Direct detection of exoplanets and circumstellar disks using NaCo APP and NaCo PDI

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An Apodizing Phase Plate (APP) for NaCo - Increasing the contrast at small IWA in the L band

NaCo-APP facts

- Sits in pupil plane -> no special alignment of source
- Increases contrast between ~0.2\"-0.7\" by ~1.5-2.5 mag
- Designed for NB4.05 (but also L’)
- Can be combined with ADI

- Reduces peak flux of all objects by ~45%
- Covers only one side of the PSF

References:

Kenworthy et al. 2010, SPIE Volume 7735
Kenworthy et al. 2010, The Messenger 141
Girard et al. 2010, SPIE Volume 7736
An independent confirmation of the exoplanet beta Pictoris b with NaCo APP

Results:

Separation:
0.345'' ± 0.012''
6.8 ± 0.2 AU (@ 19.3 pc)

Position angle:
209.13° ± 2.12°

App. magnitude NB4.05:
11.20 ± 0.23 mag

Mass (DUSTY models):
7-10 \text{ M}_{\text{Jupiter}} (12 \text{ Myr})
NaCo APP data provides a first color estimate for beta Pictoris b

Results:

Spectral type:
~L0-L7

Effective temperature:
- 1500 - 2100 K
  (from BD comparison)
- ~1500 K
  (from DUSTY models)

Quanz et al. 2010, ApJL 722, 40
Additional information about APP

- Talk by Johanan Codona on Thursday
  "Achromatic Optics for Phase Apodization Coronagraphy"

- Poster by Julien Girard
  "NaCo's coronagraphic upgrades"
Polarimetric differential imaging (PDI) - Basic principle

Simultaneous observations of 2 polarization directions orthogonal to each other

1. Stellar flux cancels out as its largely unpolarized!

2. Disk flux is polarized as light was scattered on dust grains - a "butterfly"-pattern appears!
HD100546 - A showcase system

- Distance: ~103 pc
- Age: ~10 Myr
- Spectral type: B9Vne
- Disk inclination: 40°-50°
- Disk position angle: 140°-150°
- Disk features:
  - Warps and spirals
  - Inner gap and suspected planet

Cartoon from Benisty et al. 2010, A&A 511, 75
NaCo PDI probes the inner 10-100 AU of the HD100546 disk

Planets are expected to form mainly here

HST ACS image of HD100546
Disk orientation, brightness profiles and disk colors in the inner regions can be compared with HST results.

Quanz et al. 2010, in preparation
Structures in the inner disk may hint at ongoing dynamical processes or planet formation.

- 25-35% less polarized flux
- Gap in dust @20 AU
- Inner rim of "outer" disk?

Quanz et al. 2010, in prep.
Summary - Take away messages

• NaCo APP has been successfully commissioned and has demonstrated its capabilities with an independent confirmation of beta Pic b

• VLT/NaCo is the only instrument on an 8-m telescope worldwide that is equipped with an APP providing unique high-contrast capabilities at 4 micron

• NaCo PDI can directly image and resolve the innermost regions of dusty disk down to ~0.1" and provide important information about dust grain and disk properties complementary to HST