Optical Sorting and Alignment of Small Objects in Fluids.

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The use of optical forces for the manipulation of small particles in suspension has proven to be an invaluable tool in many biological applications\(^1\). It has been shown that the single beam optical trap is a convenient means for the non-invasive confinement of single beads or living cells\(^2\). More recently, calibrated optical traps have been used for the measurement of the physical forces involved in biological systems. These cell-based measurements demonstrate the possibility of analysis of single cells based on optical trap strength, hydrodynamic forces, and the mechanical properties of the cell. Measurements of this type, however, have tended to be limited in throughput (one cell at a time) and in general have focused on mechanical and structural properties of the cell rather than on function or biological processes. Current analysis techniques of cellular processes typically include the use of fluorescent probes or other markers. Although the use of markers provides a high degree of specificity to the biological assay, markers have the potential for perturbing the native environment of the cell and leave open the question of how the marker itself may be altering the measurement\(^3\). Additionally, appropriate markers are not always available, or are difficult to introduce into the cell. A significant advantage can be obtained if properties of a cell can be probed in a non-invasive, all-optical fashion.

In this paper, a novel, non-invasive measurement technique for quantitative cellular analysis is presented that utilizes the forces generated by an optical beam to study the physical properties of live cells in suspension. Analysis is performed by rapidly scanning a focused laser line with a high cross-sectional intensity gradient across a field of many cells and monitoring their interaction with the beam. The response of each cell to the laser depends on its size, structure, morphology, composition, and surface membrane properties; therefore, using this technique, cell populations of different type, treatment, or biological state can be compared. Measurements on the experimental platform show detection of cellular changes earlier than other tag based approaches. Because no labeling or additional cell processing is required and because accurate assays can be performed with a small number of cells, this measurement technique may find suitable applications in cell research, medical diagnostics, and drug discovery.