Observing the Sun with micro-interferometric devices: a didactic experiment

D. Defrère[1], O. Absil[2], C. Hanot[3], P. Riaud[2], A. Magette[3], O. Wertz[2], F. Finet[2], M. Steenackers[4], S. Habraken[2], J. Surdej[2]

(1) Max Planck Institut für Radioastronomie (Germany), (2) Université de Liège (Belgium), (3) Techspace Aero (Belgium), (4) Technische Universität München (Germany).

Contact : *ddefrere@mpifr-bonn.mpg.de*

Abstract

Measuring the angular diameter of celestial bodies has long been the main purpose of stellar interferometry and was its historical motivation. Nowadays, stellar interferometry is widely used for various other scientific purposes that require very high angular resolution measurements. In terms of spatial scales probed, observing distant stars located at 10 to 100 pc away with a large hectometric interferometer is equivalent to observing our Sun with a micrometric baseline. Based on this idea, we have manufactured a set of micro-interferometric devices and tested them on the sky. The micro-interferometers consist in a chrome layer deposited on a glass plate that has been drilled by laser lithography to produce micron-sized holes with configurations corresponding to proposed interferometer projects such as CARLINA, ELSA, KEOPS, and OVLA. In this paper, we describe the interferometric devices and present interferometric observations of the Sun made in the framework of Astrophysics lectures being taught at the Liege University. By means of a simple photographic camera placed behind a micro-interferometric device, we observed the Sun and derived its angular size. This experiment provides a very didactic way to easily obtain fringe patterns similar to those that will be obtained with future large imaging arrays. A program written in c++ also allows to reproduce the various point spread functions and fringe patterns observed with the micro-interferometric devices for different types of sources, including the Sun.

The principle

The Sun has an angular diameter ranging between 0.524 and 0.542 degree, depending on the Sun-Earth distance. In order to resolve it in the middle of the visible wavelength range (i.e., 555.5 nm), a single monolithic pupil should have a linear diameter of approximately 70 µm.

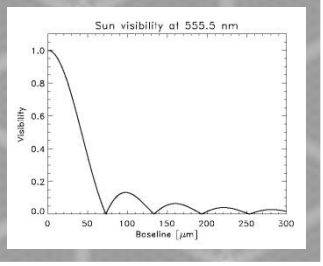


Fig. 1: Absolute visibility of the Sun with respect to the baseline length at 555.5 nm. The Sun is resolved for a baseline of about 70 µm.

The micro-interferometric devices

The micro-interferometers consist a chrome layer deposited on a glass plate that has been drilled by laser lithography to produce micron-sized holes with configurations corresponding to proposed interferometer projects such as CARLINA, ELSA, KEOPS, and OVLA. The set of micro-interferometers is arranged on a single plate with holes of typically 10 µm in diameter located several tens of microns from each other.

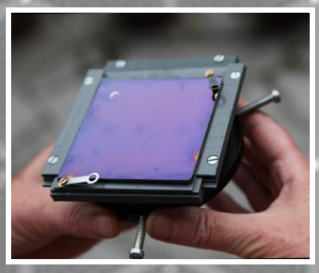


Fig. 2: Picture of a micro-interferometer plate in its mechanical support. This plate contains about 50 different interferometric configurations that have been drilled by laser lithography. The plate and its support are mounted at the front of a classical digital camera to observe fringes.

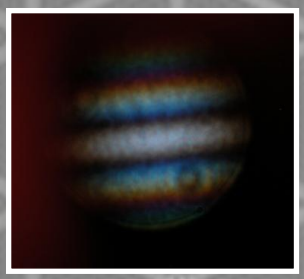
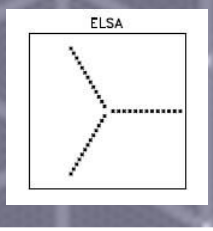
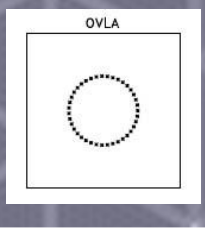


Fig. 3: First fringes on the Sun obtained on September 2010 with a 2-hole configuration:
- Baseline = 29.4 µm
- Hole diameter = 11.8 µm

Example PSFs

The pictures below show the PSF observed with the configurations ELSA and OVLA with the following parameters:
- Main baseline of 50 µm
- Hole diameter of 14 µm





Observing the Sun

In the framework of Astrophysics lectures being taught at the Liege University, students have observed the Sun with the micro-interferometric devices in order to measure the angular diameter of the Sun. This experiment was ideal to make them more familiar with the notions of fringe visibility, background subtraction, and model fitting.

A program to reproduce the fringe patterns observed with the micro-interferometric devices for various kinds of sources is available for download here: http://www.aeos.ulg.ac.be/

Fig. 4: Observation of the Sun with the ELSA configuration (main baseline of 24 µm and hole diameter of 7.2 µm).