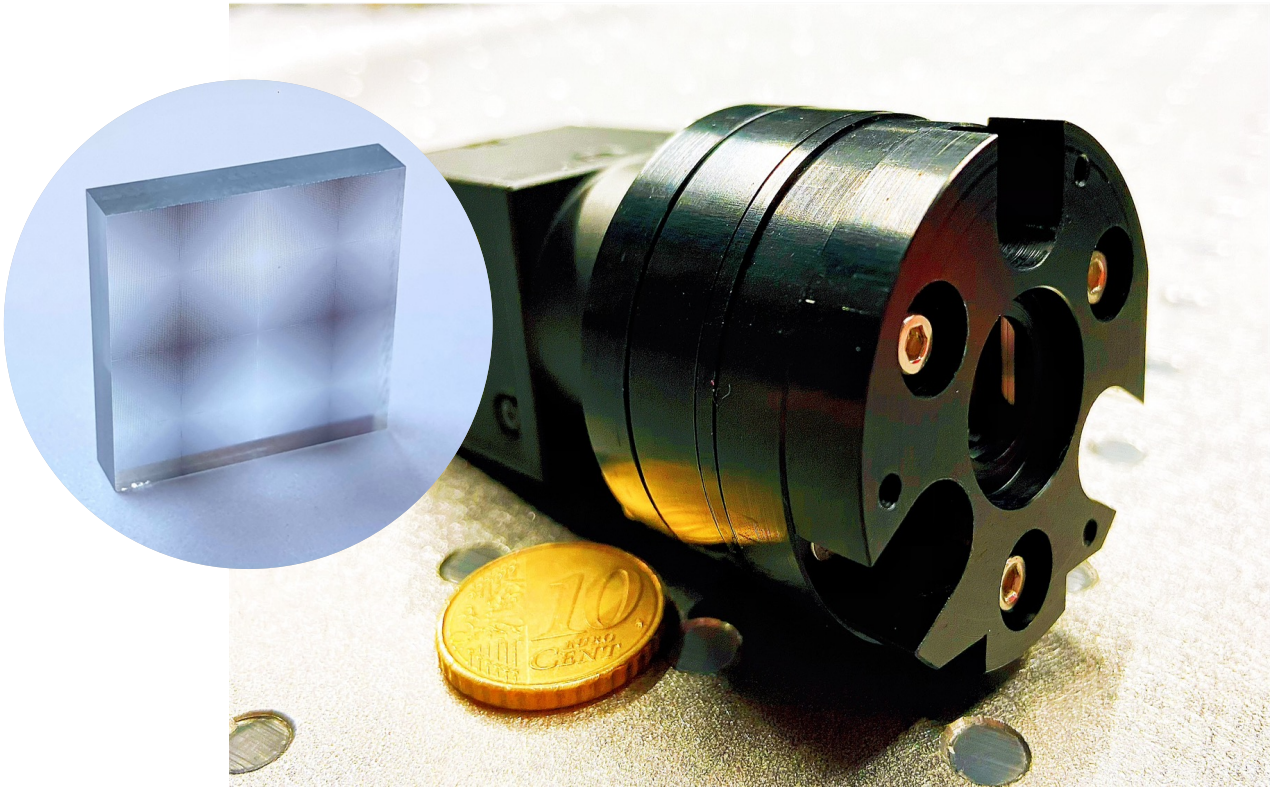
ASONG
optical surface characterisation

cnrs IPAG Institut de Planétologie et d'Astrophysique de Grenoble

Linksium technology transfer & startup building Grenoble Alpes



Analyseur de Surface d'Onde de Nouvelle Génération

Crossed-Sine Wavefront Sensor

