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Characterisation and Calibration of the Kepler KL4040 sCMOS camera for Optical Observations at the UFS/Boyden Observatory

The Kepler KL4040 sCMOS camera by Finger Lakes Instruments was evaluated for its suitability as an affordable alternative to older CCD sensors for optical photometry at the Boyden Observatory. Due to the sensor architecture where each pixel has its own electron to voltage converter, a thorough characterisation and calibration study was conducted to identify key performance factors and necessary considerations for operational implementation. The KL4040 achieves a high dynamic range by merging two 12-bit images into a single 16-bit image, with binning performed via software.
Laboratory tests examined bias stability, dark current, and photo-response characteristics. Bias frames exhibited a 7.5% increase in mean counts as temperature rose from -15℃ to 10℃, with dark current showing a linear temperature dependence. A small offset between the merged images for the 12bit to 16bit conversion was identified but was correctable through adjustments to the gain transition parameter that determines the offset value between high and low gain. Photo-response curves for the B, V, R, and I bands confirmed linearity across all bands. Fixed pattern noise (FPN), a known issue in sCMOS sensors, was effectively mitigated through bias, dark, and flat-field corrections.
On-sky tests included standard field photometry of the AAVSO SA107 field. Transformation coefficients enabled photometric corrections to within 2% of known values. Additionally, high cadence photometry of the pulsating white dwarf binary system AR Sco was performed to test fast photometry throughput. A full orbital period of AR Sco was captured at a 6 s cadence, revealing the 118.2 s beat period via Lomb-Scargle analysis. The folded light curve displayed clear periodic variations.
These results confirm the KL4040 as a viable, cost-effective alternative to CCDs for photometry at the Boyden Observatory. While it lacks single-photon sensitivity, its quantum efficiency, fast readout, and large sensor size make it a strong contender for astronomical imaging on a budget. In addition, because of image manipulation such as binning and sub-frame selection happening post image readout and is not hardware based, image quality, size and throughput can be optimized through software development and is not limited to hardware capabilities.

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Primary author: Dr VAN HEERDEN, Hendrik Jacobus (University of the Free State)

Co-authors: Prof. VAN SOELEN, Brian (University of the Free State); Mr SMIT, Wian (University of the Free State)

Presenter: Dr VAN HEERDEN, Hendrik Jacobus (University of the Free State)

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