AO@ESO
Adaptive Optics Facilities at ESO
C. Lidman
NACO, SINFONI, CRIRES and MAD
NACO = NAOS + CONICA

ESO’s multi-purpose AO facility

- Shack-Hartmann wave-front sensing - in the visible and near-IR
- Uses natural guide stars (R=16, K=13) or the laser guide star (R=19)
- CONICA has many Modes covering the 1 – 5 micron spectral range
  - Imaging
  - Coronography
  - Polarimetry
  - Spectroscopy
  - SAM – Sparse Aperture Masking
  - SDI – Simultaneous Differential Imaging
  - 4QPM, Cube mode, ADI – Angular differential imaging, ...
Near-IR WFS

- For red objects that are too faint for the visible WFS, e.g. brown dwarfs

NACO - Imaging

Near-IR WFS

- For highly obscured objects, e.g. The Galactic Center

S. Gillessen et al. (2009)

IRS7 reference

1"

C. Lidman – 214th AAS Meeting - Pasadena June 8th 2009
Simultaneous differential imaging (SDI)


Eps Indi Ba/b - McCaughrean et al. (2004)
Sparse Aperture Masking (SAM)

What is it?

- High contrast and high angular resolution imaging.
- Narrow fields of view (few 100 mas)
- Relatively bright targets

What is it used for?
SAM – a second example

IRS +10216
• A clumpy carbon star

Full AO and full pupil

Full AO + SAM

Courtesy of Peter Tuthill
SINFONI – 3D spectroscopy

An AO fed near-IR integral field unit (IFU)

• Uses natural guide stars (R=16) or laser guide stars (R=19)
• Curvature AO system
• Natural seeing mode
• Seeing enhancer mode - new
• A lot more extragalactic science
Galactic Center Studies

- Orbits
- Stellar populations
- Super massive black hole

S. Gillessen et al. (2009)
Extragalactic Science with SINFONI

Much more done with SINFONI than NACO

Velocity fields of distant galaxies

H alpha line map of BzK-15504

Förster Schreiber et al.
CRIRES

ESO’s AO fed high resolution (R=100,000) 1-5 micron spectrograph

- Uses natural guide stars
- Natural seeing mode
- Curvature system
- Mostly stellar astronomy
Milli-arcsecond imaging of molecular gas in protoplanetary disks

Pontoppidan et al.
Radiative transfer model
CRIRES Spectro-astrometry

SR 21
4.7 μm CO v=1–0

centroid x (1+F_c/F_c) [AU]

Velocity [km/s]
Anisoplanatism

Even relative photometry is difficult!
What is anisoplanatism?

Decorrelation of the wavefront for an off axis source.

Characterized by the isoplanatic angle \( \theta_0 \).

Depends on the height of the turbulence layers \( \theta_0 \sim 1/h \).

Strong dependence on airmass

\( (\text{airmass})^{-8/5} \)
Jet streams

The jet stream is time variable

Strong Jet Stream (60 m/s) on the 18th

1 week
Anisoplanatism

Wind direction

AO reference
Multi-Conjugate AO - MCAO
The MAD experiment

- Multi-Conjugate Adaptive Optics (MCAO)
- MAD Star Oriented system
  - Wavefront sensing on 3 Natural Guide Stars in 2 arcmin FoV
  - Correcting with 2 deformable mirrors (0 & 8.5 Km)
  - IR camera imager CAMCAO
- Three science demonstration runs (Nov’07-Jan’08-Aug’08)
Trumpler 14

MAD [H] 0.028”/px
$T_{\text{exp}}$: 1680s
DIMM: 1.20”

NACO [H] 0.054”/px
$T_{\text{exp}}$: 690s
DIMM: 0.85”

60” x 60”

Courtesy: J. Ascenso
30 Doradus

Guide Star

5" x 5"

120 arcsec

Sep 0.17"

Guide Star

5" x 5"

15" x 15"

FWHM: 90 to 140 mas

Guide Star

3" x 3"

5" x 5"
Omega Centauri

ISAAC: 1600s
FWHM: 400mas

MAD Ks 600s
FWHM: 100mas
K~20.5
DIMM: 0.69"

20 x 20 arcsec
Omega Centauri

Guide stars @ 60"

20” x 20”

MAD [Ks] (0.028”/px) FWHM: 100mas – Texp: 600s

MAD [Hα] (0.060”/px) FWHM: 100mas – Texp: 600s

ISAAC [Ks] (0.148”/px) FWHM: 0.6” – Texp: 1548s

HST/ACS [F435W] (0.050”/px) FWHM: 100mas – Texp: 340s
MAD completeness w.r.t. HST/ACS
Ks: 90%

~10 White Dwarfs detected in Ks all having IR excess
Ground layer AO - GLAO
Ground Layer AO - GLAO
Beyond MAD?

Thank You

2013?