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ANNI



UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

**PhD course of National Interest in Technologies for  
Fundamental Research in Physics and Astrophysics**

## Annual report

**Name and surname: Maria Bazzicalupo**

**Cycle and a.a.: 39, 2023/2024**

**Supervisor: Busoni Lorenzo**

- **Research activity carried out during the year**

Describe the aim of the project (very briefly), discuss the research activity carried out during the year mentioning the difficulties encountered until now and the actions taken to face them. 1 page max in total.

During this year, my research focused on the development of an optical test bench for the implementation and characterization of the CiaoCiao Wavefront Sensor (WFS), a rotational shearing interferometer proposed as part of the MORFEO project. This WFS is designed to detect phase discontinuities at the Extremely Large Telescope (ELT).

The Multiconjugate adaptive Optics Relay For ELT Observations (MORFEO), which will provide multiconjugate adaptive optics (MCAO) correction for the ELT, will be equipped with Shack Hartmann (SH) WFSs.

Being slope sensors, SH WFSs are not able to measure phase jumps across the spiders of the ELT since the distance between the sectors is larger than the atmospheric coherence length. Pupil fragmentation can then be a major issue for the performance of the ELT Adaptive Optics assisted instruments.

The CiaoCiao WFS senses phase discontinuities across the pupil sectors of the ELT: by taking advantage of the rotational symmetry of the ELT pupil, we use a rotational shearing interferometer to make interference between two pupil sectors separated by a spider in order to sense phase differences between adjacent sectors.

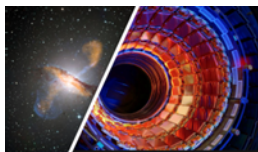
I began my PhD work by studying the optical design and underlying theory of the CiaoCiao.

Following this, I worked on setting up the optical bench at the Arcetri Astrophysical Observatory, aiming to replicate the instrument's design in a laboratory environment.

To date, we have succeeded in proving the instrument concept using a monochromatic source and in the absence of residual aberrations: with the current setup we have been able to sense differences of 3nm between pupil islands along the entire capture range (633nm) of the sensor. One of the main challenges encountered thus far has been constructing the optical setup in a way that operates efficiently and accurately across a broad range of light wavelengths—a key requirement to operate a WFS in astronomical applications.

In the next phase we will extend the setup to broader bandwidth (10-100nm), using broadband light source and fibers and redesigning the setup to accommodate to the much shorter coherence length.

Finally we will introduce a deformable mirror in the optical train to introduce wavefront aberrations similar to the residual aberrations after the MCAO correction, to assess the performances of the CiaoCiao WFS in on-sky working conditions.



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In the project, I am personally responsible for the laboratory optical activities and the development of the data analysis software.

● **List of attended courses and passed exams**

- Fundamentals of system engineering and project management for large scientific projects, Prof. Xompero Marco Prof. Runa Antonio Briguglio Pellegrino
- Adaptive Optics for Astronomy, Prof. Arcidiacono Carmelo
- Deep Networks & Structured Learning, Prof. Basili Roberto
- Ottica adattiva per l'astrofisica, Prof. Busoni Lorenzo Prof. Esposito Simone
- Radio and optical interferometry, Prof. Fabrizio Massi Prof. Giovanni Comoretto (Exam to be taken)

● **List of attended conferences, workshops and schools, with mention of the presented talks**

The ORP International school Observing with Adaptive Optics that will take place at Observatoire de Haute Provence in France from 29th September to 4th October 2024

● **List of published papers/proceedings**

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● **Thesis title ( even temporary)**

Sensing phase discontinuities on ELT segmented pupil with a rotational shearing interferometer

Date, 5/09/2024

Signature... *Marco Bezzicalupo*

Seen, the supervisor

*Lorenzo Busoni*