Advances in SPAD array-based time-resolved wavefront sensing

Jean-Pierre Veran*[1], Simon Carrier[2], Maaike Van Kooten[3], Kathryn Jackson[1], and Charlebois Serge[2]

[1]NRC Herzberg Astronomy and Astrophysics – Canada
[2]Université de Sherbrooke – Canada
[3]NRC Herzberg Astronomy and Astrophysics – Canada

Abstract

SPAD array-based detectors are becoming an affordable option for very high-speed photon counting. SPAD array cameras able to deliver frame rates of up to 100kHz with no read-noise are now commercially available, with the next generation of these devices promising even more efficiency and functionalities. We have proposed to leverage this emerging technology to improve wavefront sensing for adaptive optics. Our first application is with pyramid wavefront sensors (PWFSs), where the high-frame rate capability is used to resolve the modulation process. Instead of one frame integrated over the modulation cycle, SPAD arrays allow us to obtain many frames, one for each position in the modulation cycle, with no noise penalty. With more measurements, we are able to make more accurate reconstructions, especially for low-order modes for which the sensitivity is reduced due to the modulation. Overall, a time-resolved PWFS (TRPWFS) is more sensitive than a conventional modulated PWFS, and has more dynamic range than a non-modulated PWFS. In this paper, we will present our latest end-to-end simulation results of a TRPWFS-based AO system and compare them with more conventional system setups. We will also show initial laboratory results and we will describe our near-term plan to demonstrate TRWFS on sky, using a commercial SPAD array and REVOLT, the HAA on-sky AO demonstrator.

Keywords: SPAD, Pyramid Wavefront Sensor, Wavefront Reconstruction

*Speaker