New Wavefront Sensing Technology

Yan FENG

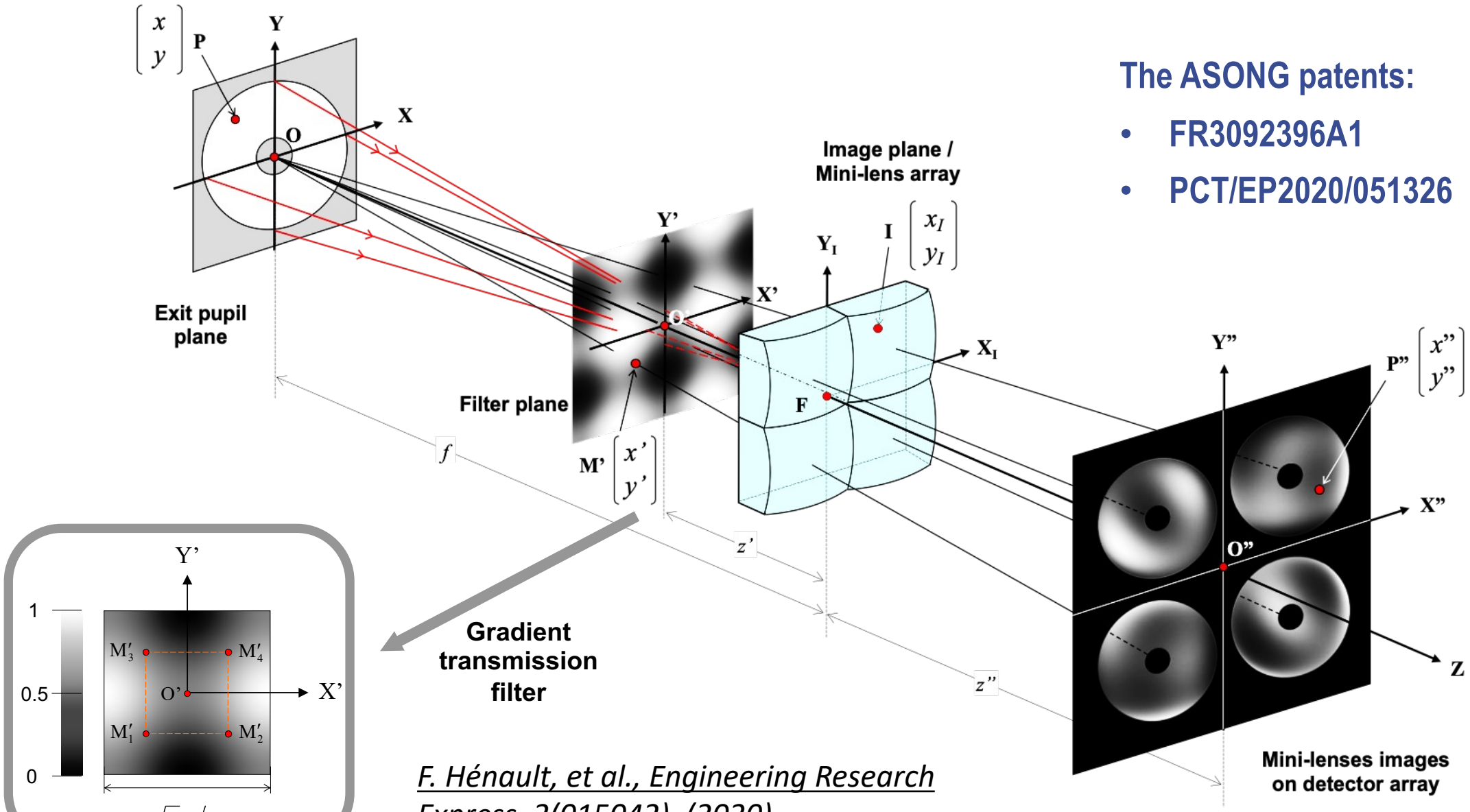
19/10/2022

WAVEFRONT SENSING IN THE VLT/ELT ERA VII

Porto, Portugal

ASONG Concept

The pupil images of the tested optical system are formed on a detector array, enabling high spatial resolution of the measured wavefront errors.

