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SUB-PIXEL DETECTOR CHARACTERIZATION FOR HIGH PRECISION PHOTOMETRY MISSIONS

Abstract

Exoplanet detection using planetary transits requires very high precision photometry. Instrument systematic noise requirement on such missions is limited to tens of parts per million over few hour timescales. One of the most significant sources of noise is the detector sub-pixel response variation that can lead to increased systematic error in the presence of pointing instability. The paper presents simulation results showing the effects of sub-pixel response variations and jitter on photometric precision and the population of stars that can be studied in the context of upcoming and future planetary transit missions. Limited work has been done to study the effect of intrapixel variations on photometric precision through on-orbit experiments. On-orbit studies are time consuming, depend on the availability of the space telescope and take away time from the science operations. Laboratory studies would overcome these challenges but require simulating on-orbit conditions and very high photometric stability of the light source to obtain precise measurements. The paper describes the design, fabrication and calibration of a state-of-the-art facility with an automated testbed to make precision measurements in a laboratory setting. Specific application to the Transiting Exoplanet Survey satellite (TESS) will be presented. TESS is an Astrophysics Explorer mission selected by NASA for launch in 2018, and is expected to discover more than a thousand planets that are smaller in size than Neptune, orbiting bright dwarf stars. TESS will employ four wide-field optical charge-coupled device (CCD) cameras with a band-pass of 650 nm - 1050 nm to detect temporary drops in brightness of stars due to planetary transits. The precision measurement of error sources associated with the CCD detectors, especially over the redder wavelengths is a crucial part of the characterization process because it will hugely aid in detecting transits around M stars. In addition to presenting the application of the present work to TESS, the effects of instrument systematics on asteroseismology and astrometry will also be discussed.