Vortex Fiber Nulling Demonstration at Keck and Predicted Performance on the TMT

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Abstract

Vortex fiber nulling (VFN) is an interferometric method for suppressing starlight in order to observe exoplanets at small angular separations from their star, $1\lambda/D$. This technique may enable the discovery and characterization of young giant planets at separations smaller than conventional coronagraphs can reach. On the ELTs, this will push direct imaging to unprecedented separations of < 15 mas in K-band, allowing us to probe exoplanets at less than 1 au around stars at 50 parsec. A pathfinding VFN mode was deployed to the Keck Planet Imager and Characterizer (KPIC) instrument at the Keck II telescope in February 2022 and is now operational on-sky. Commissioning results demonstrate an on-sky starlight suppression of _˜1e-2 in K-band, primarily limited by residual wavefront error from the AO system. This performance already enables KPIC to efficiently search for new companions at separations of 20 to 80 mas from their star whereas the alternative observing mode requires precise, prior knowledge of companions. In late 2022, the KPIC VFN mode successfully detected a new companion at a 1:50 flux ratio at 50 mas from its G0-type host and a survey for other companions, guided by Gaia astrometry measurements, is now underway. Here we present the results of commissioning with the VFN mode, the capabilities that it unlocks, and pathways to improving the performance on KPIC. We also present the implications of these results on the upcoming pathfinder VFN mode on HISPEC at Keck and ultimately on MODHIS at the TMT. This includes predicted performance curves based on extrapolations from the current KPIC VFN performance to the expected ELT AO performance.

Keywords: Planet Detection, Planet Characterization, Direct Imaging, Fiber Nulling, Cross Aperture Nulling

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