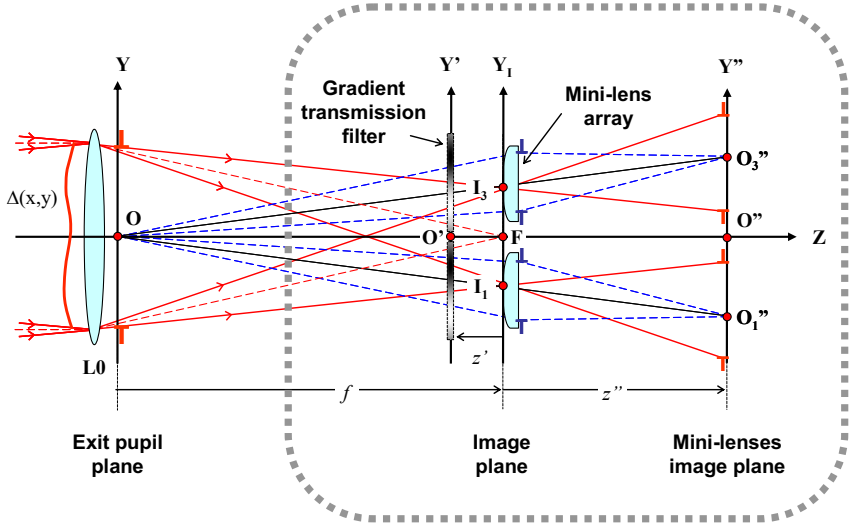


The ASONG patents:

- FR3092396A1
- PCT/EP2020/051326

F. Hénault, et al., Engineering Research Express, 2(015042), (2020).

Wavefront Reconstruction



1. Acquire 4 pupil images simultaneously;
2. Calculate wavefront x and y derivatives from the intensities of pupil images;
3. Convert the WFE slopes to a WFE map by an iterative Fourier method and modal reconstruction.

The WFS gain: g

$$g = 2\pi\sqrt{2}\,(f + z')/p$$

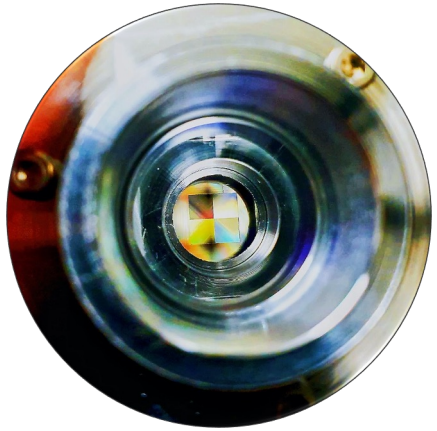
The contrast factor: $\cos\gamma$

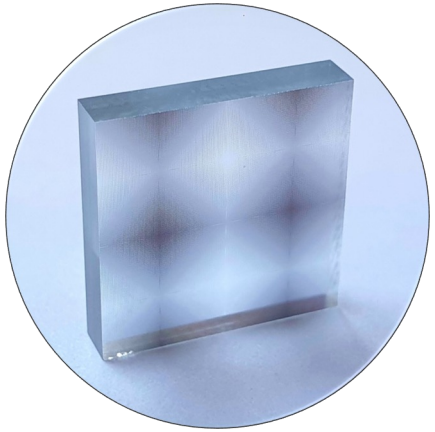
$$\gamma = 4\pi\lambda\frac{z'(f+z')}{f\,p^2} \longrightarrow 0$$

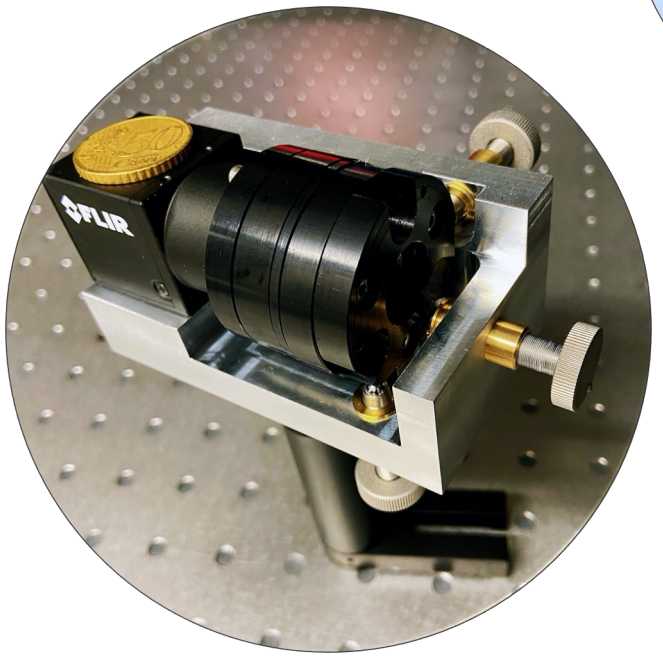
$$\frac{\partial\Delta}{\partial x}(x,y) = \frac{z'}{f(f+z')}x + \frac{1}{g}\arcsin\left(\frac{I_4''(x,y) - I_3''(x,y) + I_2''(x,y) - I_1''(x,y)}{\cos\gamma}\right)$$

