A Giant Step: from Milli- to Micro-arcsecond Astrometry
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ESPRI data-reduction strategy and error budget for PRIMA

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Abstract. The Exoplanet Search with PRIma (ESPRI) will use the PRIMA dual-feed astrometric capability on the Very Large Telescope Interferometer (VLTI) to perform astrometric detections of extra-solar planets. We present an overview of our data-reduction strategy for achieving 10-μarcsecond accuracy narrow-angle astrometry using the PRIMA instrument. We discuss the error budget for astrometric measurements, and those aspects of our strategy which are designed to minimise the astrometric measurement errors.

Keywords. astrometry, planetary systems, instrumentation: interferometers, techniques: interferometric, methods: data analysis, techniques: high angular resolution, infrared: stars

1. Introduction

The Phase-Referenced Imaging and Microarcsecond Astrometry (PRIMA) instrument will provide a dual-beam capability for the ESO VLTI. It is designed to provide 10-μarcsecond-accuracy relative astrometry using the VLTI 1.8-m diameter Auxiliary Telescopes (ATs), as well as phase-referenced imaging with both the ATs and the 8-m Unit Telescopes. Observations will typically measure the separation vector between unresolved targets less than 20 arcseconds apart, with at least one target brighter than K = 11.

2. Error budget for astrometry with VLTI-PRIMA

Fig. 1 shows a summary of the principle sources of error in a 30-minute measurement of the separation of two stars within 10 arcseconds of each other, where one star has K = 8, and the other has K = 13.5 (the dependence of astrometric accuracy on the stellar brightnesses is shown graphically in Launhardt *et al.* (2008)).

The two error sources which remain a particular concern are associated with the VLTI ATs. The ATs were designed before the PRIMA instrument, so they were not built with an interferometric dual-feed capability (for observing two stars simultaneously), and the ATs were not specified to provide a stable narrow-angle baseline for differential astrometry. ESO is currently fitting two ATs with *Star Separator* units to allow dual-feed interferometry. The narrow-angle baseline is defined by the separation vector between the

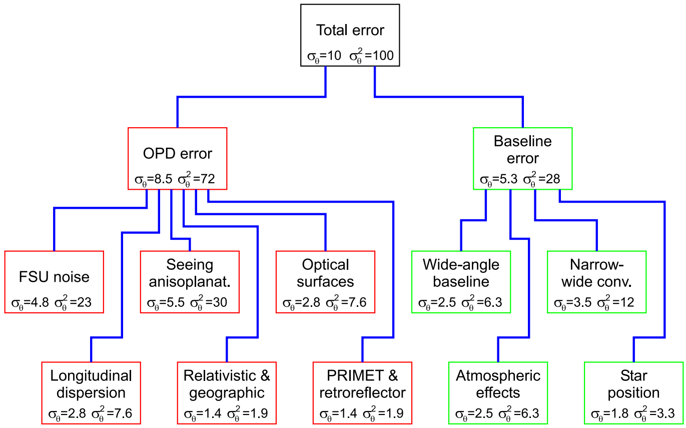

Figure 1. Error requirements tree for astrometry with VLTI-PRIMA. σ_θ represents the allowed RMS contribution towards the error in the measured separation, in μarcseconds.

images of the metrology retroreflector reference points in the entrance pupils of the two ATs. The ESPRI consortium has undertaken an assessment of the narrow-angle baseline stability, and has reached the following conclusions about the current AT design:

(a) The motion of the narrow-angle baseline end-points due to typical wind-loading on the ATs is at the limit of that is acceptable for narrow-angle astrometry, when the AT autoguider correctly compensates the induced pointing errors.

(b) With the current AT design, the baseline variation due to motion of the AT derotator axis is too large for the stringent astrometric requirements described in Fig. 1. The consortium is in the process of determining the most cost-effective approach for monitoring and/or stabilising the narrow-angle baseline end-points on the ATs. Possible solutions include careful monitoring of the derotator, or relocation of the metrology retroreflector to a point before the AT derotator (probably on M2).

3. Data-reduction strategy

The astrometric data-reduction software (ADRS) processes fringe, delay, environmental, and calibration data. The on-line pipeline averages, fits, or interpolates all raw data onto a fixed $\sim$ one-second time grid. A number of intermediate diagnostic quantities are also generated. The off-line processing corrects delays for instrumental, environmental, and astrometric effects. After searching very large datasets, long-term instrumental trends will be found and fit every $\approx$ six months (see Elias *et al.* (2008)).

The primary observable, after corrections, is the differential delay between the target and reference stars, which is ultimately converted to a separation angle. An ensemble of such data is used to fit planetary orbits with no ambiguity due to the unknown inclination. Other data include squared visibilities and Fourier-transform spectra.

References

Elias II, N. M., Tubbs, R., Köhler, R., Reffert, S., Stilz, I., Launhardt, R., de Jong, J., Quirrenbach, A., Delplancke, F., Henning, T., Queloz, D. & ESPRI Consortium 2008. Astrometric Data Reduction Software and error budget for PRIMA. *In: Proc. IAUS 249 (in press).*

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