# Optical Tweezers Principles And Applications





## BROWN WINTERS

**Single Molecule Analysis** Springer
Optical science and engineering affect almost every aspect of our lives. Millions of miles of optical fiber carry voice and data signals around the world. Lasers are used in surgery of the retina, kidneys, and heart. New high-efficiency light sources promise dramatic reductions in electricity consumption. Night-vision equipment and satellite surveillance are changing how wars are fought. Industry uses optical methods in everything from the production of computer chips to the construction of tunnels. Harnessing Light surveys this multitude of applications, as well as the status of the optics industry and of research and education in optics, and identifies actions that could enhance the field's contributions to society and facilitate its continued technical development.
**Optical Trapping and Manipulation of Neutral Particles Using Lasers** Cambridge University Press
This up-to-date overview describes in detail the physics of localized surface plasmon polaritons excited near fine metallic structures and the principles of near-field optics and microscopy related to this localized field. It also covers wider fields, from local spectroscopy to atom manipulation.
*Optical Tweezers* Taylor & Francis
This book describes the recently-discovered artificially curved light beam known as the photonic hook. Self-bending of light, a long-time goal of optical scientists, was realized in 2007 with the Airy beam, followed by the first demonstration of the photonic hook by the authors of this book and their collaborators in 2015 and experimentally in 2019. The photonic hook has curvature less than the wavelength, along with other unique features described in this book that are not shared by Airy-like beams, and so deepens our understanding of light propagation. This book discusses the general principles of artificial near-field structured curved light and the full-wave simulations of the photonic hook along with their experimental confirmation. The book goes on to show how the photonic hook has implications for acoustic and surface plasmon waves and as well as applications in nanoparticle manipulation.
**The Photonic Hook** Cambridge University Press
Intended for advanced undergraduates and beginning graduates with some basic knowledge of optics and quantum mechanics, this text begins with a review of the relevant results of quantum mechanics, before turning to the electromagnetic interactions involved in slowing and trapping atoms and ions, in both magnetic and optical traps. The concluding chapters discuss a broad range of applications, from atomic clocks and studies of collision processes, to diffraction and interference of atomic beams at optical lattices and Bose-Einstein condensation.
*Optical Holography* John Wiley & Sons
This important volume contains selected papers and extensive commentaries on laser trapping and manipulation of neutral particles using radiation pressure forces. Such techniques apply to a variety of small particles, such as atoms, molecules, macroscopic dielectric particles, living cells, and organelles within cells. These optical methods have had a revolutionary impact on the fields of atomic and molecular physics, biophysics, and many aspects of nanotechnology.In atomic physics,

the trapping and cooling of atoms down to nanokelvins and even picokelvin temperatures are possible. These are the lowest temperatures in the universe. This made possible the first demonstration of Bose-Einstein condensation of atomic and molecular vapors. Some of the applications are high precision atomic clocks, gyroscopes, the measurement of gravity, cryptology, atomic computers, cavity quantum electrodynamics and coherent atom lasers.A major application in biophysics is the study of the mechanical properties of the many types of motor molecules, mechanoenzymes, and other macromolecules responsible for the motion of organelles within cells and the locomotion of entire cells. Unique in vitro and in vivo assays study the driving forces, stepping motion, kinetics, and efficiency of these motors as they move along the cell's cytoskeleton. Positional and temporal resolutions have been achieved, making possible the study of RNA and DNA polymerases, as they undergo their various copying, backtracking, and error correcting functions on a single base pair basis.Many applications in nanotechnology involve particle and cell sorting, particle rotation, microfabrication of simple machines, microfluidics, and other micrometer devices. The number of applications continues to grow at a rapid rate.The author is the discoverer of optical trapping and optical tweezers. With his colleagues, he first demonstrated optical levitation, the trapping of atoms, and tweezer trapping and manipulation of living cells and biological particles.This is the only review volume covering the many fields of optical trapping and manipulation. The intention is to provide a selective guide to the literature and to teach how optical traps really work.

