High Contrast Imaging Tools at Keck Observatory

Charlotte E. Guthery[*†1], Jacques Delorme[1], Sam Ragland[1], Mike Bottom[2], Sam Walker[2], Maria Vincent[2], Rebecca Jensen-Clem[3], Maissa Salama[3], Vincent Chambouleyron[3], Maaike Van Kooten[4], Kent Wallace[5], Charlotte Bond[6], Sylvain Cetre[7], and Peter Wizinowich[1]

[1]W.M. Keck Observatory – United States
[2]Institute for Astronomy – United States
[3]Department of Astronomy and Astrophysics [Univ California Santa Cruz] – United States
[4]NRC Herzberg Astronomy and Astrophysics – Canada
[5]Jet Propulsion Laboratory – United States
[6]UK Astronomy Technology Centre – United Kingdom
[7]Department of Physics [Durham] – United States

Abstract

High contrast imaging (HCI) is limited in practice by uncorrected wavefront errors within traditional adaptive optics (AO). Keck observatory experiences roughly 130nm of residual wavefront error even with well calibrated AO. Multiple HCI tools currently in development are presented, focused on minimizing these errors and improving contrast during typical observation nights: (1) Fast and Furious is a focal plane wavefront sensing algorithm shown to correct for large portions of non-common path aberrations between the NIRC2 science instrument and the primary Keck wavefront sensor (WFS). On sky demonstrations of an operational version of this algorithm show an increase in Strehl ratio up to 17% in a single run. (2) The Keck primary mirror phasing is known to degrade between routine segment exchanges. A Zernike WFS (ZWFS) is currently installed within the Keck Planet Imager and Characterizer (KPIC) to take passive measurements of the primary mirror to maintain the phasing. The detection of segment piston wavefront errors down to 50 nm with the ZWFS demonstrates the first step of maintaining phasing in parallel with science observations. (3) Operational speckle nulling algorithms are in test to minimize bright speckles during HCI. (4) As an addition to an upgraded real time controller, predictive wavefront control will be further developed to minimize errors due to large windspeeds and servo lag. These HCI demonstrations will be presented as reliable, robust, and simple to control operational tools which will become available to greatly benefit observers.

Keywords: high contrast image, segment phasing, zernike wavefront sensor, focal plane wavefront sensor, predictive wavefront control, speckle nulling

[*]Speaker
[†]Corresponding author: cguthery@keck.hawaii.edu