Los Angeles Times | ARTICLE COLLECTIONS

← Back to Original Article

TRAPPING THE LIGHT FANTASTIC : Researchers' Laser Uses Borrow Pages From Science Fiction

March 20, 1989 | THOMAS V. HIGGINS | *Higgins is a free-lance science writer who lives in Encino.*

Nineteen years ago, Arthur Ashkin performed a remarkable feat at Bell Laboratories in Holmdel, N.J. The physicist levitated a tiny glass sphere with a beam of laser light.

The microscopic orb, no wider than a human hair, hovered motionless in space, helplessly ensnared by some magical force that seemingly defied both gravity and common sense.

Even though the focused light from Ashkin's laser was almost a billion times more concentrated than sunlight and could slice through a sheet of metal, the beam passed harmlessly through the transparent glass bead, or microsphere.

Ashkin's measurements revealed that the laser light was refracting, or bending, through the microsphere and subjecting it to a subtle combination of surprisingly strong forces. A microsphere placed in the laser beam is drawn to the focal point--the narrowest part of the beam. Electromagnetic forces perpendicular to the direction of the beam also keep the microsphere centered.

The result was startling. Like some force beam in a science fiction movie, the laser light trapped the microsphere within its focus. When the beam's focus moved, the microsphere helplessly followed.

Today, years of development have transformed Ashkin's laser light trap into a new, powerful research tool with mind-boggling applications.

Laser beams are being used to capture living microorganisms. And traps made from nothing but laser light can bring speeding atoms to a halt and imprison them for minutes at a time, allowing scientists to study them with a clarity never before possible.

Some of the applications under investigation range from automated sorting of biological cells to the production of antimatter rocket fuel for interstellar space flight--all made possible by the purity and intensity of laser light.

It was Ashkin's research group at AT&T Bell Laboratories who discovered that laser light traps also worked on microscopic organisms.

Reporting on their work in the journal Science, Ashkin and his colleague J. M. Dziedzic wrote: "We have used the laser light trap as 'optical tweezers' for moving live single and multiple bacteria while being viewed under a high-resolution optical microscope."

The invention of "optical tweezers" could revolutionize microbiology by providing hands-off control on a microscopic scale.

Tudor N. Buican, a researcher at the Life Sciences Division of Los Alamos National Laboratory in New Mexico, is perfecting optical tweezers into a computerized instrument he calls a "microscopic robot." Using a computer to control the positioning of laser beams, Buican can automatically sort and manipulate cells inside an airtight chamber while observing the whole process on a video monitor.

For Buican, optical cell manipulators have distinct advantages over existing mechanical cell manipulators because they are non-invasive, more precise and can operate through the windows of a sealed container. These capabilities are vital in the study of infectious diseases such as AIDS, in which contamination is a serious concern.

Optical tweezers could also be used to probe the inner workings of living cells in unique detail. David Clapham of the Mayo Clinic in Rochester, Minn., has proposed inserting chemically treated microspheres inside of cells and moving them around with optical tweezers in order to map the biochemistry of the cell.

"The microsphere can be coated with a compound that senses calcium, for example," Clapham explained. "The fluorescence of the bead would change to reflect local calcium concentrations." Clapham believes the same technique could be used to chart other ion concentrations within the cell, which is important for understanding cell function.

At the Beckman Laser Institute at UC Irvine, Michael Berns is already using laser light traps to study the biomechanics of cells. His investigations have recently uncovered surprisingly high spring tensions on the chromosomes within a cell.

"What we do," Berns explained, "is grab the chromosomes with the optical trap, and that causes the cell to exert a very strong force to pull them out of the optical trap. When they get out of the trap, there's so much force pulling on them that they then recoil at an enormously high rate of speed." Berns hopes laser light traps will help unravel some of the mystery surrounding the physical mechanisms of cell division.

Perhaps the most fascinating aspect of laser light traps is their ability to cool the atoms of a gas to record low temperatures.

To cool a gas, the average speed of its atoms must be reduced, and when the atoms are at rest, the temperature has reached absolute zero.

Although absolute zero (0 Kelvin) is technically unattainable, William Phillips, Paul Lett and others at the National Institute of Standards and Technology in Gaithersburg, Md., came within 43 millionths of a degree of it last summer by using the forces of laser light to slow and capture atoms of sodium.

The scientists first slow down the atoms by bombarding them with photons of laser light traveling in the opposite direction, a process that Paul Lett likens to throwing Ping-Pong balls at onrushing bowling balls. Once the atoms have been slowed to a virtual stop, they are snagged in an "optical molasses" created by six opposing laser beams pointing east-west, north-south and up-down. For a few minutes this collection of atoms becomes the coldest spot on earth.

Optical molasses amounts to a lot more than just an esoteric refrigerator, however. Physicists are interested in using the technique to test their theories of the atom by exploring the interaction between slow-moving atoms. Spectroscopists can also measure the light emission and absorption of ultra-cold atoms with unprecedented precision.

Optical molasses could improve the accuracy of atomic clocks by 10,000 times. And there are even schemes to use laser light traps for the manufacture and storage of solid antimatter.

Antimatter, as any Trekie will explain, is the "flip side" of ordinary matter, and when the two opposites unite, they obliterate each other with an intense burst of pure energy.

Laser light traps might one day make it possible to contain antimatter and harness its enormous potential energy. If so, the stars would literally be within our grasp.