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THE ORTEGA TELESCOPE ANDOR CCD

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ABSTRACT

We present a preliminary instrument report for an Andor iKon-L 936 charge-couple device (CCD) being operated at Florida Tech's 0.8 m Ortega Telescope. This camera will replace the current Finger Lakes Instrumentation (FLI) Proline CCD. Details of the custom mount produced for this camera are presented, as is a quantitative and qualitative comparison of the new and old cameras. We find that the Andor camera has 50 times less noise than the FLI, has no significant dark current over 30 seconds, and has a smooth, regular flat field. The Andor camera will provide significantly better sensitivity for direct imaging programs and, once it can be satisfactorily tested on-sky, will become the standard imaging device on the Ortega Telescope.

Subject headings: instrumentation: detectors – methods: data analysis – telescopes.

1. INTRODUCTION

Since being introduced ∼ 40 years ago, charge-coupled devices (CCDs) have become a dominant type of photon detector. CCDs were initially conceived as an electronic analog of the magnetic bubble system (for a more thorough history see Janesick & Elliott 1992) and their popularity stems from their ability to integrate over long time intervals, their dynamic range, high quantum efficiency, and from the relative ease with which arrays can be formed to allow two-dimensional data collection. The basic detection mechanism is related to the photo-electric effect. Light incident on a semiconductor produces electron-hole pairs. These electrons are then trapped in potential wells produced by numerous small electrodes (see, for example, Kitchin 2009). Charges are transported through the CCD by electrodes placed very close together. The voltages on the gates of the electrodes are then sequenced to move charge from one electrode to the next, hence the term charge-coupled device. Once shifted to the end of a row or column, the charges are read out and converted to digital units.

The 0.8 m (32 inch) Ortega Telescope is located atop the F.W. Olin Physical Sciences building at Florida Tech in Melbourne, FL. It is a DFM Engineering *f*/8 R-C Cassegrain telescope on an equatorial fork mount and has both direct imaging and spectroscopy capabilities. It is primarily operated by Florida Tech students undertaking research projects that benefit from differential photometry. Currently, the primary imaging device is a Finger Lakes Instrumentation Proline CCD (FLI, hereafter). However, this is to be replaced by an Andor iKon-L 936 (Andor, hereafter).

The FLI Proline is a back-illuminated SITe SI-003 scientific-grade 1024 x 1024 sensor and uses a 3-stage peltier (thermoelectric, TE) air cooler. Typical operating temperatures are ∼ 50° C below ambient. The Andor has a back-illuminated E2V grade 1 2048 x 2048 sensor and uses a 5-stage Peltier TE air cooler to reach a sensor temperature of −80° C absolute. Consequently, we expect the Andor to provide significantly higher sensitivity and slightly wider field-of-view. The factory information for the two cameras is presented in Table 1.

TABLE 1
Details of the FLI & Andor Cameras

Property	FLI	Andor
Detector	SITe SI-003	E2V CCD42-40
Active Pixels	1024 x 1024	2048 x 2048
Sensor Size	24.6 x 24.6 mm	27.6 x 27.6 mm
Pixel Size	24 x 24μm	13.5 x 13.5μm
Well Depth	300,000 e^-	100,000 e^-
Maximum air cooling	−50° C[a]	−80° C
Peak QE	80% at 550 nm	97% at 550 nm

Note. — Basic features of the two cameras.
[a]Below ambient

This paper is an instrument report that provides a qualitative and quantitative comparison of the FLI and Andor for the reference of Ortega observers. In §2 we present the details of the custom mounting plate required for the Andor, and in §3 we describe the data taken for this report and how is was reduced. §4 presents the results, and §5 sums up.

2. MOUNT

The original design of the Andor has a single machined end piece of aluminum that encloses the shutter mechanism, incorporates a Nikon F-lens mount and screws into the main body of the camera. With this design, the sensor is 46.5 mm from the front of the shutter housing. The fiducial telescope focus is 17.0 mm from the front of the housing and can move out by 24.3 mm and in by 9.6 mm, i.e., from 41.3 mm to 7.4 mm. Therefore, the original shutter housing design must be modified.

The Andor is significantly larger and more massive than the FLI, so the replacement camera mount must be light tight, lightweight, sturdy (to prevent the cam-

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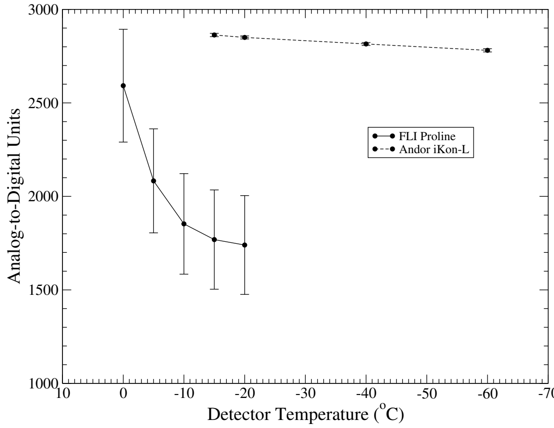

FIG. 1.— The relative bias levels of each camera as a function of sensor temperature. The lines are only provided to guide the eye, and are not a fit to the data.

era from moving as the telescope slews), not inhibit the air cooling ports, be optimized to accommodate the USB control and power cables, and minimize the distance from the fiducial telescope focus and sensor.

