PAL 30 Report Ver. November 16-20

Adam Green

University of Colorado at Boulder, SMRC

(Dated: November 24, 2015)

INTRODUCTION

Previous Results

Our Group's Efforts

CALIBRATION OF CAMERA

To determine if we are seeing even-odd layer switching effects, it is important that we know the absolute number of layers in the FSF. To this end, we have two main options: the laser and the camera.

In my experience, it has been difficult to get the uncertainty on the laser down for two main reasons. First, it is difficult to keep the system exactly the same, and any jarring or bumps will call for a re-alignment of the laser. This will mean a re-taking of the calibration date. The second is that it is difficult to get a consistent measurement off of the black glass. Hopefully, the camera setup will allow us to normalize and standardize our setup.

The camera can be modelled as a fairly simple photo diode, where the grey value recorded by a pixel is given by:

$$g_{\text{value}} = \frac{\text{Num. photons}}{s} \times \text{Quantum Efficieny [volts/photon]} \times \text{Exposure [s]} \times \frac{2^{12}}{\text{Max Voltage}} + \text{Noise}$$

The two things we can control is the total flux of photons and the exposure time. Before we can use this model, we need to verify that it works. Namely, if we change the exposure time with a constant flux, or vice versa, that we get a straight line that goes through the origin.

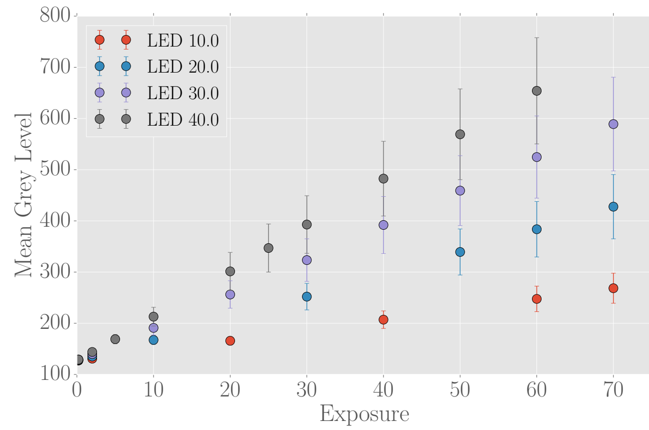

FIG. 1: As different photon flux is incident on the camera, the greyvalue-vs-exposure time has a different slope. It also looks fairly linear.

We can make this more qualitative by fitting lines to each of these data sets and then visualizing how the slope and intercepts of those lines change as the LED power is increased.

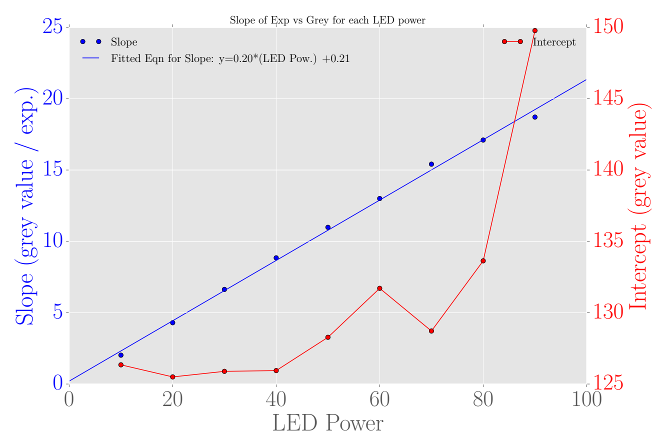

FIG. 2: The slope is nicely linear. The equation of the line is given by $y = .20 \times x + 0.21$, and following our simple model, this means that $\frac{\text{Quantum Effiency} \times 2^{12}}{\text{Max Voltage}} = .2$, and the fact that the intercept is so small ($b = .20$) and the high degree of linearity of the fit shows us that the camera is behaving well over a large range of values

As you can see, there is a constant offset. I am not clear about what would cause this, whether it is a dark current, background light/blackbody photons, but it isn't constant, as we can plot the slopes and intercepts and see how they change as more light is incident. There is also no clear discernible pattern.

