

Analysis of Autoguiding for Exoplanet Transit Research at the UNH Observatory



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1. Abstract

This paper will discuss the proper calibration technique for an autoguider of a CCD camera and the results that follow from successful exoplanet transit observations. A brief background on exoplanets, the transit method, and the analysis of their parent stars through photometry will be examined. The results will be presented in a before and after framework that will visually represent the data improvements from autoguiding as both, graphical light curves and images of the night sky. The addition of being able to autoguide at the UNH observatory will work towards providing future students with the possibility of performing follow-up ground-based observations.

2. Introduction

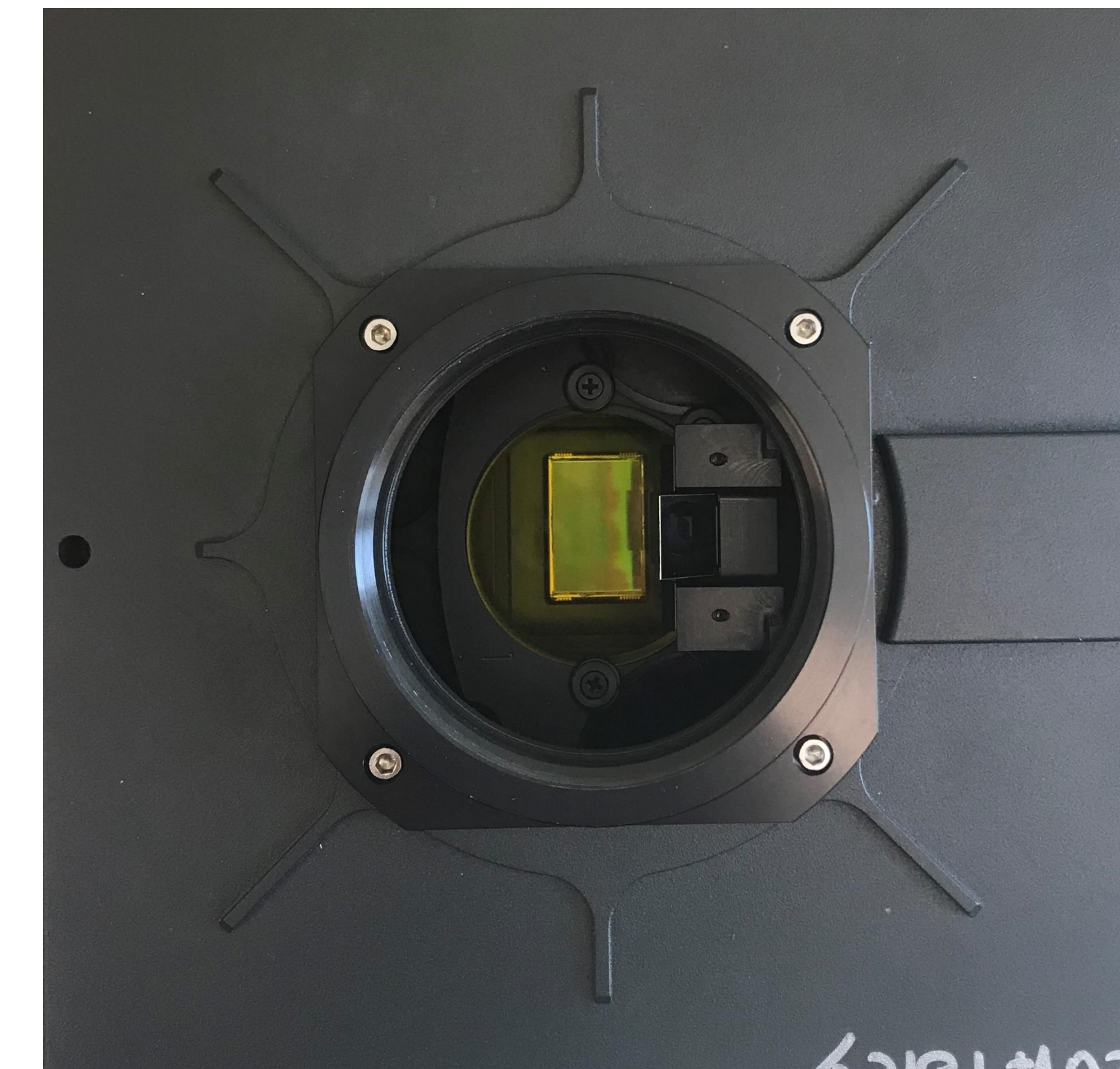
The use of autoguiding during observational astronomy is essential to cleaner images and deep space exposures. As time progresses, stars move across the night sky due to the Earth's rotation. Autoguiding allows for the telescope to track the light produced by a star throughout its journey across the night sky. Without the tracking ability of an autoguider, the observer would be responsible for adjusting the telescopes position to ensure it stays with the star. These adjustments of the telescope typically result in systematic errors and thus flawed data taken of the transit. Additionally when observing deep space objects that are either very dim or far away from Earth, exposure times are typically set for a couple minutes in order to capture more light in a single image than a short exposure would. Again, with longer exposures comes further star movement and being able to avoid a systematic error due to manually adjusting the telescope is crucial to data.

