Spotlight

On Alumnus Scott D. Murphy

Scott Murphy received a B.S. in physics from the University of Maryland in 1988. He began his career at nearby Goddard Space Center. After numerous successes as an instrument development and mechanical design engineer, he founded his own business, Rocket Science, Inc., in 1993.

With the "3 links" Jeep in Arizona
(yes we climbed over these rocks!). A respite from the integration activities of the Mars 2001 Odyssey GRS instrument.

During my undergraduate studies at Maryland, I also worked in the - then nascent - Center for Superconductivity Research (originally in the Condensed Matter Physics lab). After I graduated in December 1988, I went to work (as an on-site contractor) for NASA's Goddard Space Flight Center in Greenbelt, Maryland. While at Goddard, I decided to indulge my entrepreneurial bent and started a company, Rocket Science, Inc., in 1993. Since then, I have worked on a number of projects as an instrument development and mechanical design engineer, making the transition from physicist to engineer through experience and inclination. Under the auspices of Rocket Science, Inc. (RSI), I have had the good

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Pulling and Twisting Cells With 200 Tweeze and Optical Vortices

By Professor Wolfgang Losert

Manipulating objects with light: One of the many unexpected applications of lasers i tweezers for micron sized objects in biological systems and other soft materials. The pl principle of a laser tweezer is simple. To generate a tweezer, the laser is guided throug microscope objective and focused onto the sample. When the sample object one wants trap has a different index of refraction than the background fluid, refraction of the laser transfers some of the photon momentum to the object. One can calculate that the net f higher index of refraction materials is towards higher light intensities, i.e. those objects drawn into the focal point. For objects between ~300nm and 10 micron, the force is ge sufficient to counteract.

Brownian motion and hold the pa place, that is the laser acts as a sized tweezer. Laser tweezers w or two moveable laser beams ha been used for breakthroughs in t biosciences over the past decad example to stretch DNA and mea the forces and fluctuations durin stretching.

A new application of laser tweez provides a striking demonstratio light fields may be used to contr biological processes. In these experiments at the University of Austin, a single laser tweezer is guide the growth direction of a n ending and accelerate nerve gro shown in Figure 1.

Fig 1: Recent example of laser tweezers in the literature: Nerve growth direction guided by light. A laser beam (bright spot) directs the growth direction of a nerve. (From "Laser leads nerve growth", Philip Ball, Nature Science Update Nov 27, 2002)

Holographic laser tweezer arra newest laser tweezers go beyon point force field towards more int One aim is to address questions biological samples such as how (communicate and cooperate. An investigate the properties of simp more detail by applying very cont use of diffractive elements, which light field of a single laser beam into arbitrary patterns, has emerged as a promising tec

The first instrument that uses rapidly adjustable diffractive elements is a holographic laser tweezer array microscope. We use a system that converts a sing independently moveable focal points with submicron resolution. Dr Losert's laboratory, with Dr. English (Chemistry), Dr. Lower (Geology), and Dr. Roy (Physics) is starting a b experimental studies that take advantage of the unique capabilities of this system.

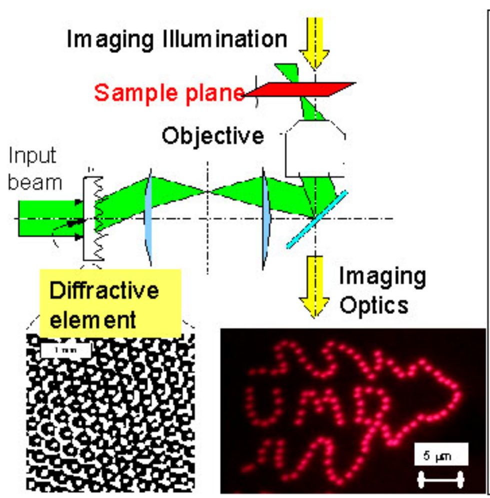

Fig. 2: Schematic of the hc tweezer array. A single las converted by a diffractive e complex pattern of focal pc plane. The diffraction patte the arrangement of laser sp can be changed rapidly. A by > 100 laser focal points right using a dyed fluid sa points are independently m

The schematic in figure 2 explains the basic operating principle. Figure 3 shows a custo more than 100 laser light points generated by the system. Several of these points can b hold and move single cells.

In addition to regular focal points, the system can also generate optical vortices, barrel-shaped distributions of light intensity that carry angular momentum and apply controlled amounts of torque to objects.

The ability to generate controlled force and torque fields with multiple laser tweezers allows us to manipulate and control a variety of complex structures on the micron scale, from crystal growth structures to systems of cells.

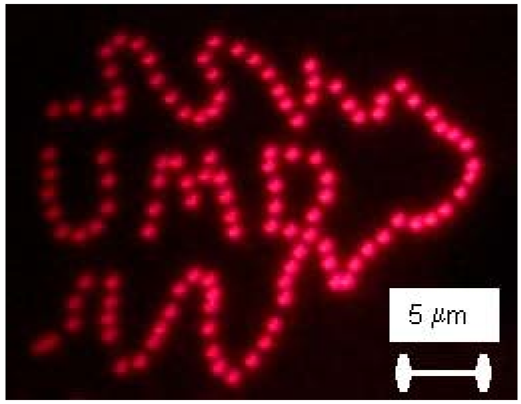

Fig. 3: Larger view of the custom pattern produced by laser focal points of the adaptive tweezer array illumi a dyed fluid sample.

