Novel Light Field Shaping for Optical Manipulation

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Advanced photonics using novel holographic beam shaping has proved to be a powerful and emergent area in biophotonics. Light may be used in various guises. A prime example is optical micromanipulation. This is a powerful non-contact technique where micrometre sized particles can be grabbed, moved and generally manipulated solely with light. Optical tweezers is the most popular way to implement these forces using a single tightly focused light beam. They have forged an important bridge between physics, chemistry and biology. In recent years there has been a proliferation of activity in this area, fuelled, in part, by the recognition that we need to advance the “optical toolkit”. This essentially means creating more elaborate 2D and 3D light patterns (beam shaping) that can create an optical landscape. Particle and cellular motion on such a landscape will enhancing our ability to move and sort particles and importantly, create 2D and 3D arrays of particles [1].

Advanced beam shaping and optimal focusing may also be considered useful for the topic of cell transfection combined with optical tweezers. Here we consider the cell membrane which represents the outer extremity of all eukaryotic cells. In mammals, this is a thin (5nm) bi-layer film of lipids, embedded with various protein molecules at interspersed locations. Under normal circumstances, the lipid nature of the cell membrane acts as an impermeable barrier to the passage of most water-soluble molecules. Thus, the selective introduction of therapeutic agents to the inside of dysfunctional or diseased cells remains problematic. Methods for puncturing the cell membrane without causing any collateral damage have been devised and importantly, this includes laser-assisted techniques particularly using multi-photon processes. Bessel modes can be used for “focus-free” photoporation (see fig.1) and offer new opportunities for the field [2]. More advanced fields such as Airy modes are also of interest [3] This talk will cover both optical trapping, manipulation and cell transfection of gold nanoparticles using advanced beam shaping. Importantly we will discuss how to obtain optimal Bessel modes with uniform intensity and in situ wavefront correction for optical beam focusing using spatial light modulation.

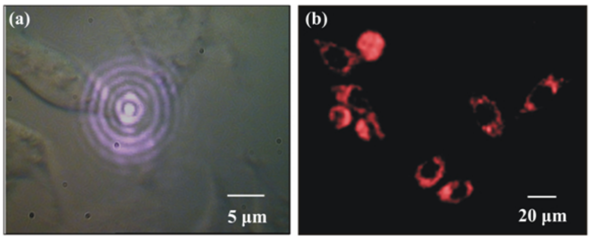

Figure 1. (a) The Bessel beam “focus” is positioned on the cell plane. (b) Upon successful transfection, the cells express the red fluorescent protein and fluoresce red (adapted from reference 2)

[1] “Optical Micromanipulation” K. Dholakia, P Reece and M Gu Chem. Soc. Rev, **37**, 42 - 55 (2008)
[2] “Femtosecond cellular transfection using a non-diffracting light beam” X. Tsampoula, V. Garcés-Chávez, M. Comrie, D. Stevenson, M.B. Agate, F.J. Gunn-Moore, C.T.A. Brown and K Dholakia, Appl Phys Lett **91**, 053902 (2007).
[3] **“**Optically mediated particle clearing using Airy wavepackets**”**, Jörg Baumgartl, Michael Mazilu & Kishan Dholakia. Nature Photonics 2, 675 (2008).