The transit method for observing exoplanets is the process of taking an image of the planets parent star while the planet comes in between Earth and the parent star. During this time, the planet will block the light given off by its parent star, and when graphed, can be seen as a "dip" in the light curve.

3. Calibration Process

The first step in calibrating the autoguider came by allowing the GEM and CCD Filter Wheel to communicate with one another and work in sync. This came relatively simple as the camera was already set up to work with the mount. The drivers for the Filter Wheel had to be updated before the connection between the two was made. The next step involved adjusting the pick-off mirror with the telescope in order to align the mirror with the optical axis. This step was necessary to ensure the mirror did not stretch the resolution of the images produced. Adjustment of the CCD camera's focus was next. This step required extreme attention to detail due to the fact that how good of a camera's focus is directly correlated to how clean and detailed the images produced are. The equipment used can be seen below:

- FW8G-STXL 6303E CCD Camera from SBIG Imaging Systems (Now owned by Diffraction Limited)
- Celestron C14, 0.35m Schmidt-Cassegrain Telescope (SCT)
- Paramount MX+ German Equatorial Mount (GEM)



4. Results and Conclusions

As mentioned before, autoguiding will allow for cleaner, data-filled images of the light exposed by a parent star. Autoguiding has success due to the ability of the telescope mount to communicate with the CCD camera and lock-onto the pixels generated from the star. This allows for the star to stay in the field of view of the telescope and as it moves throughout the night sky, the telescope mount adjusts its position to follow the star. Truly successful autoguiding lies within the polar axis of the telescope mount. By aligning the polar axis of the telescope with the north celestial pole of Earth, the observer can be certain that the autoguider will follow the parent star and reference stars near the edge of the telescope's field of view will not be lost. The polar alignment along with the use of autoguiding will ensure that the field of view of the star field is held fixed in respect to the CCD chip's pixels, which will keep stars near the edge of the star field from being lost.

5. Future Research

It is clear that autoguiding is a necessity to taking exoplanet transit observations at an advanced level. The use of autoguiding along with the progress made by fellow students Tom Ireland (Image Calibration) and Nick Larose (Observatory Depth Level) the observatory here at UNH will have techniques available to future students that will make their work more professionally appealing. Observing exoplanet transits for a professional astronomer meets all these requirements for the reason being that the images produced are far superior in terms of data and clarity than without using these techniques. Additionally, in Senior Lab for Astronomy-focused majors, they will be performing a lab that consists of observing multiple exoplanet transits and attempting to produce a light curve. Given the advancements we have made to improve the astronomical methods used at the UNH observatory, future students will have the ability to publish the work they will do as ground-based follow-up observations in correlation to NASA's current TESS mission (Transiting Exoplanet Survey Satellite). This will be possible because they will be using professional astronomer techniques to minimize the error in their images to be as little as possible. It was the thought of this possibility that had convinced me on this thesis. To be able to leave a sort-of legacy here in the UNH Physics department and improve the facilities around me for future students has been beyond exciting.

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