

1222-2022
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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: Mohamed Yahia Bournane

Cycle and a.a.: 40th Cycle

Supervisor: Demetrio Magrin

- Research activity carried out during the year**

My activity is focused on MezzoCielo Project, a novel telescope designed to observe nearly the entire night sky simultaneously. It uses a spherical transparent container filled with a highly transparent liquid, where the glass shells and liquid together act as a light collector, focusing incoming light at a convenient F-number. Its main innovation is the ultra-wide field of view, about 10,000 square degrees, which is relayed through a multi-channel corrector system (about 900 channels). Each channel covers a portion of the field of view and consists of an optical train and a CMOS detector.

During the first year of my PhD, I focused on the optical design of the corrector for the 80 cm on-sky demonstrator. Initial work used preliminary liquid properties and N-BK7 shells, with a detector configuration of 800 mm EFL and $1.37 \mu\text{m}/\text{pixel}$. The design started with a narrow monochromatic field ($0-1^\circ$ at $0.5 \mu\text{m}$) to simplify the problem, gradually increasing in complexity.

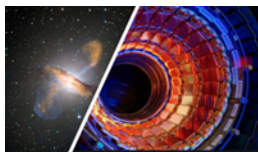
An aperture trade-off study showed that increasing the usable fraction of the sphere raised aberrations, dominated by spherical aberration, highlighting the trade-off between light collection and image quality.

The corrector design was highly iterative, involving hundreds of lens system trials. Stepwise aberration correction guided the process: dummy surfaces identified optimal correction locations, doublets near the aperture image addressed spherical aberration, early aspheres managed strong aberrations before redistributing correction to spherical lenses, triplets corrected spherochromatic aberration, and singlets repositioned rays or corrected field curvature.

The current corrector achieves a $\sim 5^\circ$ diameter field of view per channel over 500–800 nm spectral range, with a 300 mm aperture ($\approx 37.5\%$ of the 800 mm diameter sphere). It consists of eleven elements; five singlets, three doublets, three triplets, with only one aspheric surface, balancing performance with manufacturability and scalability.

Current work is focused on pushing the aperture further. A main difficulty is channel overlap, which introduces mechanical constraints on corrector size and spacing. The design must remain manufacturable and cost-efficient while preserving the performance..

- List of attended courses and passed exams**



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Project Management in Science [Passed]
Adaptive Optics for Astronomy I [Attended]
Adaptive Optics for Astronomy II [Attended]
Radio and Optical Interferometry [Attended]
Advanced Electronic Sensing Devices [Attended]

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

Gran sasso conference – Feb 2025

- **List of published papers/proceedings**

Poster + Paper: Engineering a whole sky one meter class telescope: MezzoCielo as a patrol of transients, <https://doi.org/10.1117/12.3019730>

- **Thesis title (even temporary)**

Optical Design of the MezzoCielo Telescope

Date, 10/09/2025

Signature...

Seen, the supervisor