MSci Projects in the Optical Tweezers Group, 2010-11

Nano-Optics (experiment & theory) (1 student)

Nanostructured materials have physical features with dimensions that are smaller than the optical wavelength. As a result, the interaction of light with nanomaterials can display a variety of interesting phenomena with potentially useful applications.

The aim of this project is to investigate the potential of nanostructures for control of nano- and microparticles through optical interactions. The principal nanostructures to be studied are *optical nanofibres* formed by pulling a standard optical fibre to create a tapered region with a diameter less than the wavelength of the light propagating in the fibre. In the region of the taper the light forms a strong evanescent wave that has the ability to bind particles to the fibre. Such a tapered nanofibre has potentially useful applications for particle trapping, guiding and sorting, and even quantum information processing.

The project will combine both experimental and theoretical work on the production of optical nanofibres, modelling the optical field in and around the nanofibre, and the interaction with particles. It is suitable for a student who has, or wishes to develop, experience in optics, (nano-) photonics, laser physics and optical trapping.

Suggested reading:
V I Balykin, K Hakuta, Fam Le Kien, J Q Liang & M Morinaga, *Phys. Rev. A* **70** 011401(R) (2004)
F L Kien, J Q Liang, K Hakuta & V I Balykin, *Opt. Commun.* **242** 445 (2004)
G Brambilla, G Senthil Murugan, J S Wilkinson & D J Richardson, *Opt. Lett.* **32** 3041 (2007)
G Sagué, E Vetsch, W Alt, D Meschede & A Rauschenbeutel, *Phys. Rev. Lett.* **99** 163602 (2007)

Photonic Force Microscopy (experimental) (1 student)

An optical tweezers traps microscopic objects using a single tightly focussed laser beam under a microscope. When the optical trapping force is calibrated the optical tweezers can be used to image micro- or nanostructured surfaces by dragging a trapped 'probe' particle across the surface and measuring the displacement from equilibrium in a manner analogous to the atomic force microscope. For this reason the technique can be termed Photonic Force Microscopy (PFM).

This project will calibrate an optical tweezers for imaging and force measurement using a variety of microscopic objects including (but not limited to) microbubbles, micro-rods and carbon nanotubes. It is suitable for a student who has, or wishes to develop, experience in laser physics and optical trapping.

Suggested reading:
O M Maragò, P H Jones, F Bonaccorso, V Scardaci, P G Gucciardi, A Rozhin & A C Ferrari. *Femtonewton force sensing with optically trapped nanotubes*, Nano Letters **8** 3211-3216 (2008)
P H Jones, O Marago & E P J Stride, *Parametrization of trapping forces on microbubbles in scanning optical tweezers*, J. Opt. A: Pure Appl. Opt. **9** S278 – S283 (2007)
J E Molloy & M J Padgett, *Lights, action, optical tweezers*, Contemp. Phys. **43** 241 (2002)

Note: Dr Jones will be away from 31 May – 9 June, but you can register your interest in one of these projects by email.