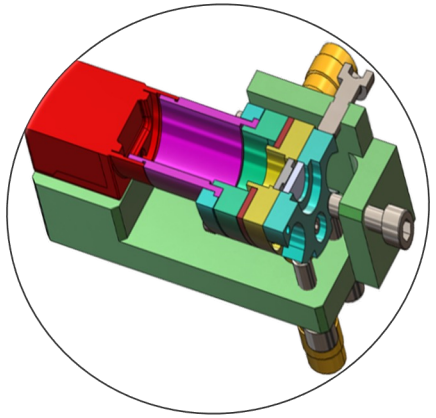
$$\frac{\partial\Delta}{\partial y}(x,y) = \frac{z'}{f(f+z')}y + \frac{1}{g}\arcsin\left(\frac{I_4''(x,y) + I_3''(x,y) - I_2''(x,y) - I_1''(x,y)}{\cos\gamma}\right);$$

ASONG Prototype



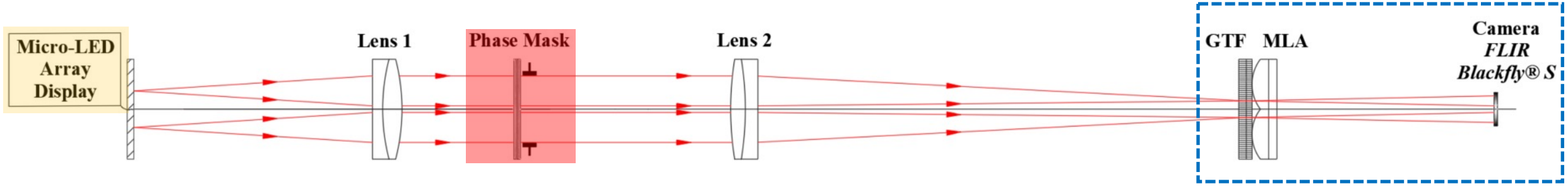


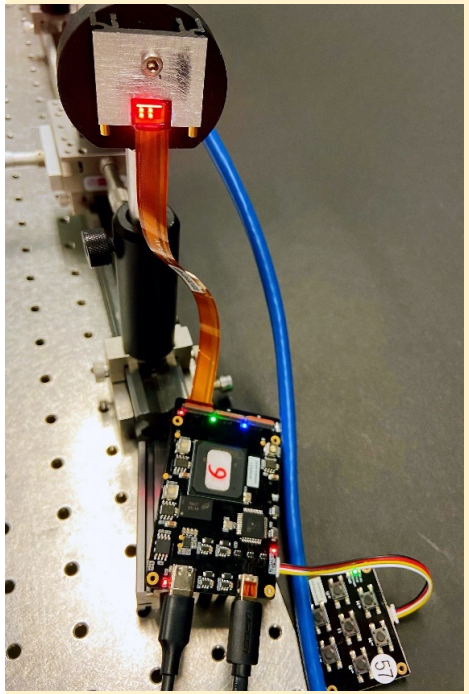




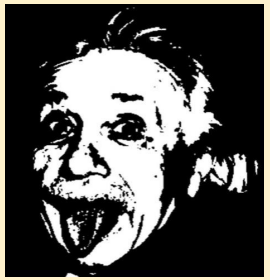
- Customized Optical Elements
  - A glass GTF (gradient transmission filter)
  - A PMMA MLA (mini-lens array)
- Small & Compact
  - **92 x 52 x 40 mm^3** including the alignment tool
  - The GTF and MLA can be adjusted in **focus**, **centering** and **rotation**
- Implemented in an optical system

