

# OPTICAL TWEEZERS

## PRINCIPLES AND APPLICATIONS

Philip H. Jones, Onofrio M. Maragò  
and Giovanni Volpe



# Optical Tweezers Applications Philip Jones Ebook

**Katrin Zwirglmaier**

## **Optical Tweezers Applications Philip Jones Ebook:**

**Optical Tweezers** Philip H. Jones,Onofrio M. Marag-,Giovanni Volpe,2015-12-03 A comprehensive guide to the theory practice and applications of optical tweezers combining state of the art research with a strong pedagogic approach The Optical Tweezers and Its Applications ,2000 **Optical Tweezers** Miles J. Padgett,Justin Molloy,David McGloin,2010-06-02 The technical development of optical tweezers along with their application in the biological and physical sciences has progressed significantly since the demonstration of an optical trap for micron sized particles based on a single tightly focused laser beam was first reported more than twenty years ago Bringing together many landmark papers on **Optical Tweezers** Taylor & Francis,2003

**Design, Construction and Biophysical Applications of Optical Tweezers** Eirini Theofanidou,2005 **Optical Tweezers** Arne Gennerich,2022-09-05 This detailed volume explores a wide variety of techniques involving optical tweezers a technology that has become increasingly more accessible to a broad range of researchers Beginning with recent technical advances the book continues by covering the application of optical tweezers to study DNA protein interactions and DNA motors protocols to perform protein un folding experiments the application of optical tweezers to study actin and microtubule associated motor proteins and well as protocols for investigating the function and mechanical properties of microtubules and intermediate filaments and more Written for the highly successful Methods in Molecular Biology series 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 practical Optical Tweezers Methods and Protocols Second Edition serves as an ideal resource for expanding the accessibility and use of optical traps by scientists of diverse disciplines Design, Construction and Biophysical Applications of Optical Tweezers Eirini Theofanidou,2004

**Optical Tweezers Applications** Raina Mooncrest,Al,2025-03-04 Optical Tweezers Applications explores how focused laser beams act as microscopic hands manipulating particles in biology physics and materials science It explains how light traps function detailing light momentum transfer and gradient forces The book demonstrates a range of applications like manipulating DNA molecules and assembling nanomaterials crucial for advancements in disease diagnostics and material fabrication The book begins with the fundamentals of optical trapping explaining how lasers create forces to move microscopic particles It progresses through different types of optical tweezers discussing necessary instrumentation and techniques Dedicated chapters cover biological applications such as studying molecular motors and DNA elasticity and materials science applications including colloidal crystal assembly and nanowire fabrication This book stands out by comprehensively covering both the theory and practical applications of optical tweezers It emphasizes the underlying physics and real world impact providing readers with the knowledge to utilize optical tweezers in their research It connects physics biology and materials science highlighting how optical tweezers aid our understanding of cellular mechanics and enable the construction of novel materials Optical

Tweezers Katherine Crystal Martin,2000

**Applications of Holographic Optical Tweezers to the Manipulation and Coalescence of Airborne Microparticles** Rory M. Power,2014

**Applications of Optical Tweezers and an Integrated Force Measurement Module for Biomedical Research** Jin-Wu Tsai,Bing-Yao Liao,Chun-Cheng Huang,Wen-Liang

Hwang,Da-Wei Wang,NATIONAL DONG HWA UNIV HUALIEN (Taiwan) DEPT OF ELECTRICAL ENGINEERING.,2000

