Analysing a UV Source Intensity Profile Using a Fluorescent Dye

Summary

Anubha Bal, Maria Maxouti

Department of Physics, Blackett Laboratory, Imperial College London, Exhibition Road, London, SW7 2AZ, UK

Abstract

We designed and performed a proof-of-principle experiment to test whether an intensity profile corresponding to a UV beam could be reconstructed through capturing an image of the beam travelling through a fluorescent dye solution. We dissolved a small amount of Coumarin-440 powder dye in water and retrieved the intensity profile of an Ultraviolet (UV) source as it penetrated a phantom containing the solution. We used a lens with a 60mm focal length, and positioned the source and water tank accordingly. The set-up was bolted to the optical table and the experiment was conducted in a light-box. The CMOS camera was connected externally to a computer to adjust its settings and analyse the captured image.

1 Experimental Summary

We configured the set-up using the focal length of the lens (60mm), we positioned the LED and the water tank such that the lens surface was equidistant, at 60mm, from the source and the centre of the water tank. This was done so that the image we captured contained the focus of the transmitted light at its centre. The camera was then connected to the computer, and we adjusted the focus of the camera to ensure the contrast was as sharp as possible. Using the software ”Spinnaker” to operate the camera, we took some initial photographs with some white paper inside the tank as opposed to water to ensure the focus was where we had predicted. Photographs of the LED source shining through air in the water tank were also taken to allow for comparison with those using the fluorescent dye. A diagram of the set-up used can be seen in Fig. 1.

We measured approximately 0.02g of the Coumarin-440 powder and dissolved it in 1.5l of distilled (deionised) water to create a weak solution. This was done using a fume cupboard to avoid any inhalation of the carcinogenic dust. Upon making the solution, the water tank was bolted to the optical table. We used an Ultraviolet LED as the light source, alongside a guiding tube and focusing lens.

The CMOS camera was connected to the computer and operated using the software ”Spinnaker”, which allowed us to adapt the Gain settings on the camera to optimise the image. Initially, to test the camera operation software, we captured some images of the set-up with the LED switched off.

The Coumarin dye is a hazardous chemical, so to avoid inhaling fumes, a solution was made in a fume cupboard.

By taking some preliminary images of the system with the LED switched on and travelling through the dye solution, we noted that the images were too saturated. To minimise this so that we could observe reasonable levels of contrast between adjacent bright pixels, we adjusted the camera Gain settings and we ensured that the current from the power source was at a minimum. The image used for the analysis of the LED source can be seen in Fig 2.

The initial images we took of the background showed a few randomised bright spots, so in order to get a better gauge of the background intensity, we took ten such images with intention to take an average of the

