

Software development for TCal: A mobile spectrophotometric calibration device

Sarah Hughes
4th year MSci Astrophysics student

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The generous travel grant from Royal Holloway and Santander enabled me to fly to Texas A&M where I worked alongside undergraduates and postgraduate students from across America for my internship project on an instrument called TCal and learnt about the other research that students were conducting. Whilst there we spent each morning discussing newly published astrophysical papers from the archive and had weekly lab meetings to discuss what work still needed to be completed before the first test run of TCal.

TCal is a mobile spectrophotometric calibration unit that will be used to characterise imaging systems at observatories around the world. Spectrophotometry is the measurement of the intensity of light at each wavelength across the entire electromagnetic spectrum. During my internship I helped develop software in LabVIEW to automate our scans which measure transmission as a function of wavelength, and place all calibrated systems on a common photometric baseline.

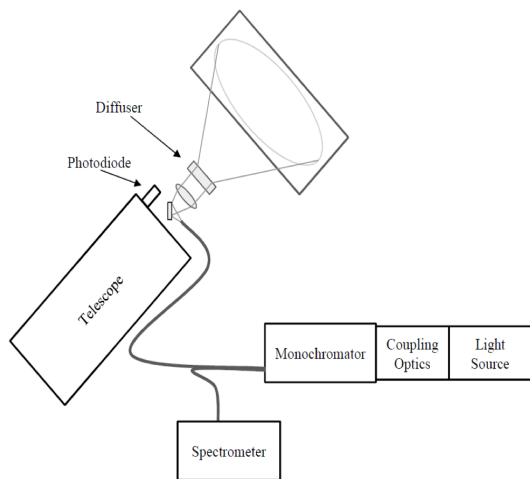


Figure 1: A schematic diagram of TCal.

Current and future generations of wide field/synoptic surveys with high precision photometry will rely heavily on follow-up efforts from other telescopes to enhance

the surveys' scientific yield. Each telescope in astronomy has a unique set of optical equipment produced by a variety of different manufacturers, and it is vital that they are calibrated using the same system in order to obtain the level of precision required to reduce systematic errors when combining data. TCal has been designed specifically for this purpose and was tested for the first time on the 250mm telescope mounted on the 30-inch telescope at the McDonald Observatory, TX.

TCal operates as follows: a broadband light source is fed into a monochromator which selects a narrow bandwidth (approximately 1nm wide at half the maximum of the peak light distribution). This light is fed into a fibre bundle which leads to a spectrometer (which measures the intensity of light as a function of wavelength) as well as a signal diffuser on top of the telescope. A schematic diagram of the system is shown in Figure 1.

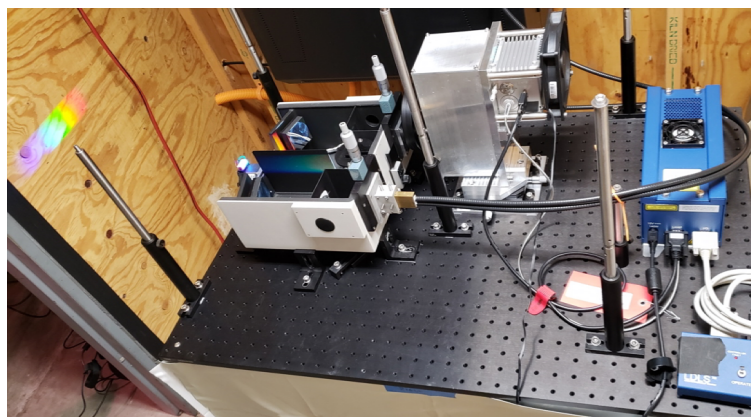


Figure 2: Image demonstrating how the monochromator and fibre bundles were arranged during the test run. It demonstrates the spectrum that is able to be produced and from this narrow wavelength bands of light can be selected for the calibration.

Each of the components for TCal came with their own individual software to operate them, however it was necessary to combine them so that both the controls and

measurements displayed on one graphical display. We developed a program to take data for the spectrometer and photodiode concurrently. This data was then written to a file for further analysis. The code was structured as a state machine with two while loops in parallel. A state machine will read a series of inputs and switch to a different state based on these. The inputs were the controls for the monochromator which adjusts the wavelength, and this was then fed into the other loop to adjust the data charts.

The second loop displayed and output signal readings for the spectrometer and photodiode. A flat sequence frame was used to ensure that certain events happened in a specific order i.e. first opening a data file in the correct path before any readings were taken. Both loops were linked so that the data flow could be managed and both sections stopped simultaneously.

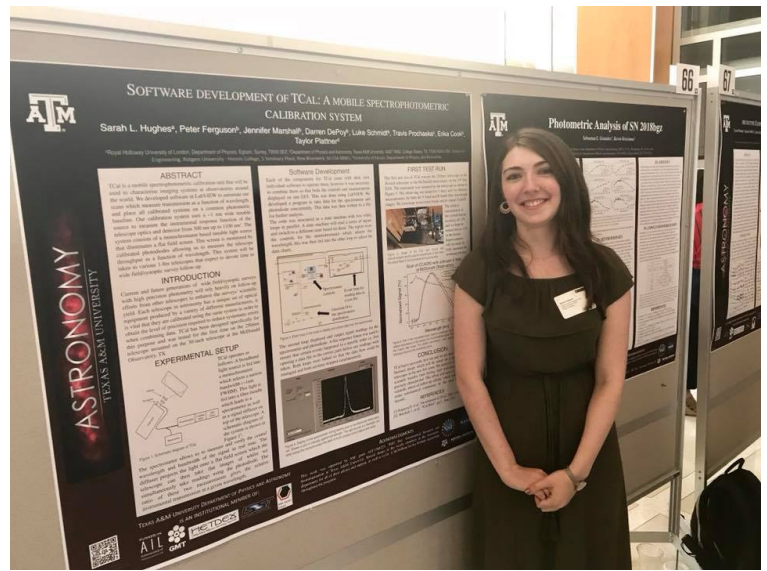


Figure 4: An image of myself next to my final poster at the Texas A&M REU poster session.



Figure 3: Image of the student interns working in the Astronomy department at Texas A&M over the summer. This photo was taken after we had all finished presenting the final posters of our projects.

The first test run of TCal was on the 250mm telescope on the 30-inch telescope at the McDonald observatory on the 19th July 2018. The observing run lasted for 3 days and we obtained measurements for both the Visible band (V) and Blue band (B) filter wavelength ranges. We soon hope to test more bands and to repeat V and B.

The relative transmission of the system had an accuracy of 2% and we hope to reduce this to 1% in the future. Improvements will be made to fully automate the scanning process.

Outside of my work within the Astronomy department, I also made life-long connections with the other

interns taking part in the program. During my second week in Texas we visited the Johnson space centre in Houston and I also engaged in outreach events such as Star-parties where members of the public would come to look through our smaller telescopes and learn about astronomy.

During my visit to the McDonald Observatory I was given the opportunity to assist on another instrument called pETSI. This instrument is designed to detect exoplanet atmospheres by measuring the intensity of light from stars as an exoplanet transits across in multiple wavelengths at once by passing the light through a bandpass filter. The intensity of the light for each band can then be measured throughout the planets entire transit and by making comparison with a companion star we can potentially detect if the exoplanet has an atmosphere.

I was also very grateful to spent time at the observatory with postgraduate students, from whom I learnt a great deal about the day-to-day life of a PhD student and other important advice such as what to look for in a potential supervisor and program. My experience at Texas A&M has been invaluable and confirmed my ambitions to continue my education to a PhD and pursue a career in research so that I may make my own contributions to astrophysics.