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FINITO: three-way fringe sensor for VLTI

M. Gai[1], L. Corcione[1], M.G. Lattanzi[1], B. Bauvir[2], D. Bonino[1], D. Gardiol[1], A. Gennai[2], D. Loreggia[1], G. Massone[1], and S. Menardi[2]

[1] INAF, Osservatorio Astronomico di Torino, Pino Torinese, Italy
[2] European Southern Observatory, Garching bei München, Germany

Abstract. The FINITO project is a collaboration between ESO and INAF – Osservatorio Astronomico di Torino for implementation of a two/three beam Fringe Sensor Unit for VLTI. We describe the instrument concept, the expected performance, and some astrophysical targets for VLTI with FINITO.

Key words. instrumentation: interferometers – techniques: interferometric

1. Introduction

The Very Large Telescope Interferometer (VLTI) is described in other contributions to this workshop (Paresce 2003) and in the literature (Glindemann et al. 2000). The Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Torino (OATo) and the European Southern Observatory (ESO) are jointly developing a Fringe Sensor Unit (FSU) to be installed at the VLTI: Fringe-tracking Instrument of NIce and TOrino (FINITO).

FINITO (Gai et al. 2001) builds on a concept tested in a prototype by the Observatoire de la Côte d'Azur (Nice); it adopts the present optical constraints for the VLTI beam geometry, standard VLT electronics, and an high sensitivity array detector; a longitudinal and angular alignment system allows off-axis tracking and compensation of atmospheric refraction.

The FSU measures the optical path difference (OPD) generated by atmospheric turbulence on two or three telescope beams (pair-wise); the OPD information is fed to an actuator in the Delay Line control loop to compensate the perturbation. Its purpose is similar to that of a wavefront sensor for adaptive optics, and some operating requirements are derived from the same framework, e.g. the time scale: the nominal loop frequency is 40 Hz, so that the elementary exposure is set in the range $0.25 - 10$ ms (i.e. below the coherence period) to retain an adequate phase margin.

FINITO is based on afocal combination of two-three beams, using temporal modulation for detection of the external OPD variation, in H band ($1.5 - 1.8$ μm). It is fed by either the 8 m Unit Telescopes (UT), for about 10% of their scheduled time, or the 1.8 m Auxiliary Telescopes (AT), devoted full-time to interferometry. The UT provide highest sensitivity, whereas AT have high-

Send offprint requests to: M. Gai
Correspondence to: INAF, Osservatorio Astronomico di Torino, Strada dell'Osservatorio 20, I-10025 Pino Torinese, Italy

est resolution (longest baselines and finer coverage of the u, v plane).

2. Observing with FINITO

The scientific instruments of VLTI (i.e. AMBER, $1 - 2.5$ μm, and MIDI, 10 μm) take advantage of a FSU to increase their on-source integration time from a few 10 ms to a few 100 s, improving both limiting magnitude (by ~ 5 mag) and visibility accuracy. Without fringe tracking, each instrument can observe in self-correlation mode, with the same constraints of speckle imaging: the elementary exposure must have sufficient signal to noise ratio.

Measurement of the visibility modulus (related to the Fourier transform of the light distribution) allows evaluation of the target structure parameters. The performance can be improved by *baseline bootstrapping*, feeding the FSU with three beams, on two short baselines, and the scientific instrument with the external ones only. The longer baseline samples the minimum of visibility, with the best signature from the target structure; besides, the FSU operates efficiently on an high visibility regime. FINITO also supports *phase closure*, i.e. simultaneous measurement over two independent baselines; factoring out systematic contributions from instrument and atmosphere, and allowing accurate determination of the intrinsic target visibility.

FINITO has a field of view for off-axis tracking of about 1 arcsec, without star separators; this small field is still appealing for mapping of complex sources or for measurement of resolved binary systems. Applications include recalibration of the effective temperature scale by diameter determination to 2%, revision of the radius-mass relation, measurement of the pulsation of variable stars (e.g. Mira, Cepheids), and distance calibration of double-lined spectroscopic binaries up to 2.5 kpc.

The FSU performance depends upon the selected operating mode. For 10 μarcsec astrometry, the residual OPD noise is specified below 30 nm; for imaging at $\lambda/20$, the requirement scales with the wavelength, as well as the coherence time. Under appropriate conditions, the expected limiting magnitude of the FINITO reference source is respectively $H = 12.5,\ 14.5,\ 16.5$ mag, for astrometry, imaging in K band and imaging at 10 μm.

3. Conclusions

The FINITO project is nearing its completion; installation at Paranal is expected by April, 2003. The benefit to the VLTI instruments is a significant improvement on the faint limiting magnitude and accuracy of the visibility measurement. Advanced techniques (baseline bootstrapping, phase closure) may be used for selected measurements.

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