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Laser Beam Optical Trapping of a Nanoparticle

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LASER BEAM OPTICAL TRAPPING OF A NANOPARTICLE

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ABSTRACT

Optical trapping is the use of a laser beam, to trap small particles, similarly to using tweezers. A straight beam of light, focused correctly, can provide a force strong enough to control a nanoparticle. The objective of this project is to set up a Modular Optical Trapping Kit for the purposes of research and teaching. The project is split into two main parts. Part one is assembling the Trapping Kit, which includes building a Printed Circuit Board (PCB). Part two is measuring the necessary laser-force for different particles. This is an on-going project.

Introduction

A laser is an amplified monochromatic light source that emits beams that do not lose energy along their path. This energy can be converted into a force of up to a few PicoNewtons (~1.0×10^{-12} N), just enough to trap and manipulate a nanoparticle (~1.0×10^{-9} m). The Optical Trapping Kit (OTKB) works by bouncing the laser beam off of a series of mirrors and through a series of lenses (as shown in Figure 1) eventually guiding the beam through a sample of freely moving nanoparticles. When one of the particles is within the trap's reach, it falls into the trap and ceases to be free moving. It can now be manipulated or held in place by the user.

Because the required movements of the particle are so miniscule, human motion alone cannot be used to move the sample. For this purpose, we make use of piezoelectric material, which, when subjected to electricity, changes its physical size accordingly. This allows for very small motion which can be detected and controlled by voltage measurement.

Project Objective:

The objective of this project is to set up and calibrate the Modular Optical Trapping Kit for the purposes of research, teaching as well as laboratory experimentation.

Part 1 Solution: Assembly

- Complete initial assembly of major Optical Trapping Kit components
- Design and assemble voltage follower for force detection
- Align all mirrors to achieve trapping in field of view (FOV)

