Practical session on calibrators

Euro Summer School
Active Galactic Nuclei at the highest angular resolution: theory and observations

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With input from similar contributions at earlier VLTI schools by Boden and Percheron

Calibrations for interferometric instruments

- Detector characteristics (flatfield, bad pixel mask, linearity)
- Baseline
- Wavelength
- Photometry
- Interferometric transfer function

- Calibration plan available for MIDI at http://www.eso.org/instruments/midi
- Quality control parameters are monitored by the ESO Quality Control department. See:

  http://www.eso.org/observing/qc

Interferometric transfer function

μ : measured visibility (coherence factor)
V: theoretical visibility (calibrator), calibrated visibility (science)
T: interferometric transfer function* describing the loss of coherence due to atmospheric turbulence and instrumental effects

$T(\lambda) = \mu(\lambda) / V(\lambda)$

-> calibration star: know V, measure μ, obtain T
-> science target: use T, measure μ, obtain V

$V_{sci} = (\mu_{sci} / \mu_{cal}) * V_{cal}$

*T is also called system visibility or interferometric efficiency.

Error sources

$V_{sci} = (\mu_{sci} / \mu_{cal}) * V_{cal}$

- Errors in measurement of μ_{sci}, μ_{cal}

  Systematic effects in case of different types of sources

  in terms of, for instance, brightness, spectral type (effective wavelength)

  => Use a calibrator of similar magnitude and similar spectral type

  AMBER: Δ K<1

- Error of V_{cal}

  => Use a well known and small calibration star

  Single unresolved star without any special features such as a dust shell

  Completely unresolved point source -> V_{cal}=1.

- Variability of T between measurements of calibration star and science target (as function of airmass, seeing, coherence time,…)

  => Measure T close in time and on sky

  => Verify the stability of T

How to find a good calibrator

- Find a good compromise between the different criteria.
  This may depend on your scientific goal and the characteristics of your instrument.

- Use single stars with known (and possibly small) angular diameter.

1. Angular diameter from previous high resolution measurements
   => CHARM (catalog of high angular resolution measurements),
   Richichi, Percheron, Khristoforova 2005, A&A, 431, 773.
2. Catalogs of angular diameter based on spectrophotometric measurements:
   Cohen et al. 1999, Borde et al. 2002, Merand et al. 2005, MIDI calibrator catalog
3. Find spectrophotometry in the literature, and derive the angular diameter. Tools: Aspro (JMMC), getCal (MSC)
4. Combinations, e.g. of 1 and 2.

CalVin tool (http://www.eso.org/observing/etc)

- Based on a fixed underlying list of calibrators for each VLTI instrument.
- Interface to select a suitable calibrator based on different criteria (distance to science target, brightness, spectral type, etc.).

Advantage: Well-known calibrators that are better and better verified in the course of VLTI observations. Well-known calibrators are very important for service mode observations that don't allow an interaction during the observation.

Disadvantage: There might not be a calibrator available for certain needs (e.g. faint calibrators close on sky to the science target).
=> Use one of the other techniques to find a calibrator.

MIDI calibrators

Catalog provided by the MIDI instrument consortium:

- 511 candidates selected based on IRAS and MSX point source catalog taking into account MIDI magnitude limits and accessible coordinates.
- Spectrophotometric observations of the candidate stars.
- Spectrophotometry fitted to theoretical atmosphere models (MARCS, ATLAS). Yields χ_ν^2 and angular diameter θ. A large χ_ν^2 indicates deviations from a regular atmosphere for instance due to a dust shell (infrared excess) or a composite spectrum.
- A limit of $\chi_\nu^2 < 5$ in CalVin leads to 178 MIDI calibrators.

AMBER calibrators

- CalVin/AMBER includes the calibrator catalogs by

  Borde et al. 2002, A&A, 393, 183

  Merand et al. 2005, A&A, 433, 1155

  These are based on spectrophotometric observations.

- CalVin/VINCI includes additional calibrators based on existing measurements (e.g. CHARM catalog) and empirical calibrations (e.g. V-K color).