

Reconnaissance of the β Pictoris system down to 1.75 AU with the L'-band vector vortex coronagraph on VLT/NACO

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Abstract

High contrast imaging has thoroughly combed through the limited parameter space accessible with first-generation ground-based adaptive optics instruments and the HST. Only a few objects were discovered, and many non-detections reported and statistically interpreted. The field is now in need of a technological breakthrough. We aim at opening a new parameter space with first-generation systems such as NACO at the Very Large Telescope, by providing ground-breaking inner working angle (IWA) capabilities in the L' band. This mid-infrared wavelength range is a sweet spot for high contrast coronagraphy since the planets-to-star brightness ratio is favorable, while Strehl ratio is naturally higher.

An annular groove phase mask (AGPM) vector vortex coronagraph optimized for the L' band, made out of diamond subwavelength gratings has been manufactured and qualified in the lab. The AGPM enables high contrast imaging at very small IWA (here 0".09), potentially being the key to a new parameter space. Here we present the results of the installation and successful commissioning of an L'-band AGPM on VLT/NACO. During a recent science verification run, we imaged the inner regions of Beta Pictoris down to the previously unexplored projected radius of 1.75 AU with unprecedented point source sensitivity. The disk was also clearly resolved down to its inner truncation.

The new NACO mode is an opportunity to introduce a more rigorous framework for deriving detection limits at very small angles, which is also relevant for SPHERE and GPI and every high contrast imaging instrument with small IWA ambitions. Indeed, classical tools assuming Gaussian statistics, perfectly

valid at large separations, lose significance close to the center simply because the sample size decreases dramatically (fewer resolution elements at a given radius). Moreover, the probability density function (PDF) of speckle noise and associated confidence level for detection depend on radius. ADI was shown to transform speckles' modified Rician PDF into quasi-Gaussian PDF at large separations, but it is expected that this property of ADI does not hold true at small angles. Finally, the flux attenuation induced by ADI, potentially significant at small angles, does not scale linearly with the companion brightness, which makes its calibration more difficult.