Optical tweezers are useful for manipulating biological samples and measuring biological forces in the present study we have integrated a forward scatter analysis FORSA module into the single beam gradient force optical tweezers The entire set up was then incorporated onto an inverted microscope in the FORSA module a Helium Neon probing laser was spotted at a slightly out of focus way onto the object being trapped by the infrared laser based tweezers and generated a diffraction pattern Images of the diffraction pattern were captured by a charge coupled device cCD and digitized and processed by a computer We demonstrated that tracking the amplified diffraction pattern was much more precise to determine the movement of the object within the trap than analyzing the minute motion of the object itself Displacement of the object could then be translated into the force being applied by the tweezers Also using an algorithm developed in the lab we were able to follow the movement of the scattering pattern at a temporal resolution close to video rate We have used this system to investigate the binding force associated with cell cell interactions and molecular interactions in these studies a cell was carefully positioned to make contact with another cell or a microparticle coated with proteins of interest by optical tweezers in a well controlled manner During these events we noted a progressive increase of cell adhesion at the immediate early period i e a few minutes after initial contact of cell cell interactions Also binding of a disintegrin rhodostomin and its mutant to the counterpart integrin on the cell surface could be assessed with great convenience and accuracy Our results demonstrated that addition of the forward scatter analysis module to conventional optical tweezers provides an effective and convenient way for monitoring biological activities in situ and measuring changes of biological forces with precision

**SPM and Optical Tweezers ,2011 Application-specific Optical Tweezers** Ronald Kampmann,2017 Motiviert wird diese

Arbeit durch die Entwicklung hocheffizienter optischer Systeme welche das optische Fangen mikroskopischer Objekte ermöglichen Dazu muss der klassische Optikdesignprozess mit einer neuen Zielfunktion der optischen Kraft erweitert werden Konventionelle optische Pinzetten sind oftmals in invertierte Lichtmikroskope integriert Die Erweiterung der abbildenden Funktion des Mikroskops zu einer optischen Pinzette stellt häufig nur einen Kompromiss aufgrund des bereits existierenden optischen Aufbaus dar Speziell an die Anwendung angepasste optische Pinzetten erfordern die Optimierung der optischen Kraft im Hinblick auf die gestellten Anforderungen und die vorherrschenden Randbedingungen Hierfür wird eine optische Kraftsimulation auf Basis der geometrischen Optik entwickelt Diese ermöglicht das Simulieren optischer Kräfte bezüglich frei wählbarer Eingangsparameter wie der numerischen Apertur der Optik der zu fokussierenden Intensitätsverteilung optischer Aberrationen und anderer Zweier Systeme welche das optische Fangen in gasfreien und flüssigen Umgebungsmedien

realisieren werden mit dem erweiterten Optikdesignprozess entwickelt wobei die Komponenten extern gefertigt werden. Nach der optischen Charakterisierung der Elemente sowie der anschließenden justierten optischen Systeme wird zunächst theoretisch überprüft ob beide Systeme eine stabile optische Falle erzeugen. Anschließend wird experimentell das optische Fangen mikroskopischer Quarzglaspartikel mit beiden Systemen nachgewiesen. Auf Grundlage der Bereinstimmung der experimentellen und theoretischen Ergebnisse wird das Verhalten optischer Pinzetten unter dem Einfluss optischer Aberrationen untersucht. Das gezielte Einbringen von Aberrationen in eine optische Pinzette sowie die entsprechende Reaktion der optischen Falle werden experimentell und theoretisch analysiert. Es stellt sich heraus, dass Aberrationen welche die Symmetrie der Kaustik des optischen Systems zerstören, die Stabilität und Leistungsfähigkeit der optischen Pinzette stark beeinflussen. Achssymmetrische Aberrationen hingegen beeinträchtigen die optische Falle deutlich weniger.

