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Internal optical path calibration system for VLTI

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Abstract

A metrology system is needed to calibrate the internal Optical Path Difference (OPD) within the interferometric array. The objective is to determine the differential optical path between any pair of telescopes of the array with an accuracy of some 100μm. This OPD will be monitored from the Interferometric Laboratory to a retroreflector located on the telescope's secondary mirror or to a flat mirror located at the folded Nasmyth focus. It will be performed "off-line" every time a change in the interferometer configuration has happened or when thermal disturbances have occurred. A concept has been derived which uses an external light source located in the pupil plane area. In order to verify its applicability, a test bench has been procured and integrated at ESO. This test bench includes a mock-up of two delay lines with translation stages and control units, and metrology units. First results are presented.

1. Need for internal calibration

In order to obtain fringes from an astronomical source with an interferometer which consists of several independent telescopes, the optical paths as seen from the object while propagating through individual telescopes towards a common beam combiner must be equalised.

The OPD to be created by the delay line is

$$OPD=\vec{S}.\vec{B}+OPD_{int} \quad (1)$$

where **S** is the 3D unit vector pointing towards the object under study at a given time.
B is the vector Baseline defined in 3 dimensional space.
OPD_{int} is the internal OPD obtained when the delay lines are at their mechanical reference positions.

The measurement of OPD_{int} is needed to rapidly acquire fringes even after relocation of Auxiliary telescopes and to trace internal optical path changes within the array and update the OPD model [Lévêque et al, 1996]. The desired accuracy is 100 μm.

2. Concept for an Internal OPD calibration

The internal OPD calibration is based on white light interferometry since the goal is to detect the white light fringe corresponding to the Zero Path Difference (ZPD) position [Lévêque, 1995]. Laser diodes are used instead of conventional white light sources. Indeed, laser diodes offer a better collimation efficiency which is important when long distances are involved, a lower power dissipation and are less expensive. The emitted light propagates in both interferometric arms, is retroreflected at each telescope's secondary mirror and recombined. One optical path is modulated for fringe detection. The Zero Path Difference (ZPD) is obtained by moving a delay line until the superposition of the 2 returning beams creates an interferometric signal with a maximum contrast. The delay line position is then recorded by its own metrology system. Figure 2 presents the calculated fringe visibility as a function of optical path difference for a source whose spectral distribution is shown on Figure 1.

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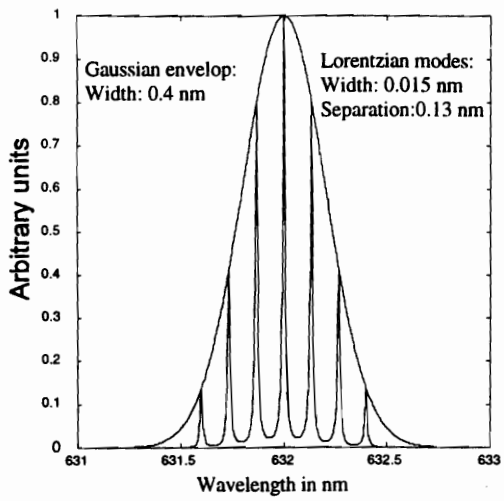