Optical Tweezers CRC Press

Life scientists believe that life is driven, directed, and shaped by biomolecules working on their own or in concert. It is only in the last few decades that technological breakthroughs in sensitive fluorescence microscopy and single-molecule manipulation techniques have made it possible to observe and manipulate single biomolecules and measure their individual properties. The methodologies presented in Single Molecule Techniques: Methods and Protocols are being applied more and more to the study of biologically relevant molecules, such as DNA, DNA-binding proteins, and motor proteins, and are becoming commonplace in molecular biophysics, biochemistry, and molecular and cell biology. The aim of Single Molecule Techniques: Methods and Protocols is to provide a broad overview of single-molecule approaches applied to biomolecules on the basis of clear and concise protocols, including a solid introduction to the most widely used single-molecule techniques, such as optical tweezers, single-molecule fluorescence tools, atomic force microscopy, magnetic tweezers, and tethered particle motion. Written in the highly successful Methods in Molecular BiologyTM series format, chapters contain introductions to their respective topics, lists of the necessary materials and reagents, step-by-step, readily reproducible laboratory protocols, and notes on troubleshooting and avoiding known pitfalls. Authoritative and accessible, Single Molecule Techniques: Methods and Protocols serves as an ideal guide to scientists of all backgrounds and provides a broad and thorough overview of the exciting and still-emerging field of single-molecule biology.

**Handbook of Single-Molecule Biophysics** Humana

This text begins by describing the basic principles and diagnostic applications of optical techniques based on detecting and processing the scattering, fluorescence, FT IR, and Raman spectroscopic signals from various tissues, with an emphasis on blood, epithelial tissues, and human skin. The second half of the volume discusses specific imaging technologies, such as Doppler, laser speckle, optical coherence tomography (OCT), and fluorescence and photoacoustic imaging.

*Thermoplasmonics* Peter Beyersdorf

The aim of this volume is to provide a comprehensive overview of optical tweezers setups, both in practical and theoretical terms, to help biophysicists, biochemists, and cell biologists to build and calibrate their own instruments and to perform force measurements on mechanoenzymes both in isolation in vitro and in living cells. Chapters have been divided in three parts focusing on theory and practical design of optical tweezers, detailed protocols for performing force measurements on single DNA- and microtubule/actin-associated mechanoenzymes in isolation, and describing recent advances that have opened up quantitative force measurements in living cells. Written in the highly successful Methods in Molecular Biology series format, chapters include introductions to their respective topics, lists of the necessary materials and reagents, step-by-step, readily reproducible laboratory protocols, and tips on troubleshooting and avoiding known pitfalls. Authoritative and cutting-edge, Optical Tweezers: Methods and Protocols aims help to further expand the accessibility and use of optical traps by scientists of diverse disciplines.

Biomedical Optical Imaging Oxford University Press

This 1996 book is an expanded edition of one of the best known introductions to optical holography.

Viscosities of Sucrose Solutions at Various Temperatures Elsevier

Combining state-of-the-art research with a strong pedagogic approach, this text provides a detailed and complete guide to the theory, practice and applications of optical tweezers. In-depth derivation of the theory of optical trapping and numerical modelling of optical forces are supported by a complete step-by-step design and construction guide for building optical tweezers, with detailed tutorials on collecting and analysing data. Also included are comprehensive reviews of optical tweezers research in fields ranging from cell biology to quantum physics. Featuring numerous exercises and problems throughout, this is an ideal self-contained learning package for advanced lecture and laboratory courses, and an invaluable guide to practitioners wanting to enter the field of optical manipulation. The text is supplemented by www.opticaltweezers.org, a forum for discussion and a source of additional material including free-to-download, customisable research-grade software (OTS) for calculation of optical forces, digital video microscopy, optical tweezers calibration and holographic optical tweezers.