Our chosen design comprises of three separate pieces. An upper and lower brace, and a shutter housing-telescope mount hybrid. As it is considerably larger than the FLI camera, the braces account for the extra weight and length of the new Andor camera. The braces run along the sides of the camera to coincide with cylindrical grooves at the 4 corners of the camera body. This allows for significant support with a minimum of material. By combining the shutter housing and telescope mount the final mass of the whole mount is minimized, as is the distance of the sensor to the fiducial focus. However most of the original shutter housing design is retained keeping the system light tight and simple. The major differences are in the removal of the Nikon F-mount, and in the extension of the end of the housing to enable telescope mounting. The two brace pieces screw into the modified shutter housing-telescope mount, and this screws into the main camera body. In this design, the sensor is 34 mm from the front of the housing and well within the focus limits. The new mount was milled from T-6061 Al (the same material as used for much of the telescope) at the Florida Tech machine shop, and was given a standard black anodize. Once on the telescope, no movement of the camera could be detected as the telescope was slewed around the sky.

3. DATA

Inclement weather on the night of our test run prevented the dome from being opened. Therefore, we have yet to test the Andor on-sky, verify that the telescope can be focused onto the new sensor or determine if there is any variation in the focus as a function of hour-angle (which may signal some movement of the camera in its new mount). However, we have used both cameras, while mounted to the telescope, to collect bias frames, flat fields and dark frames of 1.0, 10 and 30 seconds. All data received 2 x 2 binning. With the FLI, these data were taken at 5 different temperatures: 0, -5, -10, -15, and -20^{o} C. The ambient temperate was $+25^{o}$ C and the TE coolers of the FLI could not hold a stable temperature below -20^{o} C. The TE coolers of the Andor camera could not hold a stable sensor temperature above -15^{o} C, so

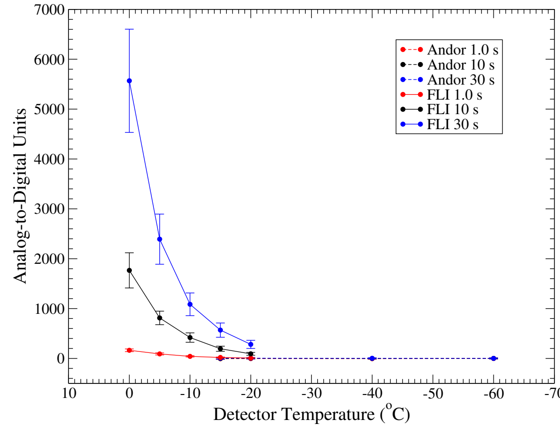

FIG. 2.— The relative dark currents in each camera, for several exposure times, as a function of sensor temperature. The lines are only provided to guide the eye, and are not a fit to the data..

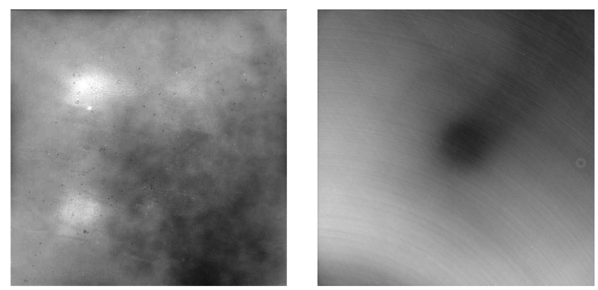

FIG. 3.— Flat field images at -20^{o} Celsius. The FLI is to the left, the Andor is to the right. The cut levels have been chosen to show as much detail as possible.

these data were collected at -15, -20, 40, and -60^{o} C. To enable cosmic ray rejection, each data set was repeated 3 times and median combined. The relevant bias frames were subtracted from the dark frames, and the mean and standard deviation of the pixel values for each final reduced frame were calculated.

4. RESULTS

In Figure 2 we plot the mean and standard deviations of the reduced (median combined) bias frames, from each camera, as a function of sensor temperature. The relative signal to noise ratios (μ/σ) at -20^{o} C of the FLI and Andor cameras are 6.6 and 350 respectively. The Andor camera has over 50 times less noise than the FLI, so it is curious that the Andor camera has such a relatively large bias applied.

In Figure 2 we plot the mean and standard deviations of the reduced (bias subtracted, median combined) dark frames, from each camera and exposure time, as a function of sensor temperature. The FLI dark current is significant, however the Andor dark current is consistent with zero under all the tested conditions.

A striking difference is seen when comparing the flat field images taken at -20^{o}Celsius (see Figure 3). The FLI appears blotchy and irregular in many places, but the Andor appears to be significantly more clear and distinct. The relative quality of the two cameras is profound.

5. SUMMARY

We have constructed a custom mount for an Andor iKon-L CCD camera to enable astronomical imaging at the Florida Tech Ortega Telescope. The basic characteristics of this camera have been determined and compared to the FLI Proline currently used for imaging. We have found that the Andor camera has significantly less noise than the FLI, that it has negligible dark current, and that the flat field is considerably more smooth.

As soon as practical, the Andor will be tested on sky. At this point, the focus will be confirmed at ~ 34 mm from the front of the housing, the new field-of-view (in arc seconds) will be determined, and some test images of well known objects will be performed. In addition, to confirm that the new mount does not allow the Andor camera to move, the focus will be determined with the telescope at various altitudes. Once these procedures have been satisfactorily carried out, the Andor camera will become the standard imaging device for the Ortega Telescope.

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REFERENCES

Janesick, J., & Elliott, T. 1992, Astronomical CCD Observing and Reduction Techniques, edited by Steve B. Howell, Astronomical Society of the Pacific, vol. 23, San Francisco, CA.

Kitchin, C. R. 2009, Astrophysical Techniques, Fifth Edition, by C. R. Kitchen, CRC Press, Taylor & Francis Group