TITLE

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1 Introduction

An optical trap, or optical tweezers, is a technique that is frequently used in molecular biology to study particles at the micro- and nanometre scale. By trapping a particle in a focussed laser beam, the particle is limited in movement. This allows the user to study microscopic manipulations and measurements on microscopic particles and therefore proves to be very useful in the field of biophysics. Examples of which are sorting of cells, unzipping of DNA and enzyme interactions [**?**][**?**]. In order to perform quantitative measurements using optical tweezers, it is vital to know what force it exerts on the particle. This force is defined by the trap constant and is dependent on various parameters such as the particle size and laser power. The aim of this report is to find the relation between the laser power and the trap constant. Secondly this report serves to get familiarised with the optical tweezers technique and to investigate its limitations and possibilities. Due to the COVID-19 virus no experiments were carried out for this report and data of previous experiments by other students is used. This data contains images of a trapped bead for laser beams with different powers. For each laser intensity, there is a set of images at fixed time intervals such that the movement of the bead can be studied. For this report, the images are processed by a MATLAB algorithm which calculates the trap constant in two perpendicular directions. Using these two values, the overall trap constant can also be determined. The relation between each trap constant and the laser power is found using a distance regression method and the theoretical linear dependence. In section 2 the theory regarding the report will be described followed by the experimental method in section 3. The results and discussion can be found in section 4. Lastly the conclusions in section 5.

2 Experimental Method

3 Results

3.1 Results of the datasets

The results of the experiment were gathered by taking a 1000 photos of the particles in the trap and for each of the laser power output (P) settings and then using an automated MATLAB script to track the location of the centre of the bead for all of the 1000 photos and all of the laser output power settings. Using this information the script was able to calculate the trap stiffness in the x and y direction denoted as k_x and k_y respectively.
The script was not perfect, for most of the image stacks of the first dataset the script was not able to track the centre of the bead, this was the result of a piece of debris in the trap which was like the bead circularly shaped with rings around it, this threw the program off. The corresponding data points have been entered in the table 1 below but the points were not used for fitting a line to the dataset. The second dataset was much better and did not have any faulty measurements, its values are shown in table 2.

Laser Power $[mW]$	0*	10*	20	30*	40	40
k_x $[pN/nm]$	$2.36 \cdot 10^{-5}$	$2.45 \cdot 10^{-7}$	$1.60 \cdot 10^{-5}$	$8.35 \cdot 10^{-7}$	$1.99 \cdot 10^{-5}$	$9.60 \cdot 10^{-5}$
k_y $[pN/nm]$	$8.29 \cdot 10^{-5}$	$2.94 \cdot 10^{-7}$	$1.65 \cdot 10^{-5}$	$9.71 \cdot 10^{-7}$	$1.72 \cdot 10^{-5}$	$8.96 \cdot 10^{-5}$

Table 1: Results of the first dataset. The values are truncated to two decimal places. * denotes a faulty measurement

Laser Power $[mW]$	0	5	10	20	30	40
k_x $[pN/nm]$	$3.64 \cdot 10^{-7}$	$8.24 \cdot 10^{-5}$	$1.08 \cdot 10^{-4}$	$3.03 \cdot 10^{-4}$	$6.14 \cdot 10^{-4}$	$7.55 \cdot 10^{-4}$
k_y $[pN/nm]$	$5.55 \cdot 10^{-7}$	$4.18 \cdot 10^{-5}$	$2.53 \cdot 10^{-5}$	$1.10 \cdot 10^{-4}$	$1.69 \cdot 10^{-4}$	$2.54 \cdot 10^{-4}$

Table 2: Trap results, values are truncated to two decimal places for formatting reasons

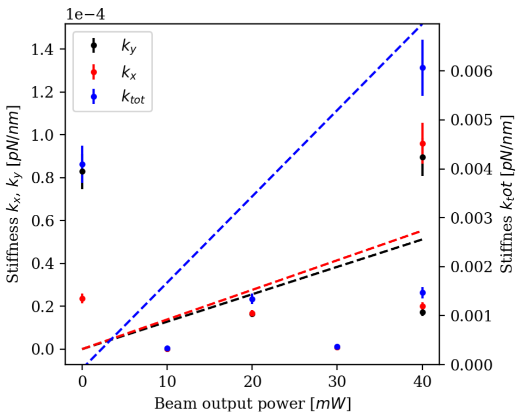

Figure 1: Results of the first dataset plotted and fitted.

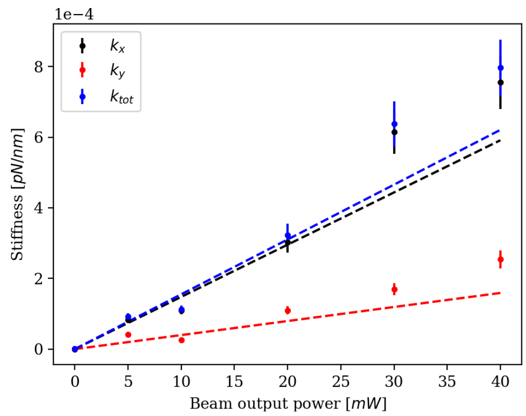

Figure 2: Results of the second dataset plotted and fitted.

The data shown above in tables 1 and 2 are plotted in figures 1 and 2 respectively. In the plots the individual data points and their corresponding error flags are shown as well as the least squares fit of these data points for the k_x, k_y and k_{tot} values. The fit of the k_{tot} values is plotted on a secondary axis.
For the least squares fit a relation of $k = a \cdot P$ was used since it is expected that for zero laser output power there would not be a restoring force acting on the particle. The resulting coefficients are shown below in table 3.

coefficient for	a_x $[pN/(nm \cdot mW)]$	a_y $[pN/(nm \cdot mW)]$	a_{tot} $[pN/(nm \cdot mW)]$
dataset 1	$1.382 \cdot 10^{-6}$	$1.280 \cdot 10^{-6}$	$1.740 \cdot 10^{-4}$
dataset 2	$1.478 \cdot 10^{-5}$	$3.974 \cdot 10^{-6}$	$1.551 \cdot 10^{-5}$

Table 3: fit results

3.2 Python program results

During this practical we were also tasked with rewriting a MATLAB script in to Python. The piece of script we needed to rewrite was the function that tracks the centre of the bead in the image, this function was comprised of interpolation method and a method that found the symmetry centre of the bead using Fourier transforms. The second part was easily implemented in Python as it was mostly just finding the right Python functions that were equivalent to their MATLAB counterparts. The interpolation function was a lot harder to implement in Python since most of the existing Python interpolation functions did not have the same functionality.

4 conclusion

References

5 Appendix

5.1