**Quantitative Biomedical Optics** Cambridge University Press

Plasmonics is an important branch of optics concerned with the interaction of metals with light. Under appropriate illumination, metal nanoparticles can exhibit enhanced light absorption, becoming nanosources of heat that can be precisely controlled. This book provides an overview of the exciting new field of thermoplasmonics and a detailed discussion of its theoretical underpinning in nanophotonics. This topic has developed rapidly in the last decade, and is now a highly-active area of research due to countless applications in nanoengineering and nanomedicine. These important applications include photothermal cancer therapy, drug and gene delivery, nanochemistry and photothermal imaging. This timely and self-contained text is suited to all researchers and graduate students working in plasmonics, nano-optics and thermal-induced processes at the nanoscale.

*Single-molecule Techniques* Cambridge University Press

Nanoscience has become one of the key growth areas in recent years. It can be integrated into imaging and therapy to increase the potential for novel applications in the field of photomedicine. In the past commercial applications of nanoscience have been limited to materials science research only, however, in recent years nanoparticles are rapidly being incorporated into industrial and consumer products. This is mainly due to the expansion of biomedical related research and the burgeoning field of nanomedicine. Applications of Nanoscience in Photomedicine covers a wide range of nanomaterials including nanoparticles used for drug delivery and other emerging fields such as optofluidics, imaging and SERS diagnostics. Introductory chapters are followed by a section largely concerned with imaging, and finally a section on nanoscience-enabled therapeutics. - Covers a comprehensive up-to-date information on nanoscience - Focuses on the combination of photomedicine with nanotechnology to enhance the diversity of applications - Pioneers in the field have written their respective chapters - Opens a plethora of possibilities for developing future nanomedicine - Easy to understand and yet intensive coverage chapter by chapter

Microscale Acoustofluidics CSHL Press

Polarized Light and Optical Systems presents polarization optics for undergraduate and graduate students in a way which makes classroom teaching relevant to current issues in optical engineering. This curriculum has been developed and refined for a decade and a half at the University of Arizona’s College of Optical Sciences. Polarized Light and Optical Systems provides a reference for the optical engineer and optical designer in issues related to building polarimeters, designing displays, and polarization critical optical systems. The central theme of Polarized Light and Optical Systems is a unifying treatment of polarization elements as optical elements and optical elements as polarization elements. Key Features Comprehensive presentation of Jones calculus and Mueller calculus with tables and derivations of the Jones and Mueller matrices for polarization elements and polarization effects Classroom-appropriate presentations of polarization of birefringent materials, thin films, stress birefringence, crystal polarizers, liquid crystals, and gratings Discussion of the many forms of polarimeters, their trade-offs, data reduction methods, and polarization artifacts Exposition of the polarization ray tracing calculus to integrate polarization with ray tracing Explanation of the sources of polarization aberrations in optical systems and the functional forms of these polarization aberrations Problem sets to build students’ problem-solving capabilities.

**Optical Tweezers** Springer Nature

Thanks to the pioneering works of Ashkin and coworkers, optical tweezers (OTs) have become an invaluable tool for myriad studies throughout the natural sciences. Their success relies on the fact that they can be considered as exceptionally sensitive transducers that are able to resolve pN forces and nm displacements, with high temporal resolution, down to µs. Hence their application to study a wide range of biological phenomena such as measuring the compliance of bacterial tails, the forces exerted by a single motor protein, and the mechanical properties of human red blood cells and of individual biological molecules. The number of articles related to them totals to a whopping 58,000 (source Google Scholar)! Microrheology is a branch of rheology, but it works at micrometer length scales and with microliter sample volumes. Therefore, microrheology techniques have been revealed to be very useful tools for all those rheological/mechanical studies where rare or precious materials are employed, such as in biological and biomedical studies. The aim of this book is to provide a pedagogical introduction to the physics principles governing both the optical tweezers and their application in the field of microrheology of complex materials. This is achieved by following a linear path that starts from a narrative introduction of the "nature of light," followed by a rigorous description of the fundamental equations governing the propagation of light through matter. Moreover, some of the many possible instrumental configurations are presented, especially those that better adapt to perform microrheology measurements. In order to better appreciate the microrheological methods with optical tweezers explored in this book, informative introductions to the basic concepts of linear rheology, statistical mechanics, and the most popular microrheology techniques are also given. Furthermore, an enlightening prologue to the general applications of optical tweezers different from rheological purposes is provided at the end of the book.