Implementation in the Lab _ ASONG Prototype



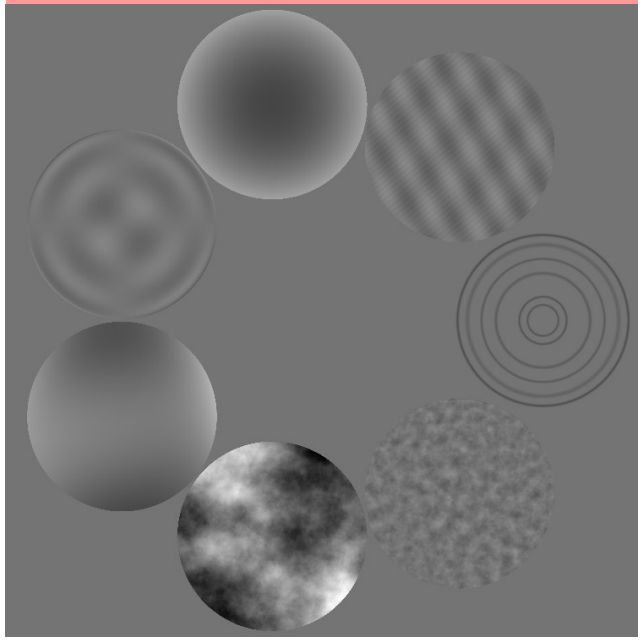


The input image @ Micro-LED Array

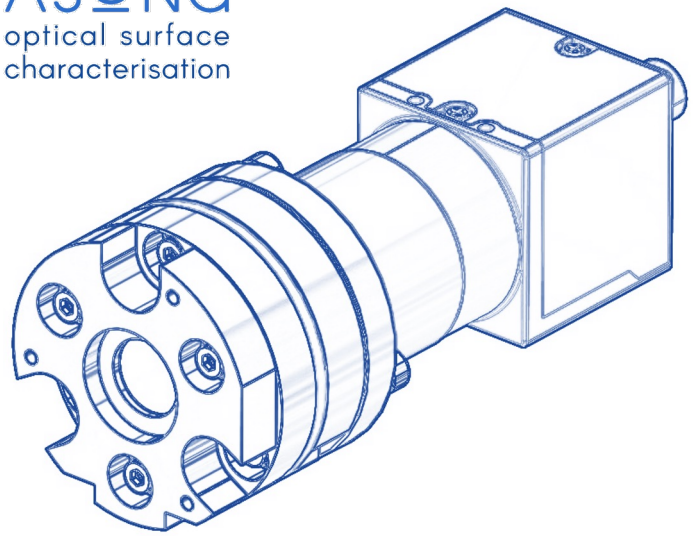


The output image @ FLIR Camera

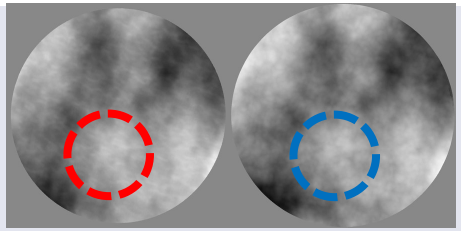
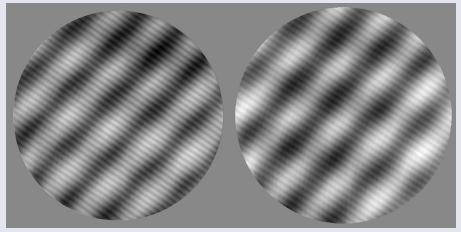
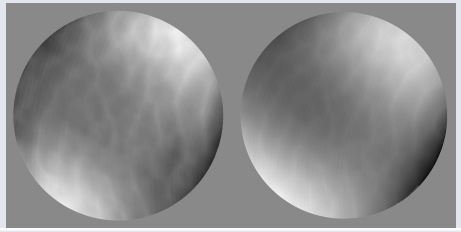
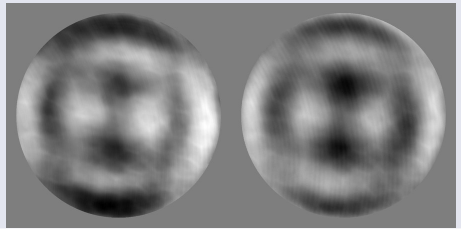
The Phase Masks