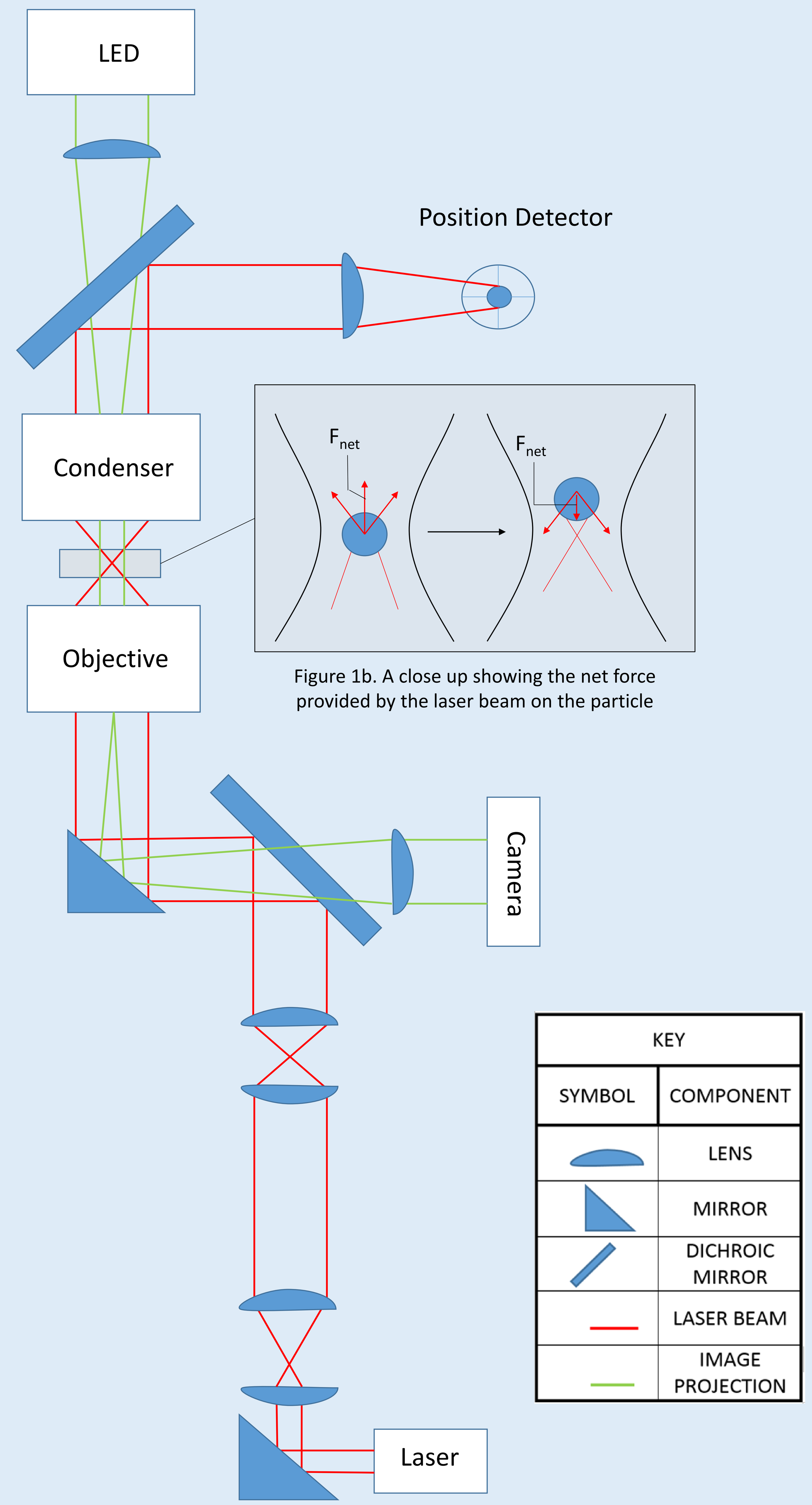

Figure 1b. A close up showing the net force provided by the laser beam on the particle

Figure 1a. A schematic of the overall assembly, including beam and image paths.

Acknowledgments and Resources:

1. FRG – Andrews University (Kwon)
2. URS – Andrews University (Musvosvi)

Part 2: Force Measurement

- Develop Graphical User Interface (GUI) for data interpretation and system control (DAQ)
- Determine force levels necessary for silica bead trapping