**Handbook of Optical Biomedical Diagnostics** CRC Press

Fully revised and in its second edition, this standard reference on nano-optics is ideal for graduate students and researchers alike.

**Microrheology with Optical Tweezers** Humana Press

Microscale Diagnostic Techniques highlights the most innovative and powerful developments in microscale diagnostics. It provides a resource for scientists and researchers interested in learning about the techniques themselves, including their capabilities and limitations. The fields of Micro- and Nanotechnology have emerged over the past decade as a major focus of modern scientific and engineering research and technology. Driven by advances in microfabrication, the investigation, manipulation and engineering of systems characterized by micrometer and, more recently, nanometer scales have become commonplace throughout all technical disciplines. With these developments, an entirely new collection of experimental techniques has been developed to explore and characterize such systems.

*Optical Trapping and Manipulation* Springer Science & Business Media

Many universities now offer a course in biomedical optics, but lack a textbook specifically addressing the topic. Intended to fill this gap, An Introduction to Biomedical Optics is the first comprehensive, introductory text describing both diagnostic and therapeutic optical methods in medicine. It provides the fundamental background needed for grad

Principles of Nano-Optics BoD – Books on Demand

A multimedia interactive guide to developing practical skills for optics research. Use as a class lab manual, an instructional tool or as an indispensable reference. In concise, high-def videos, various skills and techniques are demonstrated and explained. These cover topics for the novice, such as mounting and cleaning of optics, as well as for the more advanced learner, such as balanced detection, and lock-in amplifiers. Various interactive widgets let you simulate the experience of aligning a laser beam to an optical system, aligning an interferometer to get fringes, or adjust a Fabry-Perot cavity while observing the mode spectrum. Other tools help you quickly find the Gaussian beam parameters of your laser from measured beam radii, and to calculate the position of a lens or pair of lenses to mode match a laser to a cavity.

Laser Tweezers in Cell Biology Springer

In Optical Nano and Micro Actuator Technology, leading engineers, material scientists, chemists, physicists, laser scientists, and manufacturing specialists offer an in-depth, wide-ranging look at the fundamental and unique characteristics of light-driven optical actuators. They discuss how light can initiate physical movement and control a variety of mechanisms that perform mechanical work at the micro- and nanoscale. The book begins with the scientific background necessary for understanding light-driven systems, discussing the nature of light and the interaction between light and NEMS/MEMS devices. It then covers innovative optical actuator technologies that have

been developed for many applications. The book examines photoresponsive materials that enable the design of optically driven structures and mechanisms and describes specific light-driven technologies that permit the manipulation of micro- and nanoscale objects. It also explores applications in optofluidics, bioMEMS and biophotonics, medical device design, and micromachine control. Inspiring the next generation of scientists and engineers to advance light-driven technologies, this book gives readers a solid grounding in this emerging interdisciplinary area. It thoroughly explains the scientific language and fundamental principles, provides a holistic view of optical nano and micro actuator systems, and illustrates current and potential applications of light-driven systems.

*Polarized Light and Optical Systems* CRC Press

We are pleased to present “Optical Trapping and Manipulation: From Fundamentals to Applications”, a Special Issue of Micromachines dedicated to the latest research in optical trapping. In recognition of the broad impact of optical manipulation techniques across disciplines, this Special Issue collected contributions related to all aspects of optical trapping and manipulation. Both theoretical and experimental studies were welcome, and applications of optical manipulation methods in fields including (but not limited to) single molecule biophysics, cell biology, nanotechnology, atmospheric chemistry, and fundamental optics were particularly welcome in order to showcase the breadth of the current research. The Special Issue accepted diverse forms of contributions, including research papers, short communications, methods, and review articles representing the state-of-the-art in optical trapping.