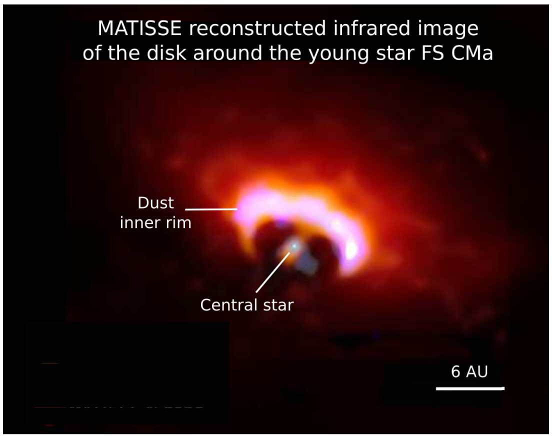
Observing the planet-forming region in protoplanetary disks



SUMMARY.

As of today, more than 4000 exoplanets have been discovered and show a great diversity. Understanding such a diversity requires direct observations of protoplanetary disks at a very high angular resolution in the infrared domain. MATISSE is a 2^{nd} generation instrument for the Very Large Telescope Interferometer (VLTI) of the European Southern Observatory (ESO), built by a consortium of european institutes led by the J.-L. Lagrange Laboratory at OCA. By combining the light of 4 telescopes, this instrument is able to probe the dust and gas content in the innermost regions ($\sim$ 0.1-10 au) of protoplanetary disks, and thus characterize the planet building blocks. In this METEOR, we will explore the basics of optical interferometry and see how MATISSE works. We will then learn how to create disk models, using radiative transfer, and simulate disk observations with MATISSE.

OBJECTIVES

- Understanding optical interferometry and its applications.
- Developing knowledge and skills in radiative transfer, including the use of a radiative transfer code.
- Linking observations and constraints on the physics of disks.
- Developing a critical view on the feasibility of disk observations.

PREREQUISITES

- ✗ S1. Fourier Optics
- ✗ S2. Stellar physics
- ✗ S2. Dynamics & Planetology

THEORY

by A. Matter & B. Lopez

I) Optical interferometry
- Basics : temporal and spatial coherence, observables.
- the MATISSE instrument: Concept, sensitivity, accuracy, sources of noise.

II) Radiative transfer
- Basic equations of radiative transfer.
- Absorption and scattering processes by dust grains.

III) Observation of protoplanetary disks
- The inner disk regions: which wavelength and angular resolution ?
- Physical processes in disks and related spatial structures; effect on the observations.

APPLICATIONS

by A. Matter & B. Lopez

The project will consist of 3 steps:
1) after getting familiar with the radiative transfer code RADMC3D (and its python interface radmc3dPy), the students will produce a set of disk models including the corresponding brightness maps (synthetic images). This set of models will focus on one particular structure (e.g., gap, inner disk rim shape) or disk physical parameter that MATISSE may be able to detect or constrain in the inner disk regions.
2) From the synthetic model images, the students will then use the tool ASPRO2 to produce simulated MATISSE observations.
3) The simulated MATISSE data will then be examined to assess the feasibility of detection/characterization of the considered disk physical parameters.

MAIN PROGRESSION STEPS

For instance:

- Week 1-2: lectures on optical interferometry (+2 exercise sheets) and radiative transfer.
- Week 3: bibliographic study on MATISSE and disks + familiarization with RADMC3D.
- Week 4-6: feasibility study on disks observations (radiative transfer simulations + use of ASPRO2)
- Week 7: preparation of the final oral presentation.

EVALUATION

- Theory grade [30%]
  - Written exam (100%): homework assignment on optical interferometry and its applications.
- Practice grade [30%]
  The students will conduct a feasibility study based on radiative transfer disk simulations. The project will be evaluated on the level of initiative, progress and critical analysis of the results by each student. The final oral presentation will be based on that feasibility study.
- Defense grade [40%]
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- The MATISSE instrument : Link
- RADMC3D website : Link
- radmc3dPy website : Link
- ASPRO2 website : Link

CONTACT

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