

OBITUARIES

Arthur Ashkin

Arthur Ashkin, a groundbreaker in the study of light-matter interaction and the discoverer of optical trapping, died on 21 September 2020 in Rumson, New Jersey. He shared the Nobel Prize in Physics in 2018 for “optical tweezers and their application to biological systems.”

On 2 September 1922, Ashkin was born into a Ukrainian Jewish family in Brooklyn, New York. He received a physics BS from Columbia University in 1947. At Columbia’s Radiation Laboratory, he constructed magnetrons for US military radar systems. He then went to Cornell University, where he interacted with many physics luminaries, including Hans Bethe and Richard Feynman.

In 1952, after getting his doctorate in nuclear physics under William Woodward, Ashkin went to work for Bell Labs. He initially studied microwaves but switched to lasers in 1961 and worked on parametric oscillators and nonlinear aspects of light propagation in optical fibers. His curiosity about radiation pressure had already been piqued. At a lecture, he heard about the peculiar motion of small particles inside a visible laser’s resonant cavity. Called runners and bouncers, the particles were moving back and forth and doing crazy things. Ashkin said at the time, “We think it might be radiation pressure.”

Ashkin’s vision was to exploit the momentum of light and its interaction with matter. He showed in a seminal 1970 paper that two laser beams pointed at one another could hold tiny inert objects. Removing one laser propelled a particle along the other’s direction of propagation. Ashkin built on those concepts and developed optical tweezers. He was interested in both trapping and moving different-sized objects, from atoms to cells. Having gained through that work a deeper insight into the role of radiation pressure and dipole forces of light, Ashkin became part of a team aiming to cool and trap an ensemble of atoms. The researchers succeeded in slowing atoms in “optical molasses” cooled to a mere 300 μ K.

Confining atoms close to absolute zero was parallel to trapping larger particles in water. In 1986 Ashkin trapped micron-sized objects using a single tightly focused laser beam. Thus the

field of optical tweezers was born. The elegance of the approach cannot be overstated. The insights Ashkin gained were built on exploiting the momentum of light.

Ashkin was also part of a team that applied the principle of a single-beam (dipole) trap to grab a few hundred sodium atoms, for a few seconds, directly from optical molasses. Although minuscule, those studies showed that momentum may impart meaningful and important forces and displacements to objects ranging from a single atom to cells and beyond. Ashkin then initiated the use of optical tweezers on various living systems, including the tobacco mosaic virus, bacteria, red blood cells, and algae, with no damage. In his Nobel Prize interview, he said that when he told colleagues he was “catching living things with light, people said, ‘Don’t exaggerate, Ashkin.’”

It’s no exaggeration, though, to say that optical tweezers have revolutionized biological science, particularly single-molecule biophysics. Although the forces exerted by tweezers are small and cannot break a covalent bond, they are ideal for exploring protein-protein interactions and the forces produced by most motor proteins. Optical tweezers are versatile; they demonstrate an exquisite example of a calibratable, Hookean spring. Scientists became adept at trapping microscopic beads tethered to molecules to make precision measurements.

Importantly, Ashkin’s work moved the science away from exploring ensembles of molecules to performing true single-molecule studies. However, to focus solely on the impact of optical tweezers to biology would be a disservice. They have expanded and enriched our understanding of startlingly diverse areas, including nonequilibrium thermodynamics, the very nature of the linear and angular momentum of light, and colloidal science. Today optical tweezers are successfully used in levitated optomechanics, which is poised to provide one of the highest-precision terrestrial sensors and probe the puzzling classical-quantum boundary for mesoscopic particles. At SPIE’s 2015 annual meeting on optical trapping and manipulation, Ashkin sent a warm message saying that he was excited to see everyone working on “an ever-expanding field” of tweezers



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and “wished the community continued success.”

Ashkin was also a lauded mentor and teacher. Ursula Gibson, a physics professor at the Norwegian University of Science and Technology and past president of the Optical Society, met Ashkin when she had an internship at Bell Labs. She says of him, “His generous humor, geniality, and interest in a wide range of discussions were wonderful parts of lunchtime conversations. I was not working with him directly, but learned of his experiments. It was a special treat to use optical tweezers while on sabbatical in 2004, furthering the techniques he pioneered.”

Retiring from Bell Labs in 1992 did not abate Ashkin’s passion for new discoveries. When he heard about his Nobel Prize, he was working on a project in his basement to improve solar energy collection. Physicists consider light to hold a privileged place in the universe; Ashkin saw the potential of light’s interaction with matter and exploited it in a unique way. His insight and genius have left an exceptional imprint and legacy, and he has inspired and enthused generations of scientists. Optical tweezers continue to fascinate and pervade many areas of science.

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