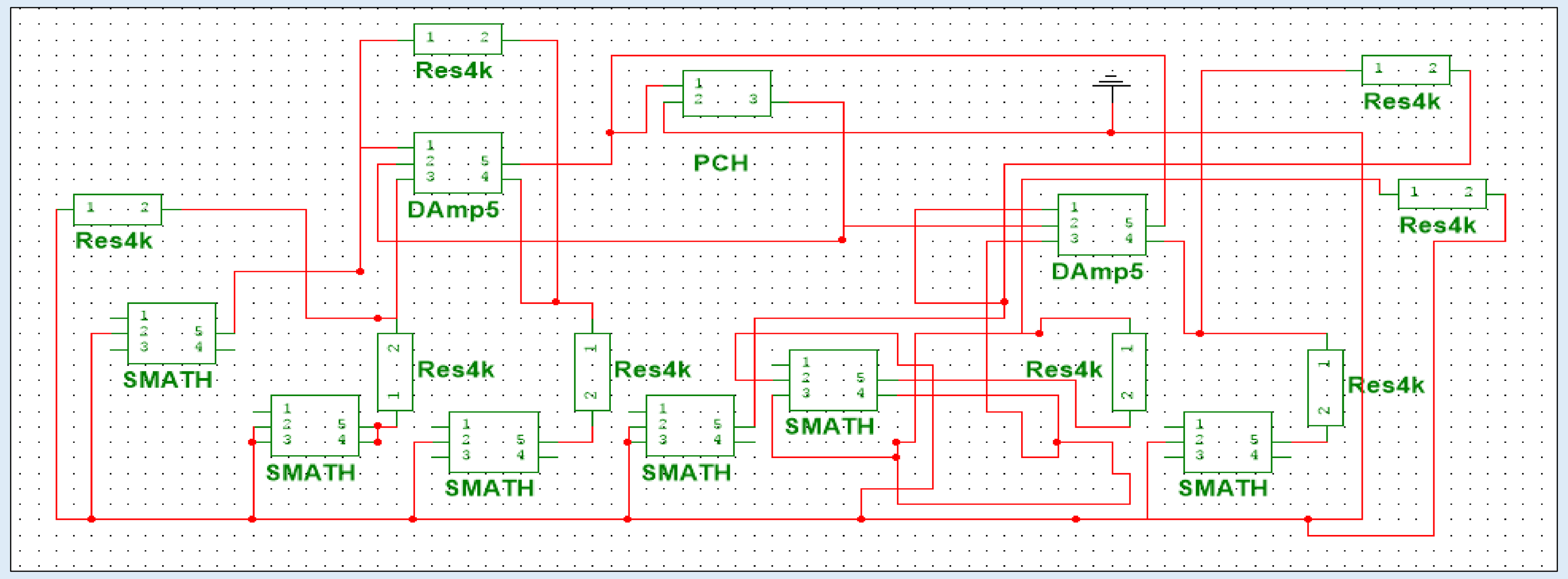

Figure 2. A schematic of the voltage follower used for data acquisition and interpretation

Results and Conclusion:

- The voltage follower was designed, printed and assembled
- The overall assembly was completed and relevant segments connected
- Trapping of silica beads (micron sized) was achieved
- GUI is currently in development

An OTKB has a lot of potential for applications in STEM fields, particularly engineering, physics, chemistry and biology.

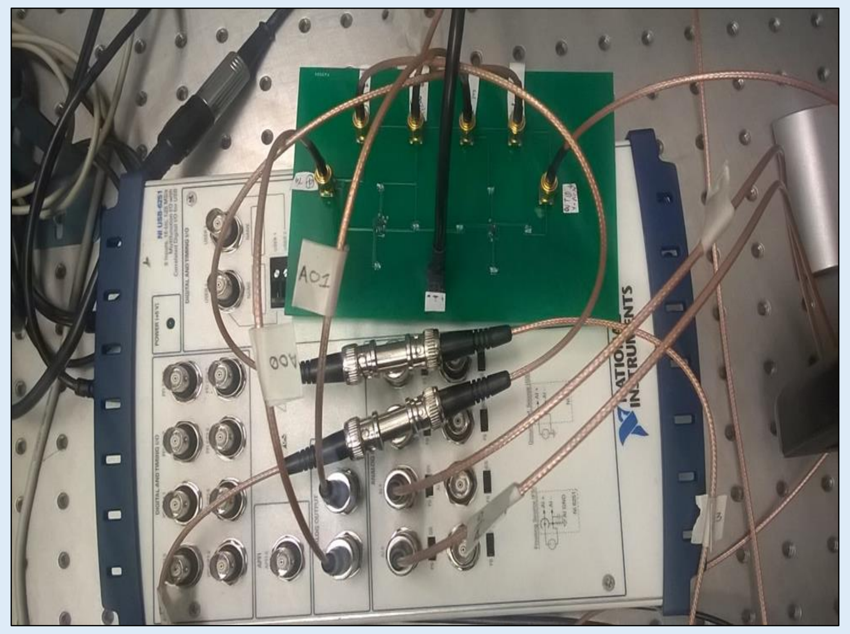

Figure 3. Data acquisition including completed voltage follower.