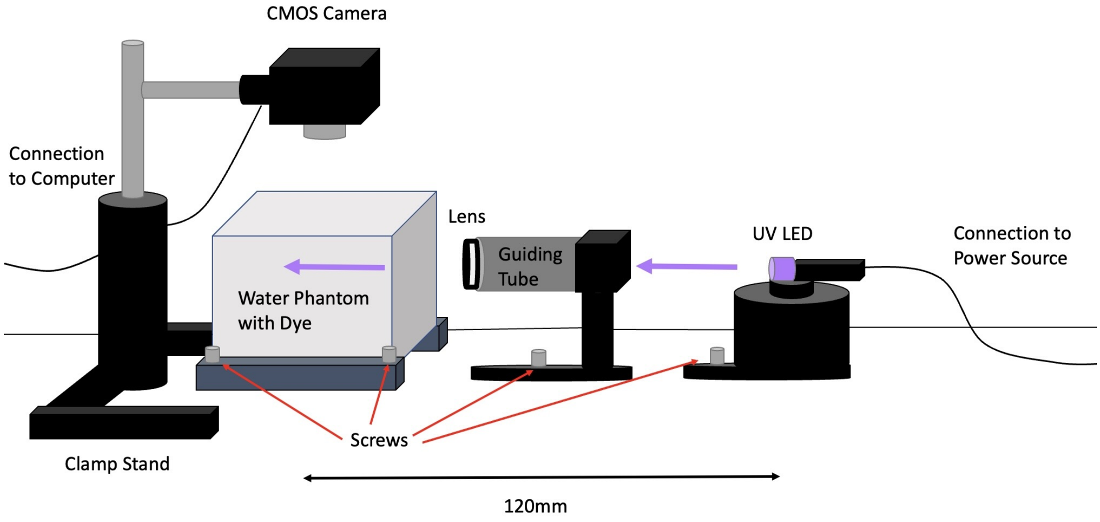

Figure 1: A diagram of the set-up used. The experiment was conducted in a lightbox and the camera and LED were connected externally to a computer and a power source respectively.

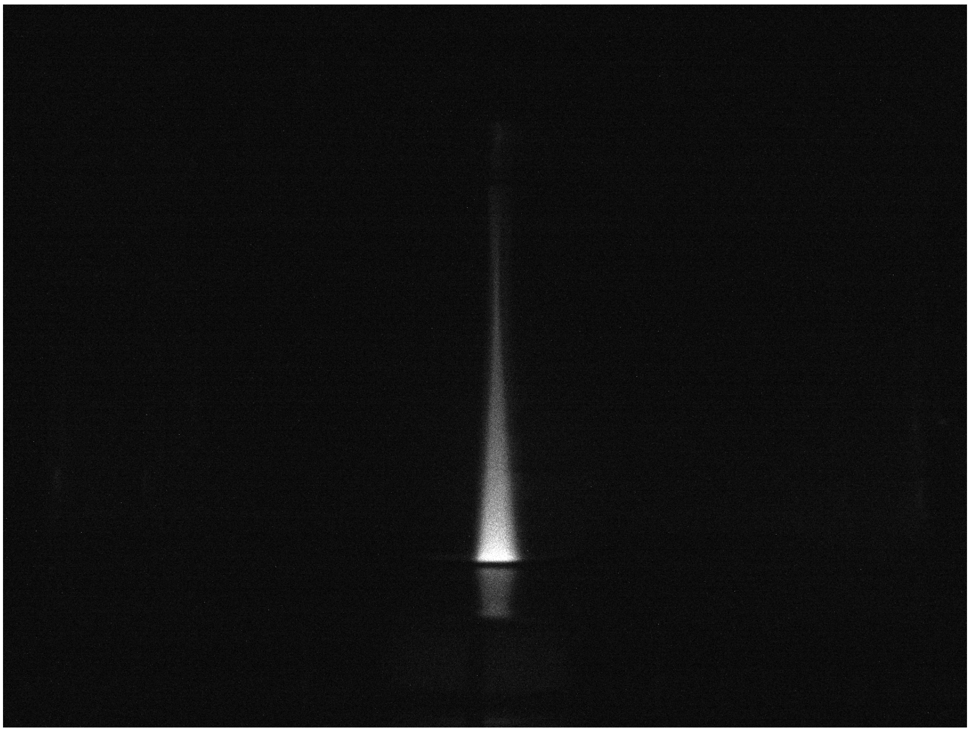

Figure 2: An image of the UV light travelling in the solution taken at minimum current without background subtracted from it.

