Wavefront Control for Improved Starlight Rejection Through a Single-Mode Fiber

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Abstract

Connecting a coronagraph instrument to a high resolution spectrograph via a single-mode optical fiber is a promising technique for characterizing the atmospheres of exoplanets with ground and space-based telescopes. However, due to the small separation and extreme flux ratio between planets and their host stars, instrument sensitivity will be limited by residual starlight leaking into the fiber. To minimize stellar leakage, we must apply a control loop on the wavefront at the fiber input. Implicit electric field conjugation (iEFC) is a model-independent wavefront control technique in contrast with classical electric field conjugation (EFC) which requires a detailed optical model of the system. We present here the first demonstration of an iEFC-based wavefront control algorithm to improve stellar rejection through a single-mode fiber. As opposed to image-based iEFC which relies on minimizing intensity in a dark hole region, our approach aims to minimize the amount of residual starlight coupling into a single-mode fiber. We present both simulation and lab results demonstrating the effectiveness of this technique. Having no need for an optical model, this fiber-based approach is easier to implement than conventional EFC on future ground and space-based telescope missions.

Keywords: AO, Wavefront control, iEFC, EFC, single mode fibers, actuators, coronagraphy, optical fibers, wavefronts

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