Improving the performances of current optical interferometers & future designs
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OHANA

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Abstract. The Optical Hawaiian Array for Nanoradian Astronomy (OHANA) project aims to convert the large adaptive optics equipped telescopes present on top of Mauna Kea into a long-baseline optical interferometer. This contribution gives a brief overview of the timeline and key achievements of the OHANA project, since the Mariotti et al. (1996) founding paper.

1. 2000-2006: Components construction and qualification

Obtained in 1999, the first public funding for the project allowed gathering support from the Mauna Kea observatories and start the construction of the components for a demonstrator of the OHANA concept. The first delivered components, an engineering grade NICMOS camera and an optomechanical interface between short single-mode fibers covering the J, H, and K bands, were used to test, in 2002-2003, the adaptive optics coupling performance with the fibers on the Keck, Gemini, and Canada-France-Hawaii telescopes (Woillez et al. 2003, 2004). In parallel, 300 meter-long dispersion-balanced fiber pairs were produced and qualified, at Le Verre Fluoré and Observatoire de Paris for the K-band fluoride glass single mode fibers (Kotani et al. 2005), and at XLIM and Observatoire de Paris for the J-band and H-band polarisation-maintaining fibers (Vergnole et al. 2004, 2005). A beam-combiner, capable of measuring interference and photometric signals due to the combination of co-axial fiber coupler followed by a multi-axial recombination stage, was developed and tested on sky with three technical runs, carried out between 2003 and 2006 on the IOTA interferometer. Finally, Observatoire de Paris (LESIA and GEPI) and INSU technical division completed the construction of a delay line providing an optical delay of 50 meter. This delay line was then shipped for installation at the Canada-France-Hawaii Telescope at the beginning of 2006. At that time, all the components needed for a demonstration between the Canada-France-Hawaii and the Gemini telescopes were ready to be assembled.

2. 2004-2009: First fringes on the Keck Interferometer

In the meantime, with coupling tests between adaptive optics and single-mode fibers completed and a pair of 300-meter-long K-band single-mode fibers available and qualified, the project was offered to perform a demonstration on the Keck Interferometer. The goal was to use these single-mode fibers to link the adaptive optics at the Nasmyth focus of the two Keck Telescopes to the already operational interferometric basement, bypassing the existing Keck Interferometer coudé and optical train. The fiber length exceeded the need of an 85 meter baseline: it could have been used on a $\sim$ 500 meter baseline. Following an initial installation in August 2008, and two weathered-out attempts in December 2004 and January 2005, first stellar interference fringes by long coherent transport through single-mode fibers were obtained on June 17, 2005 (Perrin et al. 2006). Between 2006 and 2009, two out of four additional attempts to improve on this demonstration were lost to weather. One may have been lost to crossed polarisations resulting from an overlooked difference in the alignment of polarisation in double-pass and single-pass (respectively, laboratory and sky configurations). A final night was lost to operational problem with the adaptive optics. At the end of 2009, the focus of the project shifted to the OHANA Iki on-sky demonstration, hosted by the Canada-France-Hawaii Telescope.

3. 2007-2011: OHANA Iki demonstrator

Before embarking directly into the planned connection between the Canada-France-Hawaii and Gemini telescopes, it was considered more prudent to validate on sky using smaller telescopes the individual components assembled in a complete interferometric setup. This is how the OHANA Iki project was born. Two off-the-shelves 20 cm telescopes were equipped with tip/tilt guiders in order to feed the 300 meter long fiber pairs, connected to the delay line installed inside the Canada-France-Hawaii Telescope coudé room, itself linked with short fibers to the beam combiner. The details and first calibrated contrast measurements obtained with this setup in the summer of 2010 are the topic of a publication in preparation.

4. Conclusion

The OHANA project was designed in 3 phases: a phase to demonstrate fiber injection at the large telescopes at Mauna Kea, a phase to demonstrate interferometric coupling with long lengths of fibers, and a final phase to build the full OHANA array. The prototypes were made to address the first two phases. Long baseline interferometry with coherent transport of light with fibers was demonstrated with the Keck telescopes and the OHANA Iki experiment using both fluoride glass standard fibers in the K band and silica polarization maintaining fibers in the J and H bands. Those experiments have established fibers as possible candidates to coherently transport light in long baseline interferometers but they have also shown their sensitivity to vibrations. An operational facility would require both mechanical and temperature sensitivities to be tackled with either passive or active systems.

References

Mariotti, J.-M., Coudé du Foresto, V., Perrin, G., Zhao, P., & Léna, P. 1996, A&AS, 116, 381

Woillez, J., Guerin, J., Perrin, G., et al. 2003, Proc. SPIE, 4838, 1341

Vergnole, S., Delage, L., & Reynaud, F. 2004, Optics Communications, 232, 31

Woillez, J., Perrin, G., Guerin, J., et al. 2004, Proc. SPIE, 5491, 1425

Kotani, T., Perrin, G., Vergnole, S., Woillez, J., & Guerin, J. 2005, Appl.Optics, 44, 5029

Vergnole, S., Kotani, T., Perrin, G., Delage, L., & Reynaud, F. 2005, Optics Communications, 251, 115

Perrin, G., Woillez, J., Lai, O., et al. 2006, Science, 311, 194

Table 1.: *Timeline of the OHANA project*

	Injection tests on Mauna Kea
2002.08	CFHT
2002.12	WMKO
2003.07	Gemini
	Beam combiner test at IOTA
2003.06	First run
2004.10	Second run
2006.06	Third run (last IOTA run)
	Keck Interferometer demonstration
2004.08	Installation
2004.12.01	Weathered out
2005.01.31	Weathered out
2005.06.17	First fringes on 17 Her (K=4.6)
2006.05.08	No fringes, polarizations might have been crossed
2007.11.19	Lost to high humidity
2009.03.07	Weathered out (guest J. Cavé)
2009.08.09	Failed to inject in fibers (guest M. Perrin)
	OHANA Iki demonstration
2007.04	Delay line installation
2008.04-07	CFHT-Gemini baseline measurement (internship: B. Lenoir)
2009.04-05	Delay line commissioning
2009.04-07	IKI telescope injection tests (internship: F. Bouchacourt, G. Zahariade)
2010.04-07	IKI fringes (internship: Y. Dong)

Figure 1.: *A picture showing the Keck Interferometer in the back, and the two OHANA Iki telescopes in the front.*