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Photon-Counting CCDs for Future Spectroscopic Surveys

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The next generation of ground and space-based cosmic surveys in the optical to near-IR regime require extremely sensitive, virtually noiseless detectors that are capable of counting single-photon or single-electron events. Skipper charge-coupled devices (CCDs) offer the ability to achieve deeply sub-electron read noise by exploiting the technique of non-destructive readout to independently measure the charge in each pixel repeatedly to reduce noise to desired levels, while preserving the well-established characteristics of fully-depleted, backside-illuminated silicon CCDs including excellent low-light sensitivity, high quantum efficiency, and uniformity. However, the limiting factor for astronomical applications is the prohibitive read time that scales with the number of measurements per pixel. The Multi-Amplifier Sensing (MAS) CCD architecture evolved from the Skipper CCD to address this readout time penalty by allowing charge to be measured by a series of Skipper amplifiers interspersed along the serial register. This capability reduces the readout time by a factor of the number of amplifiers in the chain compared to a Skipper CCD for the same number of samples per pixel and equivalent noise level. We will present an overview of the MAS CCD and their role in the upgrade to the ongoing DESI massive spectroscopy survey and in the R&D of next generation surveys that builds on the success of the CCDs employed in the Dark Energy Camera and DESI. We will discuss the promising preliminary experimental efforts on instrumenting and testing the first MAS CCDs currently underway at LBNL and Fermilab. Finally, we will highlight science cases in the broader context of astrophysics that MAS CCDs would enable, from capturing faint transients to direct imaging and spectroscopy of Earth-like extrasolar planets.

Early Career

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