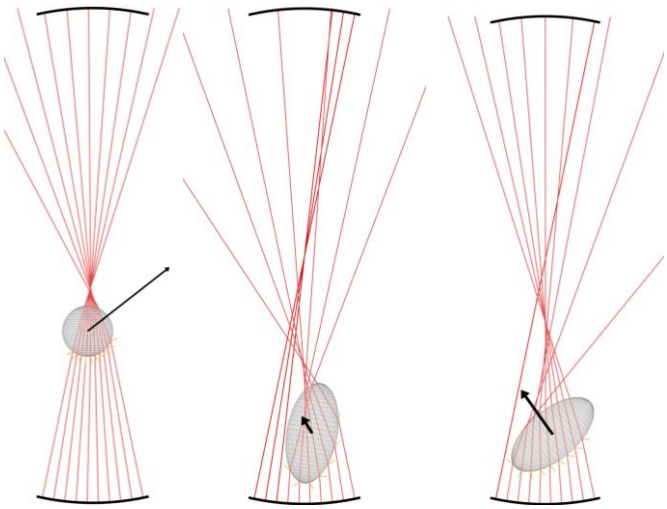
Optical trapping of particles of different shapes and optical properties



Bakgrund: Optical tweezers are a well-established scientific tool used to manipulate and study microscopic particles, both of artificial and biological nature. The optical tweezers are usually obtained by highly focusing laser beam, which, when directed at a small particle, generates optical forces that can trap it. By controlling the laser's position and power, one can trap and manipulate the microscopic particles very precisely. This technique has applications in a wide range of fields, including biology, physics, and materials science, enabling researchers to explore fundamental questions and develop innovative solutions in these areas.

Problembeskrivning: This project aims at numerically investigating optical trapping for particles of different shapes and optical properties in the limits of geometrical optics, i.e., when the wavelength of the light is much smaller than the dimension of the particles. The first step will be to understand how one can numerically calculate the optical force on a transparent dielectric spherical particle due to a focused Gaussian beam. Then, the focus of the specific project will be discussed with the students. Several scenarios are possible. For example: (i) focusing on the dynamics of absorbing particles and how they can be optically trapped, (ii) training a dense neural network to predict the optical forces and torques on a Janus Particle, (iii) investigating optical binding between particles... just to mention a few.

Arbetssätt: This study will start by implementing a basic code that calculate the optical force on a spherical particle using the OTGO toolbox, and a basic code that implements the Brownian dynamics of such a particle. Then the investigation will develop according to the specific project agreed with the students.
Note! The OTGO toolbox in in Matlab, therefore Matlab is required in this project. Depending on the specific project, other programming languages could be used. Prerequisites: some experience in programming and knowledge of Matlab. Knowledge of numerical solutions by finite differences helps. The thesis and presentation can be in Swedish.

Gruppstorlek: 3-6 student.

Målgrupp: F, GU-fysik, TM, E, Z, D, IT eller motsvarande.

Litteraturtips: (1) *[geometrical optics]* Callegari et al, Computational toolbox for optical tweezers in geometrical optics, JOSA B, 32, B11, (2015) (2) *[Brownian dynamics simulations]* Volpe and Volpe, Simulation of a Brownian particle in an optical trap, Am. J. Phys., 81, 224 (2013) (3) *[inspiration for specific project]* Bronte Ciriza et al, Faster and More Accurate Geometrical-Optics Optical Force Calculation Using Neural Networks, ACS Photonics, 10, 234 (2023)
Reference books: chapter 2 of Jones, Maragò, Volpe, *Optical Tweezers: Principles and Applications*, CUP, 2015 and chapter 5 of Argun, Callegari, Volpe, *Simulation of complex systems*, IOP, 2022.

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