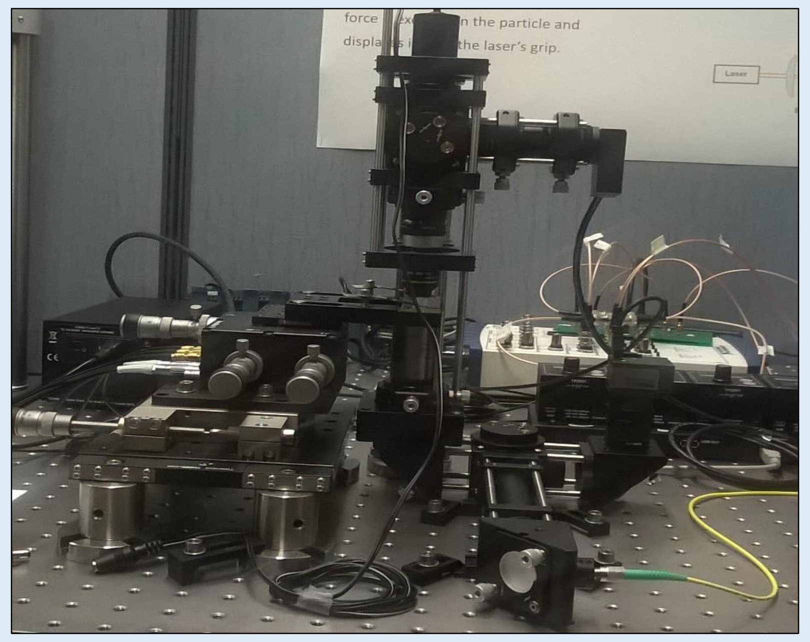

Figure 4. Complete and connected Optical Trapping setup

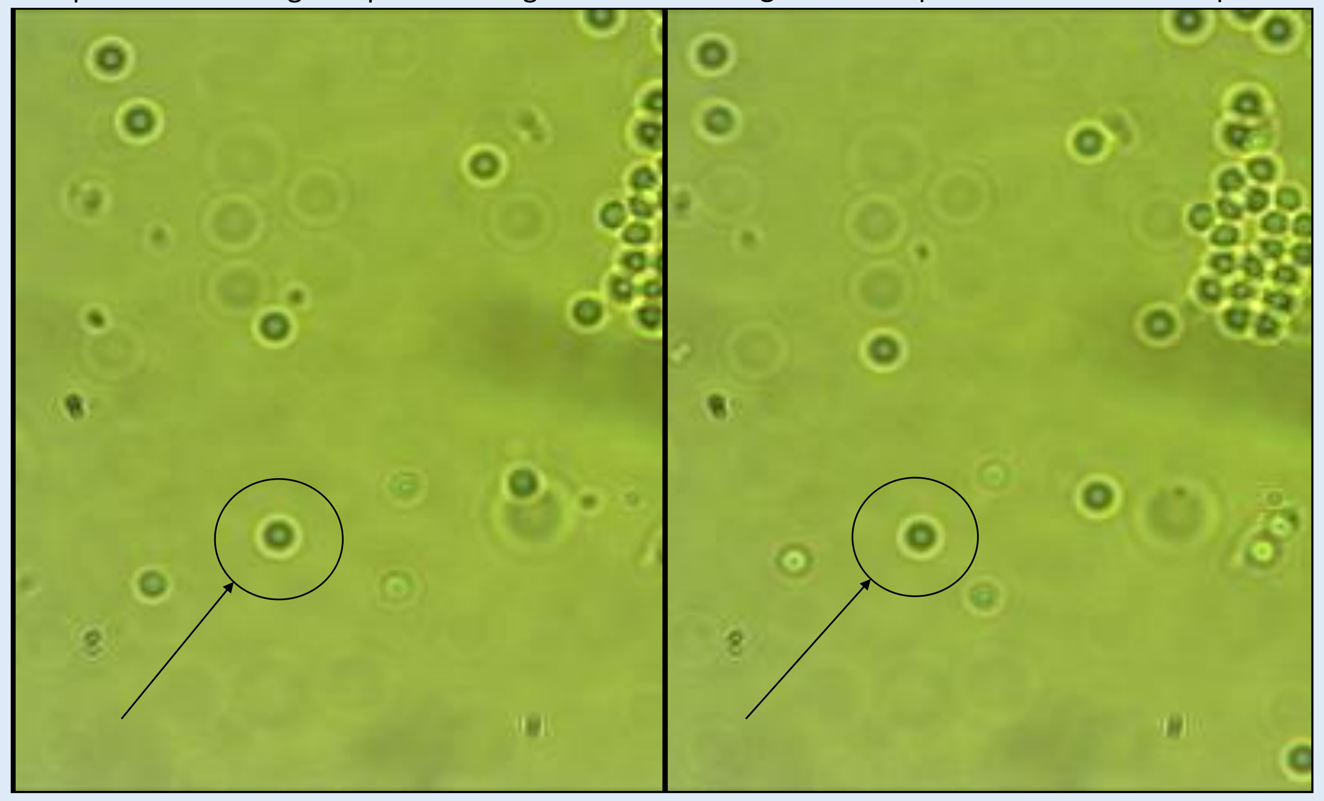

Figure 5. Still image showing trapped bead before and after movement in FOV.