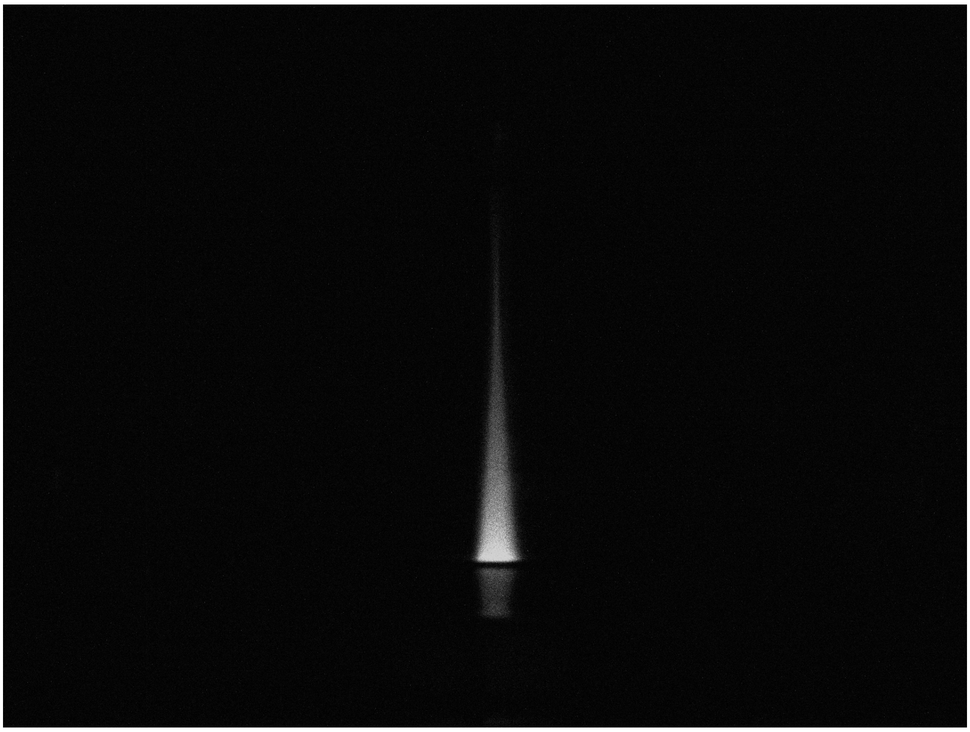

Figure 3: An image of the UV light travelling in the solution taken at minimum current with the average background subtracted from it.

background intensity. Fig. 3. shows the image of the LED source with the average background subtracted from it.

The subsequent analysis to reconstruct the intensity profile was performed on the image shown in Fig. 3.

2 Analysis and Plots

A python script was written to iterate over each pixel in an image and return an array with the intensity of each pixel. Histograms of the intensities were then plotted using a logarithmic scale. In order to ensure that the image was not saturated, a threshold was set to the maximum intensity at around 240. A histogram of the average background with the threshold applied can be seen in Fig. 4.

Similarly, a Histogram of the UV light travelling in the solution without subtracting the background can be seen in Fig. 5.

Upon correcting for the background and applying the threshold manually, we were able to generate the plot shown in Fig. 6.

We note that the plots still contain a lot of black background as seen by the large peak near zero intensity and steady decline. By cropping the image, the black background can be minimised.

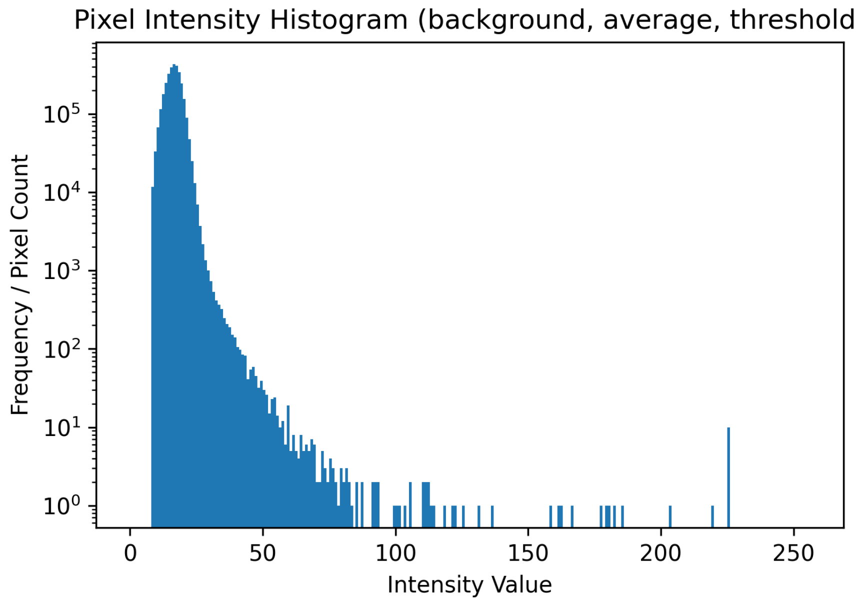

Figure 4: The histogram of the average background signal with the manual threshold applied. Note that the histogram peaks sharply at intensities close to zero as we expect. The scale is logarithmic

