GPI 2.0: Performance Evaluation of the Wavefront Sensor's EMCCD

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Abstract

Electron multiplying CCDs (EMCCDs) are detectors capable of counting single photon events at high speed and high sensitivity. In this work, we characterize the performance of the HNü 240 EMCCD from Nüvü Cameras, which was custom-built to be used in the pyramid wavefront sensor (PWFS) upgrade of the Gemini Planet Imager 2.0 (GPI 2.0). Like GPI 1.0, GPI 2.0 aims to directly image and characterize extrasolar planets, with an upgraded ultra low-noise wavefront sensor that is expected to give the adaptive optics (AO) system the capability to achieve high Strehl ratios on stars two magnitudes fainter than the current limit. The HNü 240 EMCCD's characteristics make it well suited for extreme AO: it has low dark current ($<$ 0.01 e-/pix/fr), low readout noise (0.1 e-/pix/fr at a gain of 5000), high quantum efficiency ($>$ 90% at wavelengths from 600-800 nm; $>$ 70% from 800-900 nm), and fast readout (up to 3000 fps full frame). We tested the EMCCD's noise contributors, such as the readout noise, dark current, pixel-to-pixel variability and CCD bias. We also tested the linearity and EM gain calibration of the detector. All camera tests were conducted before and after its integration into the GPI 2.0 PWFS system. After integration, the effects of temperature on the performance of the camera were explored. To test the pyramid wavefront sensor in the laboratory, we used a custom-built test source unit to simulate the light incident from the telescope to the sensor.

Keywords: wavefront sensing, detectors, EMCCD, exoplanets

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