<u>SURF 2017 First Interim Report</u>

<u>Project Title:</u> CIBER2 Automated Optical Focus Calibration System

Submitted by: Animesh Mangu, University of California Los Angeles (UCLA)
Mentor: Phil Korngut

Background + Overview:

The Cosmic Infrared Background Experiment (CIBER1) was a sounding-rocket experiment which studied near infrared background light from above the Earth's atmosphere using fluctuation studies and absolute spectro-photometry. Between 2009 and 2013, CIBER1 was flown four total times contained a suite of four separate instruments. The instrument package contained: two imaging telescopes to "characterize spatial anisotropy in the extragalactic IR background caused by cosmological structure during the epoch of reionization", a low resolution spectrometer to measure the absolute spectrum of the extragalactic IR background, and a narrow band spectrometer to measure the absolute brightness of the Zodiacal light foreground. CIBER1 was designed to be recoverable.

An important aspect of this experiment is assuring that the detectors are placed accurately at the correct focal position of the instruments. During laboratory testing for CIBER1, instruments were focused by viewing a source through a vacuum window. The source was generated using an off-axis reflecting telescope as a transmitter by placing an 8 μm pinhole at its prime focus, projecting an unresolved source to infinity. The focus is measured by scanning the pinhole precisely through the collimator's focus position. If the CIBER detectors are correctly placed at the focal plane, the best observed point spread function will be measured when the pinhole is at collimator focus. If corrections need to be applied, the pinhole position during the optimum measurement will inform the user how and what adjustments need to be made.

With the success of CIBER, CIBER2 is currently being constructed as the next generation experiment. The new instruments will contain a 28.5cm primary aperture, allowing for more sensitivity than CIBER, as well as expanded spectral coverage. Launching in 2018, CIBER2 will study fluctuations in the Near-Infrared (NIR) background in 6 bands from 0.5 to 2.0um.

Ongoing Work + Problem:

In the CIBER1 focusing procedure, a knob and a micrometer turned by hand was used to adjust the focus position. The process was incredibly tedious and tiring, especially after being repeated multiple times. This is the significant functionality that needs to be upgraded for the CIBER2 measurements, automating the previously manual task and decreasing the time for the measurement from ~2days to ~2 hours.

The key hardware innovation is to purchase a focuser with a precision and remotely controlled stepper motor to scan the pinhole in the collimator's focus.

The task I have been working on for the past few weeks has been developing an automated optical focus calibration system. To automate the movement for a scanner, we purchased a Moonlite Mini Controller V2 stepper motor. The first week, I installed the appropriate drivers and learned to communicate with the motor using both downloaded software and Python (using the pySerial library). Once I could communicate with the motor, I wrote simple scripts to move the motor position given a user input of steps. The conversion factor for the stepper motor was 6250 steps per inch, allowing me to input displacement values in inches from the 0 position of the motor, defaulted at all the way out. Once I could properly control the motor, I started to write a scanner, something which I am still working on as of right now. The scanner would be given parameters such as the “best focus position”, “course step range”, “fine step range”, “number of course steps”, and “number of fine steps”. A course step was defined to be a larger step than a fine step, and a combination of each can be inputted by the user to displace the motor from it center to its range. The path of the scanner is defined to go from its center position to the range, then back to its center using a combination of course steps and fine steps. At the conclusion of each step, a TTL pulse would be sent to the experiment electronics to set an exposure within an integration time of 10 seconds. Once the Moonlite was back at the center, or best focus position, it would repeat the same processes in the opposite, or “negative” direction. Over the past week I have been implementing this scanning algorithm in Python with a GUI to stop, reset, and focus the motor, as well as take in the specified scanning parameters and plot a graph of the data. The GUI is still in development, and I hope to have a completed scanning program within the next few days.

Challenges + Additional Resources:

Some of the biggest challenges I have faced so far involve communicating with the Moonlite controller using Python. Initially I was simply sending numerical values inside a serial command to displace the motor a certain amount of steps. Since the motor isn’t a widely used product, I had to call the company itself to figure out how the positioning system worked. Next, I realized that the inconsistency between my 3 digit and 4 digit step-position values was because the stepping value had to be sent as a 4 digit number regardless of the actual length of the integer with 0’s in-front. Once I got this to function correctly with the serial command string, I realized that my motor displacements were still incorrect. The last hurdle I had to correct was that the 4 digit values actually had to be converted into hexadecimal values before being inserted into the serial command string and sent to the controller using pySerial. Once I wrote 3 encoder and decoder functions to send and receive the position values in both steps and inches , I was able to correctly reposition the motor.

An additional resource that will be required is a TTL pulse generator to send the pulse at the beginning of each step in the scanner. My mentor has already ordered one to test my program with, and I anticipate challenges in implementing the TTL pulse sender function within my Python script, as well as talking to the device itself. As of right now, my program contains a placeholder which merely prints “Sending TTL Pulse *n...”*. This will be replaced with a function to communicate with the generator using pySerial via a Mini-USB, telling the device to send an actual pulse.

References

- Bock, Jamie. "THE COSMIC INFRARED BACKGROUND EXPERIMENT (CIBER): THE WIDE-FIELD IMAGERS." CIBER Instrument Special Issue ApJS (2012): 1, 7-8. Web.

- Zemcov, M. "THE COSMIC INFRARED BACKGROUND EXPERIMENT (CIBER): A SOUNDING ROCKET PAYLOAD TO STUDY THE NEAR INFRARED EXTRAGALACTIC BACKGROUND LIGHT." CIBER Instrument Special Issue ApJS (2011): 14. Web.

- "WELCOME TO MOONLITE TELESCOPE ACCESSORIES..." *MoonLite Telescope Accessories*. N.p., n.d. Web. 10 July 2017.