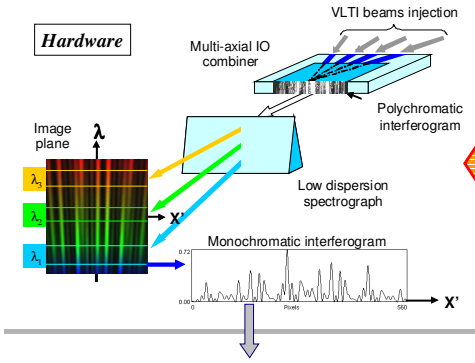
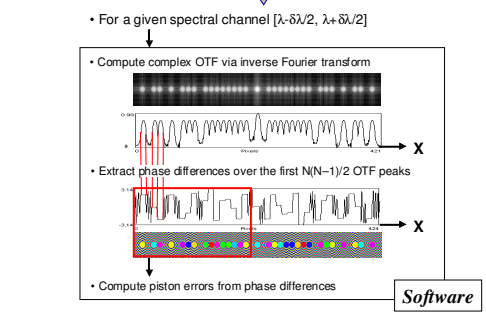
Phase-shifting fringe tracking method for sparse aperture interferometer arrays

F. Hénault
Institut de Planétologie et d'Astrophysique de Grenoble, Université Joseph Fourier, CNRS, B.P. 53, 38041 Grenoble – France

Conventional fringe tracking

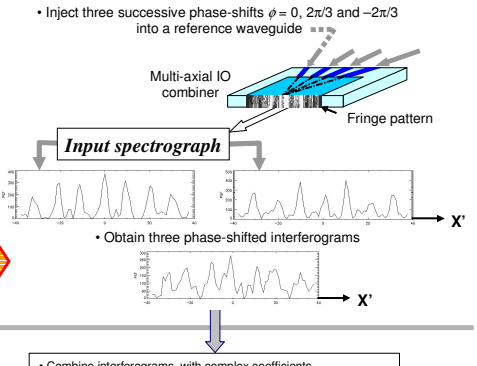


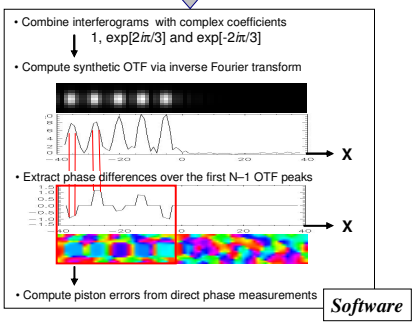


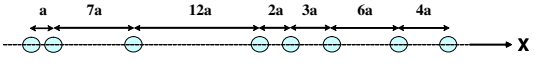
Principle

- Conventional fringe tracking is achievable by means of spectral decomposition of the interferograms generated by a multi-axial, non redundant arrangement of the fringe tracker exit sub-pupils
- The fringe tracker can also be operated in **phase-shifting mode**: Three interfeerograms are measured, for different values of the phase-shifts $\phi_1 = 0$, $2\pi/3$ and $4\pi/3$ introduced into a reference sub-pupil
- The OPDs are directly sensed on all other sub-pupils by means of simple algorithms (linear combination, FFT…)
-Those sub-pupils can be arranged into a fully redundant geometry, allowing one to decrease dramatically the total number of required pixels (see Table below) and thus the measurement noises
- Numerical simulations were carried out, based on the VLTI parameters and the optical concept of **POPS**, a 2nd-generation fringe tracker proposed to ESO in 2010, using an Integrated Optics Combiner (IOC)

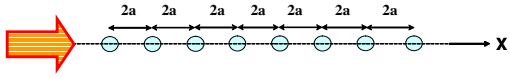
Phase-shifting mode

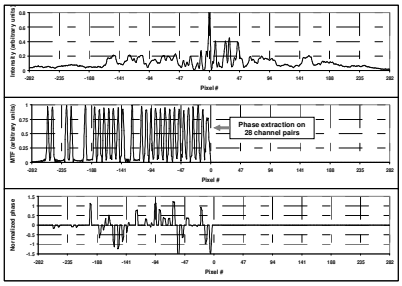






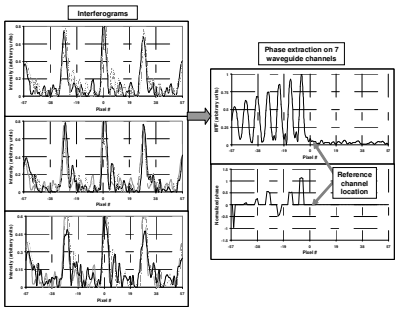
Non-redundant vs. fully redundant pupil arrangement: Allows for wider interfringe distance and less sampling pixels

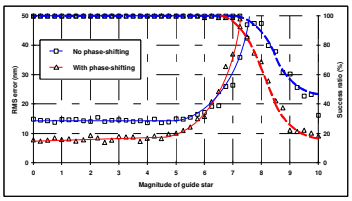




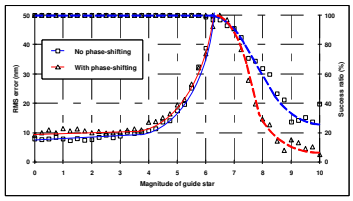
CASE		4 telescopes	6 telescopes	8 telescopes
Conventional fringe tracking	Total number of pixels	95	255	565
	Number of pixels per fringe	4.8	4.64	4.81
	IOC exit aperture	F / 4.5	F / 3.3	F / 2.5
fringe tracking in phase-shifting mode	Total number of pixels	41	75	115
	Number of pixels per fringe	4.67	4.55	4.49
	IOC exit aperture	F / 6.5	F / 5.5	F / 4.7

Fringe tracker parameters after preliminary optimization

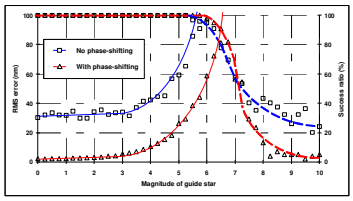




4 Telescopes, Group delay mode



6 Telescopes, Group delay mode



8 Telescopes, Group delay mode

Results

- No clear advantage for 4 and 6 telescopes, but one magnitude gain with eight telescopes
- Gain expected to increase as more and more telescopes are added (10, 12 etc…)

Contact
francois.henault@obs.ujf-grenoble.fr

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IPAG Institut de Planétologie et d'Astrophysique de Grenoble