

Using phase-mask coronagraphy in the Extreme-AO regime at Palomar to image exoplanets: lessons learned

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Starting in 2005, the Palomar 5.1-meter Hale telescope's first-generation low-order adaptive optics system (upgraded to 3000+ actuators in June 2011) was used in the ExAO regime by concentrating its power on a well-corrected subaperture of 1.5 meter, yielding $SR > 90\%$ in H and K bands. This trick allowed us to efficiently use new-generation phase-mask coronagraphs providing very small inner working angle. I will discuss the system-level optimizations we had to perform to make the most of this instrumental setup, culminating with the imaging of exoplanets: low-frequency and high frequency pointing stabilization, focus removal, non-common path wavefront errors calibrations using the modified Gerchberg-Saxton phase retrieval technique, synchronized observing strategy. Without the availability of differential imaging capabilities (ADI, SDI, PDI), we had to rely on the well-proven reference star subtraction (note that ADI and SDI are not efficient at very small angles). Fast and reproducible AO target acquisition allowed us to implement an efficient nodding method where the interval between the target and calibrator was reduced to 5-10 min, which is the key to achieve a high degree of correlation in the quasi-static speckle pattern required by smart data processing methods such as the locally optimized combination of images (LOCI).