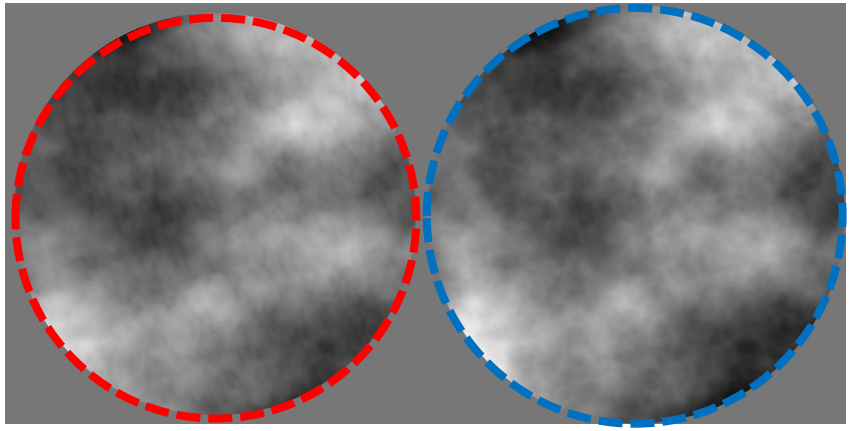


ASONG
optical surface characterisation

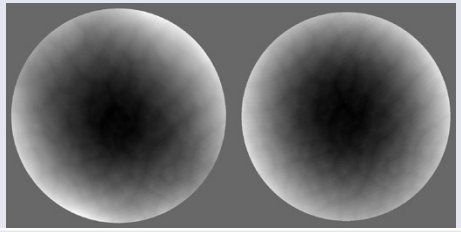
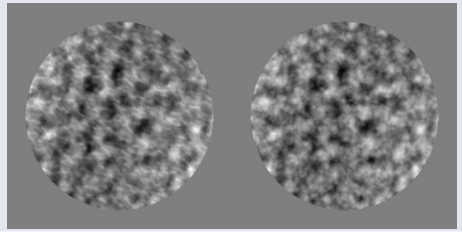


ASONG Measurements - Reconstructed WFE of Phase Masks_1

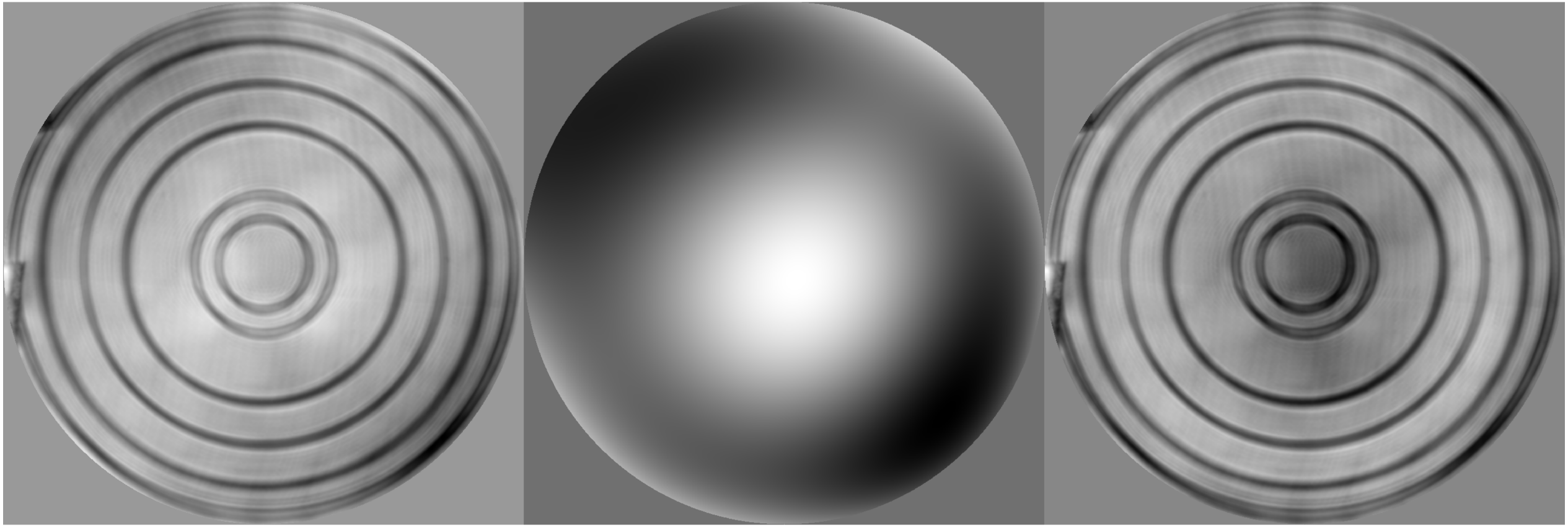
	ASONG	Interferometer	WFE (μm) RMS	PTV
Atmosphere			1.2	6.6
Sinus			0.3	1.4
Eye			0.7	3.9
Zernike 55			0.3	1.7



Zoom-in images have similar resolution!