The saving grace is that the intercept is fairly small (180 gv compared to the 1800 gv where I will be working), so it shouldn't affect the results. Also, the variance in the grey values of a sample are usually of the order of 200, so it is unlikely that the noise intercept will dramatically change the results.

We can also look at a range of LED power that would mimic the light incident on our camera from reflection from films, this is shown in Figure. 3

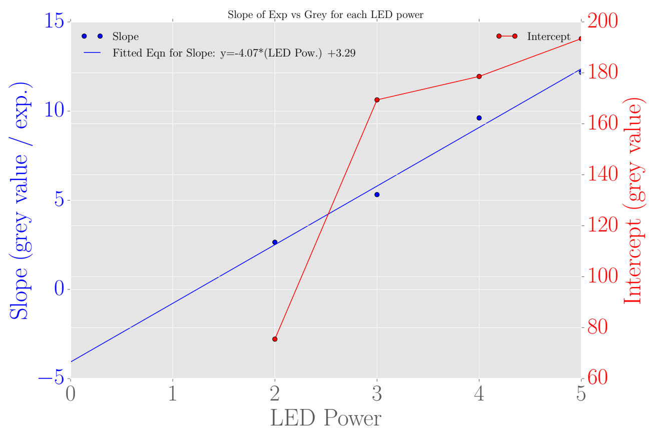

FIG. 3: Again, a strong linear correlation. However, the equation of the line is different, which suggests that either something about the quantum efficiency is changing, or my LED power is not outputting the same amount of power. I think the second option is more likely.

As seen in Fig. 3, at small light levels, the camera is still behaving linearly, however the equation of the line is different. This can be seen dramatically below, in Fig. 4.

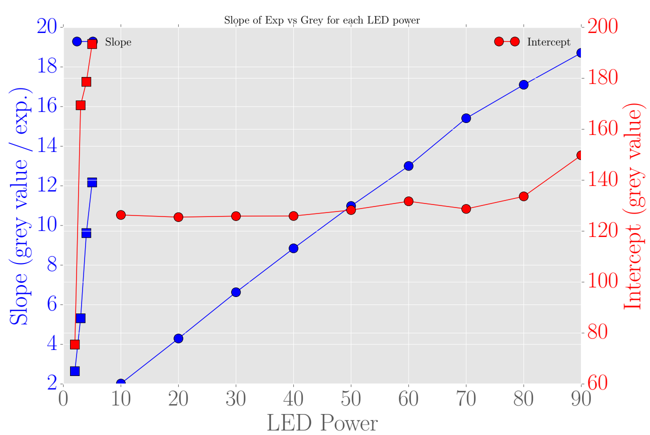

FIG. 4: This is just the two plots above plotted on the same axis. This is a piece of evidence to suggest that the LED source is not giving off constant power in time. It is worth noting that I took these two sets of measurements on different days of the week.

I've verified the model of the camera, and shown that for the regimes that we will be working in, that it is linear. Note, I have also taken a lot of data to try to cover the parameter space of this model, and it all works fairly well.

More work should be done to verify the long term stability of the LED power source, however, I've taken some data that shows that over small time scales, the LED gives consistent power out, shown in Fig. 5.

