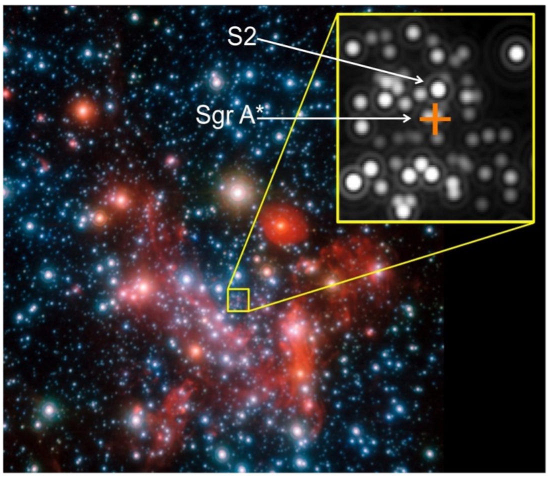
Source Detection and Extraction from Infrared Deep Space Observations



SUMMARY.
The METIS instrument is an advanced infrared camera operating in the 3 to 10 micron wavelength range, soon to be installed on the European Extremely Large Telescope (ELT), which boasts a 40-meter primary mirror. This project focuses on building a robust software pipeline to evaluate METIS's imaging capabilities, particularly for observing the Galactic Centre. The core challenge lies in simulating and accurately placing astrophysical sources on a pixel grid of the infrared detector, then analyzing the resulting synthetic images. This involves combining physical models with computational tools to assess how well METIS can perform key measurements like source localization (astrometry) and brightness estimation (photometry). By leveraging and extending existing simulation codes and data analysis packages, this work sits at the intersection of astrophysics, computational modeling, and software engineering.

OBJECTIVES

- *Master and extend the METIS simulation pipeline (ScopeSIM), focusing on wrapping and integrating it into a modular, automated software workflow.*
- *Generate realistic synthetic images of the Galactic Centre by automating ScopeSIM simulations and accurately mapping sources onto the detector grid.*
- *Integrate the classical source extraction tool StarFinder into the pipeline for automated astrometric and photometric analysis, ensuring smooth data exchange and batch processing capabilities.*
- *Develop new source extraction algorithms or tools tailored to METIS data characteristics, improving detection and measurement accuracy beyond existing solutions.*
- *Build a cohesive, scalable pipeline that combines simulation, extraction (both existing and newly developed tools), and performance evaluation with emphasis on reproducibility, modularity, and software engineering best practices.*

INSTITUTE

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THEORY

by Carlos M. Correia

The work focuses on astrometry and photometry techniques simulated images from adaptive-optics-corrected observations. Understanding image formation and source detection algorithms for precise location and flux determination are key development the students will learn and improve during the internship.

APPLICATIONS

by Carlos M. Correia

Adaptive optics performance simulations. Evaluation of Strehl ratio and residual wavefront error. Use of state-of-the-art techniques for photometry and astrometry. Deep understanding of the challenges of performing precision astrometry and photometry with ELT instruments. Scientific writing, plotting and interpretation of advanced astrophysical metrics.

MAIN PROGRESSION STEPS

- `Weeks 1-2`: Introduction to METIS, ELT instrumentation, and adaptive optics.
- `Weeks 3-4`: Training on StarFinder and ScopeSim
- `Weeks 5-7`: Performance evaluation in terms of astrometry and photometry.
- `Weeks 8-9`: Result interpretation and preparation of final report.

EVALUATION

- `Theory grade [30%]`
  Comprehension of theoretical background as part of the written report.
- `Practice grade [30%]`
  [20%]: Project development, progress, analysis, and conclusions, as detailed in the report.

  [10%]: Initiative, pro-activity, teamwork.
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

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- Brandl et al, (2021): METIS: The Mid-infrared ELT Imager and Spectrograph, (2021)
- Monty et al.. (2023): “Astrometry with MAVIS: Pushing Past the Limits of Gaia to the Crowded Centres of Globular Clusters. Adaptive Optics for Extremely Large Telescopes 7th Edition

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