Defocus		0.9	3.6
Residual		0.2	1.4

ASONG Measurements - Reconstructed WFE of Phase Masks_2



Reconstructed Wavefront Roddier & Roddier

WFE RMS = 0.159938 μm

WFE PtV = 1.08049 μm

Modal Wavefront (first 20 modes)

WFE RMS = 0.12979862 μm

WFE PtV = 0.56259562 μm

Difference

WFE RMS = 0.13973864 μm

WFE PtV = 0.96322488 μm

ASONG Specifications

Parameter	Definition / Remark	Value (existing prototype*)
Spatial Resolution	Pupil size / Number of pupil pixel sampling	25 μm
Accuracy	Closeness of the measurements to the 'true' value	λ/200
Sensitivity	The smallest WFE RMS detectable	λ/500
Repeatability	RMS of multiple sets of measurements dispersion	λ/500
Dynamic Range	Width of WFE RMS linear range	20λ defocus
Phase Point Resolution	Pupil pixel sampling	1000×1000
Wavelength	Broadband spectral range : visual and near infrared	633 nm (current)
Compact Equipment	Volume in which the device is contained	92×52×40 mm^3

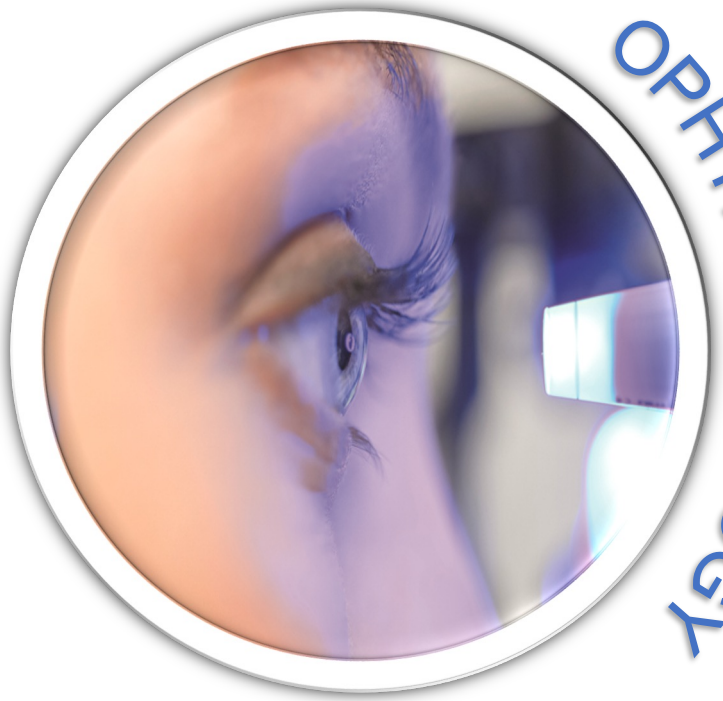
** L. Schreiber, et al., Proc. SPIE, 12188-125, 2022.*

Applications

ADAPTIVE OPTICS

METROLOGY

OPHTHALMOLOGY



- ✓ High Spatial Resolution
- ✓ High Accuracy
- ✓ Quasi-Achromaticity
- ✓ Compact & User-Friendly