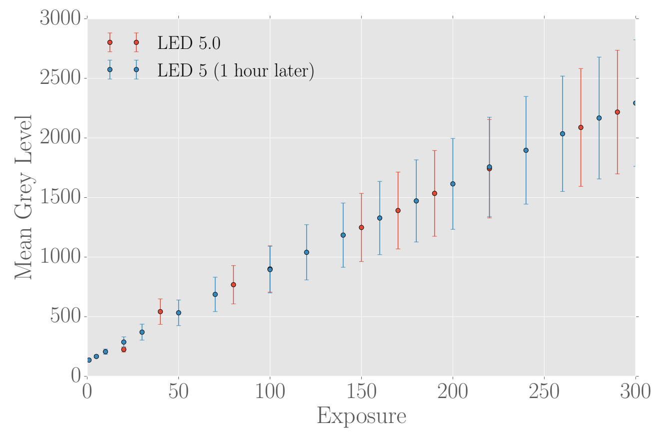

FIG. 5: Over an hour, the LED is giving a very steady output of power.

RESULTS

In this section I will present the results that I have obtained. To date, I've looked at three samples of PAL30. Unfortunately, I didn't get a lot of data with the first one, the second one gave us a lot of data but the camera had yet to be calibrated so I didn't take a black glass shot (however, we still may be able to extract the layer step number by a cleverly fitting. It is probably unlikely, however, as I was not making careful light measurements.)

The third run was the best so far. I had aligned the optical and rotation axis of the scope, so now we can rotate the stage and try to detect tilt and also see how the polarization domains change. However, I had some trouble actually drawing the films so I was only able to look at three films in depth. They are all stored in chronological order in this directory structure under PAL30.

Along the way, I've also developed numerous tools that will aid in our data analysis.

1. intenmap.py will plot the circumferential intensity of a point that a user clicks. It was made using tkinter (still needs some work to clean up)

2. rotate.py will rotate images

3. I have pretty robust tooling to automatically extract the exposure times and LED power of image files, which will allow us to process them more quickly.

I am also in the process of creating a toolchain to quickly and easily create layer step guesses.

Tilt

We haven't seen the strongest evidence of tilt yet.

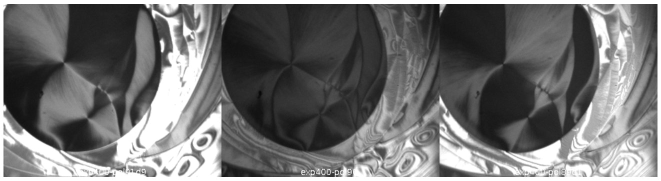

FIG. 6: Rotating the polarizer slightly through crossed

We can plot the circumferential intensity of the large defect in the upper left, and the results are displayed below.

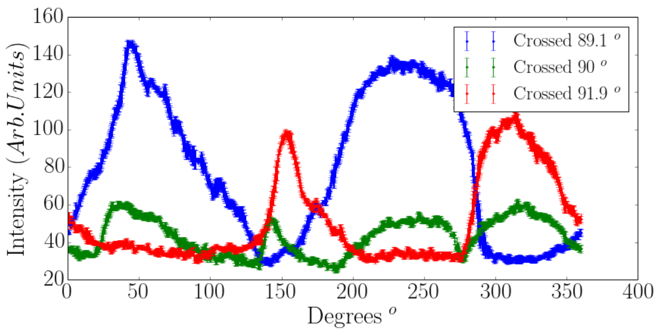

FIG. 7: Strong evidence for tilt would show up in asymmetries between the peaks at π degrees from each other– due to the fact that the light is not incident perfectly normal to the plane. This is described in detail in various thesis from the films lab.

As you can see, the structure is fairly symmetric, with non of the tell tale signs of tilting. However, I am going go go back over old SmC data to verify that our microscope is able to detect tilt.

Even-Odd

We have pretty clear evidence for even-odd switching. However, the smoking gun won't come until we can clearly identify the layer number, unambiguously, of each layer step.

THIS WEEK

To this end, this week I am cleaning the camera to get a cleaner, publishable signal. I will also preform an exhaustive data collection to verify that the camera will work to detect the layer number, comparing the results from the laser and the camera.

Additionally, I will verify that our camera and scope can detect tilt by re-investigating a SmC texture.

This will be a shorter week, but I will be in a good position to finish this next Monday/Tuesday.