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THE TESS MISSION: INSTRUMENT NOISE CHARACTERIZATION FOR PRECISE PHOTOMETRIC PERFORMANCE EVALUATION AND SCIENCE SENSITIVITY ANALYSIS

Abstract

NASA's Kepler mission revolutionized the exoplanet field by showing how abundant planets around stars are. The Transiting Exoplanet Survey Satellite (TESS) will take the next logical step in searching for planets around nearby bright stars that can be followed up using spectroscopy to measure the planetary masses and atmospheric conditions. TESS has been selected by NASA for launch in 2018 as an Astrophysics Explorer mission, and is expected to discover a thousand or more planets that are smaller in size than Neptune. TESS will employ four identical wide-field optical CCD cameras with a band-pass of 650 nm – 1050 nm to perform differential time-series photometry by monitoring at least 200,000 main sequence stars. The detectors are designed for enhanced sensitivity to the redder wavelengths because it is easier to detect small planets around small red stars. The upper limit of the band-pass cutoff at 1050 nm is driven by the quantum-efficiency curve of the detectors. Exoplanet detection using planetary transits requires very high precision photometry. The instrument noise should therefore be characterized accurately and minimized. Very precise on-ground calibration and characterization of CCD detectors will significantly assist in the analysis of the science data obtained in space. An optical test bench with significantly high photometric stability has been developed to perform precise measurements. In this paper, an integrated noise model and instrument characterization techniques developed for the TESS instrumentation will be presented. In particular, the characterization of the absolute quantum efficiency (QE), pixel response non-uniformity, gain, charge saturation and blooming, undershoot effects and intrapixel sensitivity of the CCD detectors will be presented. The effect of instrument systematics on the photometric noise budget and the science yield of the mission will also be discussed.