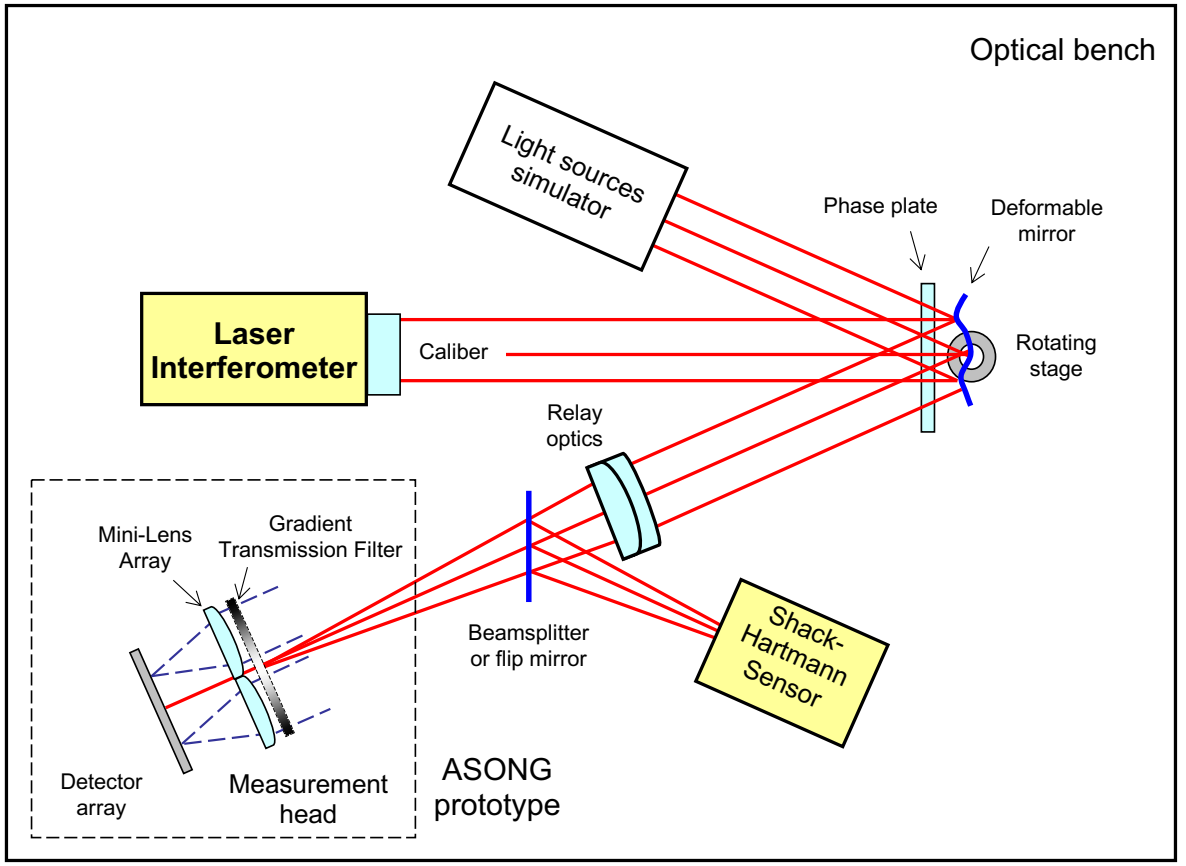
Trade-Off Table between ASONG and Other Popular WFSs

	TYPE OF SENSORS			
Advantages	**Shack Hartmann**	**ASONG optical surface characterisation**	**Pyramid**	**Fizeau Interferometer**
High spatial resolution	*	***	***	***
High measurement accuracy	**	***	***	***
High dynamics	***	**	*	*
Ability to work with extended sources	**	**	**	*
Ability to work with broadband spectral sources	**	**	**	0
Robustness to environments vibrations	**	**	*	*
Simplicity of the concept	**	**	**	0
Optomechanical simplicity	**	**	*	0

TYPE OF APPLICATIONS	**Shack Hartmann**	**ASONG optical surface characterisation**	**Pyramid**	**Fizeau Interferometer**
Ophthalmology	***	***	**	0
Optics Metrology	**	***	*	***
Astronomy / Adaptive Optics	***	**	***	*

The ASONG prototype is available for tests

- Explore the ASONG performance under various working conditions;
- Quantitatively compare with other wavefront sensors, i.e. SH WFS and pyramid WFS;
- Investigate possible application(s) in astronomy.
- Looking for industrial partners



Linksium
technology transfer & startup building
Grenoble Alpes

Yan FENG

François HÉNAULT

David MOUILLET

Jean-Jacques CORREIA

Laura SCHREIBER

Alain SPANG

ASONG

optical surface characterisation

Thank You

YAN FENG

+33 (0)7 69 61 15 68

yan.feng@univ-grenoble-alpes.fr

https://www.linksium.fr/en/projects/asong

ASONG Measurements - Reconstructed WFE of Phase Masks_3