Application: Stretching Cells

Under certain conditions, cells deform spontaneously, e.g. during nerve growth and during the spread of cancerous cells. A complex scaffolding of stiff chains of proteins drives these deformations. The chains (filaments) are very thin (5-25 nanometer in diameter), yet some are stiff enough to reach lengths of more than 10 micrometer, comparable to the size of large cells. The filaments form intricate branched networks through polymerization, and can quickly depolymerize. The ability t rapidly and reversibly polymerize into different shaped networks of filaments generates of the forces that allow cells to change shapes and move. One example of a spontaneo deformation in a simple model of a cell is shown in Fig 4. Lasers can be used to force s deformations. As a first example, Dr English and I have used the tweezer array to stret vesicles (membranes with nothing inside) as shown in Fig 5.

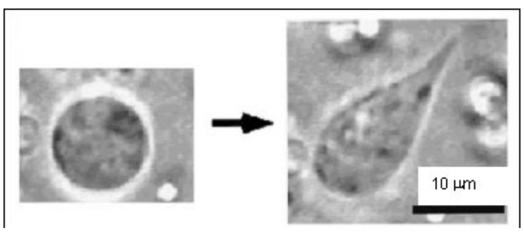

Fig. 4: A model cell: Vesicles (spheres of membrane material) filled with actin. After polymerization of the actin is induced, the vesicle changes shape, mimicking processes during the motion of cells (Miyata et al. PNAS 96, 2948 1999).

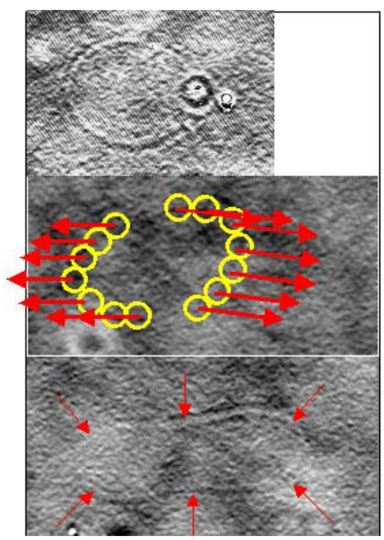

Fig. 5: Stretching of a large vesicle the laser tweezer array at Marylanc vesicle is held by two semicircles of laser tweezers each (yellow circles) two regions are pulled apart, stretcl the vesicle (vesicle position indicate arrows).

For updated movies and news from laser tweezer array experiments please visit our tweezer array webpage (www.ireap.umd.edu/granular/tweezer_array).

Dr. Losert is an assistant professor in the University of Maryland Department of Physics, working in the field of Nonlinear Dynamics & Chaos. If you have questions regarding his research, you may email him at wlosert@glue.umd.edu.

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fortune to design, build and integrate instruments for spaceflight and sub-orbital missions. Recently, I have been the lead mechanical engineer for Goddard's Gamma Analog Front End subsystem on the Mars Odyssey (which is orbiting Mars as I write this!), served as lead mechanic on Goddard's ACES and Nightglow projects (unmanned aerial vehicle and high altitude balloon respectively).

I believe that this physicist/engineer hybrid is an ideal combination for the development of advanced astrophysical instrumentation. The attention to the overall science goals (physicist) and the respect for and adherence to the practices of good design and development (engineer) make for a powerful combination of disciplines for building scientific instrumentation.

My experiences as a student researcher were formative and memorable. Working for Dr. S. Bhagat and with several graduate students during the times of the High Temperature Superconductivity discoveries in the late 1980s was exciting and provided for honing of experimental skills and judgement. While in the lab, I was given the responsibility of building and running an AC Susceptibility experiment to characterize the new High Tc superconducting compounds the lab was making. I was fortunate in that Dr. Bhagat gave me leeway to flail around (typical undergrad activity) with the instrument so long as I produced data (and I did!) while he hammered away on …er… nurtured the graduate students (typical professorial activity).

The experience of working in a physics lab as an undergraduate is one that I would highly recommend. Being involved in a professional academic environment, working with upperclassmen and working at the forefront of scientific discovery brings to full bloom the essence of a first rate educational experience.

My time as the president of a tech company and an engineer working in the space program has been a rewarding and satisfying one. Being president of a company requires one to wear many hats. Juggling the responsibilities of business and technical development forces one to learn to prioritize. You learn quickly to stay focused on the larger more important issues but, at the same time, keep the details in mind (because that's where the devil is…).

All in all, I would say a physics education is a great one. It's intellectually rigorous, provides a foundation that can transfer across many technical disciplines and allows you to design and build things for the lab, rockets, planes and spacecraft.

Ain't it cool?!

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