Figure 1: Source spectral distribution

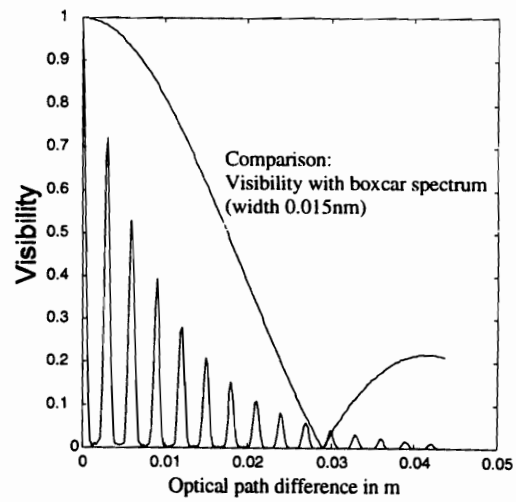

Figure 2: Corresponding fringe visibility

3. Test bench

A test bench has been integrated at ESO in order to demonstrate the feasibility of the concept applied to VLTI using multimode laser diodes, identify source of errors and determine the measurement accuracy. Two translation stages with linear motors and digital controllers are used. The displacement range is 150 mm, the resolution is 80nm and the positioning accuracy is 4μm. Multimode laser diodes have a peak power of 15mW and wavelength are centred in the red. Beams are spatially filtered with a monomode optical fiber whereas an optical path modulation of 4λ at 70Hz is obtained by a corner cube mounted on a piezo. Fringe detection is performed by a silicon photodiode and the acquisition system is developed under Labview.

4. Results

Figure 3 shows an example of a series of fringe visibility local maxima obtained by scanning one delay line around the ZPD position using a multimode laser diode centred on 680 nm. The number of local maxima depends directly on the number of modes emitted. However, the maximum visibility can be easily discriminated from other local maxima which are at least 10% smaller in amplitude for a separation of about 3mm from the ZPD position. Figure 4 presents a finer visibility scan on one side of the visibility maxima. The accuracy of the ZPD position is better than 20μm.

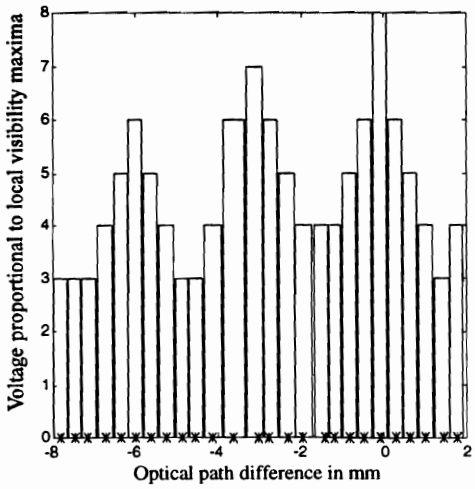

Figure 3: Position of local visibility maxima

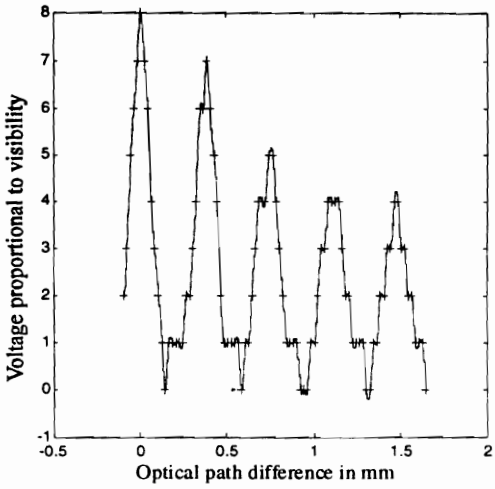

Figure 4: Visibility scan close to ZPD position

5. Conclusion

The need for an internal OPD calibration system has been presented . A concept has been proposed to determine with high accuracy the zero path difference position between a pair of telescopes. A test bench has demonstrated that the zero path difference position could be found with a 20 µm accuracy.

6. References

[1] S. Lévêque et al. "Optical Path difference Model for VLTI", Optical telescopes of today and tomorrow, Landskrona, 1996.

[2] S. Lévêque, " Overview of optical path measurement techniques for the VLTI metrology systems", ESO report VLT-TRE-ESO-15000-0765, March 1995.

[3] M. Dobosz, "Polychromatic light interferometer for high accuracy positioning",Optics and laser engineering 24, 1995, p43-56.

[4] K. Petermann,"Laser diode modulation and noise", ADOP advances in Optoelectronics, Kluwer academic publishers.

[5] Y.Ning, "Characterisctics of laser diode for interferometric use", Applied optics, 1989,vol.28, No17, p3657.