Structured light in optical tweezers for functional microstructures

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Two-photon-photopolymerisation (2PP) provides a versatile tool for rapidly fabricating micron-scale structures used for a variety of experiments relating to optical trapping, microfluidics and biological systems, among many others. Such systems are, however, highly susceptible to aberrations which can hinder the fabrication process [2]. The ability to accurately control feature size is an important step in ensuring fabrication of high-resolution structures in-house, which we discuss in this work.

We outline how a modified holographic optical trapping setup can be used for rapid fabrication of high-resolution 3D structures used for studying micron-scale biological systems. We utilise a spatial light modulator (SLM) to correct for wavefront aberrations *in-situ*, capable of correcting highly-distorted beams that frequently pass through any number of optical components [1]. We demonstrate how correcting aberrations *in-situ* enhances fabrication quality even relative to more commonplace *ex-situ* methods, enabling precise control of over 50 independent, simultaneous foci. We discuss several fabrication algorithms which can be used to produce arrays of identical structures in parallel, as well as fabricating single structures of arbitary shape in excess of 100μm.

We show how a simple optical system can be used to design, produce and utilise structures for probing the behaviour of single-cell micro-organisms at a range of length-scales from individual cells, to collective dynamics. We use a variety of custom-designed structures and micro-machines for optical trapping experiments aimed at testing theories of bacterial motion.

[1] Tomáš Čižmár, Michael Mazilu, and Kishan Dholakia. In situ wavefront correction and its application to micromanipulation. *Nature Photonics*, 4(6):388–394, 2010.

[2] Lóránd Kelemen, Pál Ormos, and Gaszton Vizsnyiczai. Two-photon polymerization with optimized spatial light modulator. *Journal of the European Optical Society-Rapid publications*, 6, 2011.