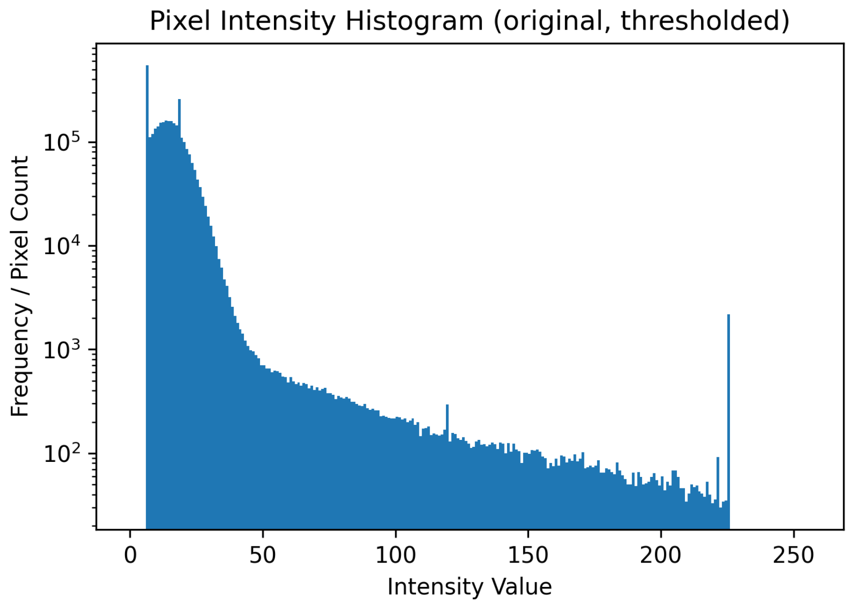

Figure 5: The histogram of the LED source without correcting for the average background. The threshold has been applied. Note that there is a peak close to zero as we expect again as most of the image is composed of low intensity pixels.

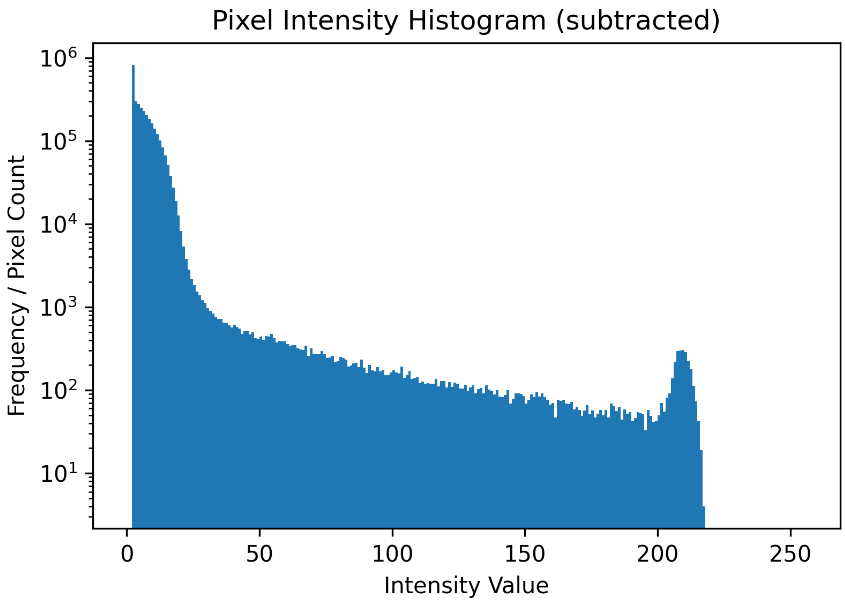

Figure 6: The histogram of the LED source, corrected for the average background. Note that there is a peak close to zero as we expect again as most of the image is composed of low intensity pixels. There is another peak which is at the maximum intensity of the source.