response and signal transduction. The stimulation of vestibular system in zebra fish enabled in depth studies of this system and the neuronal networks that participate in the signalling of this system.

Sculpted light produced using programmable spatial light modulators have significantly enhanced the configurable optical trapping. These sculpted light beams can be used for optical trapping of Bose-Einstein Condensate and their manipulation. They can also provide beams carrying angular momentum that enables introduction of rotation. Quantitative measurements of this rotation are possible through a measurement of the change of polarisation state of light after passing through the object. The transfer of the angular momentum can then be used for several applications in biology and medicine. Sculpted light can also be used to substantially enhance the trapping efficiency and therefore increase the applied forces.

1. A. Ashkin, J. M. Dziedzic, J. E. Bjorkholm, and S. Chu, "Observation of a single-beam gradient force optical trap for dielectric particles", Opt. Lett. **11**, No. 5 1986.
2. A. Ashkin and J. M. Dziedzic, "Optical Trapping and Manipulation of Viruses and Bacteria", Science **235**, 1516, I987.