The Offset Dust Ring of HR 4796A and Other Debris Disks as Revealed by NICI.

Zahed Wahhaj[1], Michael C. Liu[2], Beth A. Biller[3], Eric L. Nielsen[2], Tom L. Hayward[4], Marc Kuchner[5], Laird M. Close[6], Mark Chun[2] Christ Ftaclas[2] and Douglas W. Toomey[7]

[1]*European Southern Observatory, Chile,* [2]*University of Hawaii, USA,* [3]*MPIA, Germany,* [4]*Gemini South Observatory, Chile,* [5]*NASA Goddard Space Flight Center, Greenbelt, MD,* [6]*Steward Observatory, University of Arizona,* [7]*Mauna Kea Infrared, Hilo, HI*

We present adaptive optics images of the dust disks around the 7 young stars, HR 4796 A, β Pictoris, AU Mic, HD 141569, HD 32297, HD 15115 and HD 61005, where the relative position of the star and disk clumps and warps are captured at high-resolution (0.05″). These images were obtained using the Near Infrared Coronagraphic Imager (NICI) on the Gemini-South 8.1 meter Telescope. For HR 4796 A, we present J, H, CH_4 short (1.578 μm), CH_4 long (1.652 μm) and K_s-band images of the dust ring around the 10 Myr old star HR 4796 A. Our images clearly show for the first time the position of the star relative to its circumstellar ring thanks to NICI's translucent focal plane occulting mask. We employ a Bayesian Markov Chain Monte Carlo method to constrain the offset vector between the two. The resulting probability distribution shows that the ring center is offset from the star by 16.7±1.3 milliarcseconds along a position angle of 26±3°, along the PA of the ring, 26.47±0.04°. We find that the size of this offset is not large enough to explain the brightness asymmetry of the ring. The ring is measured to have mostly red reflectivity across the JHK_s filters, which seems to indicate micron-sized grains. Just like Neptune's 3:2 and 2:1 mean-motion resonances delineate the inner and outer edges of the classical Kuiper Belt, we find that the radial extent of the HR 4796 A and the Fomalhaut rings could correspond to the 3:2 and 2:1 mean-motion resonances of hypothetical planets at 54.7 AU and 97.7 AU in the two systems, respectively. A planet orbiting HR 4796 A at 54.7 AU would have to be less massive than 1.6 M_{Jup} so as not to widen the ring too much by stirring (Wahhaj et al. 2014). We also present our findings on the other debris disks, especially, the spiral dust sturcture in HD 141569 (Biller et al. 2014), and the orbit of the β Pictoris planet and its relative inclination to the inner and outer disks (Nielsen et al. 2014).