LN Interferometry In the MCAO Era

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[Move this list to an acknowledgement section (and add Jup? JM? JE?)]

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Contents

1 Introduction

Since the 2015 board request for an evaluation of options viz-a-viz LN wide field MCAO and LN interferometry (i.e., one, neither, or both), the SAC issued a report in April, 2016, endorsing the wide field option.

This report explores the best way forward for LN interferometry, as we progress with the wide field upgrade in parallel.

Central to any option which retains functionality for LN interferometry is the concept of operating LN with two cryostats. Relatively low overhead will be required to swap the LN cryostat (Appendix B). For LN interferometry we consider 3 phases, lucky fringing (Sec. 3), OPD lock with the existing fringe tracker (Sec. 4); followed by an upgrade to realize **on-chip** fringe tracking (Sec. 5). Finally, we evaluate the cost, time, risk, and scientific benefit for each phase (Sec. 6)

2 Executive Summary

Of the three possible phases, LN with its existing fringe tracker offers the best potential benefit for the cost; but also comes with the most risk. The first phase, lucky fringing is low risk but also likely low benefit (in terms of what can already be done with LBTI);[1] but it comes at very low risk. Both of these two phases using the exising FT could be attempted (for a demonstration only) soon; with telescope time and staffing being the primary obstacles. To make these two phases operational at the LBTI level, however, would require 0.5 FTE for lucky fringing and 2.0 for phase lock. No hardware cost is foreseen for either, but for phase lock there is the possibility that the FT will need intervention once it has been tried on sky.

The last potential phase, an upgrade to utilize on-chip FT, is a concept that is still in the very early stages of being developed.

3 Lucky Fringing with LN

Astronomers observing bright targets with LBTI have taken advantage of lucky fringing to carry out demonstration science cases (Sallum, S., et al., 2017; Conrad, A., et al., 2015b). Lucky fringing with LN will enable science cases that benefit from MCAO and/or the rotator.

[1] As an LBTI Fizeau backup, there would be an operational benefit for LBTO, however.

The risk and cost for this phase are relatively low (see table 1). The increase in enabled science cases (over LBTI LF) is relatively modest, with a few key exceptions.

4 Phase Locked Interferometry with LN

Although LN was descoped in 2015 to Lean-MCAO, the fringe tracker was delivered by the LN partners in Bonn and Cologne in what is believed to be a working state. This hardware was integrated into the cryostat approx. 6 months before LN was shipped, which allowed for no test time.

The risk and cost for this phase are high and low, respectively. (see table 1). The increase in enabled science cases (over LBTI FT) is significant, owing primarily to increased sky coverage.

5 On-Chip Fringe Tracking with LN

On-Chip Fringe Tracking with LN would offer a wide field corrected at the diffraction limit of a 23-meter telescope.

The risk and cost for this phase are medium and high, respectively (see table 1). The increase in enabled science cases (over LBTI FT) is also high.

This concept is still in the very early stages of development.

6 Cost / Benefit / Risk

The sections below are intended for providing justification for the values which appear in table 1. However, as of this writing, we only repeat the values from the table, and in some cases give a short justification.

6.1 Lucky Fringing with LN

6.1.1 Cost

No hardware cost. 0.5 FTE.

6.1.2 Benefit

Low

6.1.3 Risk

Low. Includes possibility that a re-alignment might be necessary. If so, it would likely be required for LN to be brought to the mountain clean room.

6.2 Fringe Tracking with LN

6.2.1 Cost

No hardware cost (excluding costs associated with an intervention should that be needed). 2.0 FTE.

6.2.2 Benefit

High. Greater sky coverage.

6.2.3 Risk

High. FT hardware untested post-installation into LN. Also, repositioning of LN might be required to get into the capture range of the FT. Any re-alignment should be OK following the first phase.

6.3 On-Chip Fringe Tracking with LN

6.3.1 Cost

1.65M euro (value from (Conrad and Veillet , 2015) inflated by 10%.

6.3.2 Benefit

High. Wide field science at the 23-meter diffraction limit.

6.3.3 Risk

Medium. Usual risks associated with any new project.

Table 1: Summary information, cost, risk, and benefit, for each of the phase describe in this report.

Lucky Fringing	Capability:	**FoV:**	10" × 10"
		Sky Coverage:	TBD
	Cost:	**FTE:**	0.5
		Hardware:	None
	Risk:	**Level:**	Low
		Example:	re-alignment indicated
	Enabled Science:	**Level:**	Low
		Example:	TBD
OPD Lock with existing Fringe Tracker	Capability:	**FoV:**	10" × 10"
		Sky Coverage:	99% / 48%
	Cost:	**FTE:**	2.0
		Hardware:	None (see text)
	Risk:	**Level:**	high
		Example:	untested hardware
	Enabled Science:	**Level:**	High
		Example:	Sky Coverage
Detector upgrade for on-chip fringe tracking	Capability:	**FoV:**	30" × 30"
		Sky Coverage:	99% / 48%
	Cost:	**FTE:**	9.0
		Hardware:	€1.5M
	Risk:	**Level:**	Medium
		Example:	New project
	Enabled Science:	**Level:**	High
		Example:	Wide-field

A Glossary

FT	-	Fringe Tracker
LN	-	LINC-NIRVANA
OPD	-	Optical Path Difference

B Overhead required to swap LN cryostats

TBD

C Advantages of Interferometry with LN

C.1 Sky Coverage

TBD

C.2 Field Rotation

TBD

D References

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