*Investigating the Clinical Application of Optical Tweezers* Alex Mullen, 2025

Optical tweezers are instruments that can hold in place small particles on the microscale and below using a focused laser beam. They accomplish this by making use of the scattering and gradient forces generated by the light momenta scattered by the relative refractive indices of the particle and its surrounding medium. The non-invasive nature of the optical tweezers allows for a range of samples to be trapped and examined, from individual viruses to graphene to eukaryotic cells. Of particular interest are biological samples, as when combined with work to optically cool samples, optical tweezers allow a non-destructive method of characterizing mechanical properties. Multiple mathematical models have been created for the field of light scattering, including ray optics, the dipole approximation, T-matrix methods, and Mie theory. Each will be briefly covered in the thesis, but for the purposes of the work, the dipole approximation model has proved to be sufficient. However, the use of optical tweezers to categorize material viscoelasticity properties through microrheology is more recent. This thesis is concerned with the general problem of how to investigate mechanical problems of neurons *in vivo*. Solving this problem is important to medicine in order to allow for bio-engineered neurons that can provide basic functionality to treat neurodegenerative diseases and spinal cord injuries. Here, the efficacy of optical tweezers in characterizing mechanical properties of neurons and other structures is investigated.

*Optical Tweezers* Miles J. Padgett, Kishan Dholakia, Justin E. Molloy, 2003

**High Resolution Optical Tweezers Optimized for Biological Studies** Mohammed Mahamdeh, 2011

**Applications of Holographic Optical Tweezers** Matthew A. Cibula, 2015

The development and some applications of holographic optical tweezers (HOT) are presented. Our HOT system uses a spatial light modulator (SLM) to control the location and properties of the optical trap. We have developed a method for optimizing the diffraction efficiency of a SLM that can be applied *in situ* and addresses the issues of nonlinear phase modulation and phase modulation less than  $2\pi$ . The method employs a one-dimensional blazed phase grating written on the SLM. For an ideal SLM, the phase shift is linear and covers  $0$  to  $2\pi$ , yielding a first-order diffraction efficiency of unity. For a realistic SLM with nonlinear or reduced phase shift, the efficiency is approximately  $\eta \approx 1/\sigma^2$ , where  $\sigma^2$  is the

variance of the phase error from the ideal case. Because each pixel contributes to the phase error independently this suggests a method to maximize the efficiency by adjusting the phase encoding of the SLM pixel by pixel. In practice we do this by adjusting the gray scale of each pixel while measuring the first order diffracted power. The collection of optimal gray values comprises the optimized gray scale lookup table which exhibits the nonlinearity required to produce a linear phase grating and the saturated phase encoding that maximizes the efficiency of phase limited SLMs. The optimized SLM enables strong trapping power even when distributed among multiple traps which is essential to enable our system to trap multiple nanosensors and simultaneously detect the sensors fluorescence spectra with an imaging spectrometer. Such nanosensors are capable of detecting changes in their environment such as pH ion concentration temperature and voltage by monitoring changes in the nanosensors emitted fluorescence spectra. We have used streptavidin labeled quantum dots bound to the surface of biotin labeled polystyrene microspheres to measure temperature changes by observing a corresponding shift in the wavelength of the spectral peak which is excited with a 532 nm wide field laser source. Particles with diameter greater than the wavelength of light exhibit Mie resonances in their fluorescence spectrum whose spectral locations are dependent on the size of the particle and the relative index of refraction between the particle and the surrounding medium. HOT also provides a useful platform to study the micromechanical properties of elastic materials such as collagen. Collagen gels are widely used in experiments on cell mechanics because collagen is the most abundant protein in the mammalian extracellular matrix and is the primary source of its mechanical properties. Collagen gels are often approximated as homogeneous elastic materials however variations in the collagen fiber microstructure and cell adhesion forces cause the mechanical properties to be inhomogeneous at the cellular scale. We study the mechanics of type I collagen on the scale of tens to hundreds of microns by using HOT to apply picoNewton forces to micron sized particles embedded in the collagen fiber network. We measure the local compliance and elastic modulus of the collagen network and find that particle displacements are inhomogeneous anisotropic and asymmetric. Confocal reflection microscopy is used to reveal the local fiber structure and a simulation treating the network as a triangular lattice is used for comparison to the HOT measurements. Collagen samples prepared at 21 C and 37 C show that gels formed at lower temperature are more inhomogeneous anisotropic and compliant than those formed at high temperature and cellularized samples allow us to characterize the effects of cell adhesion forces on the network mechanics.

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