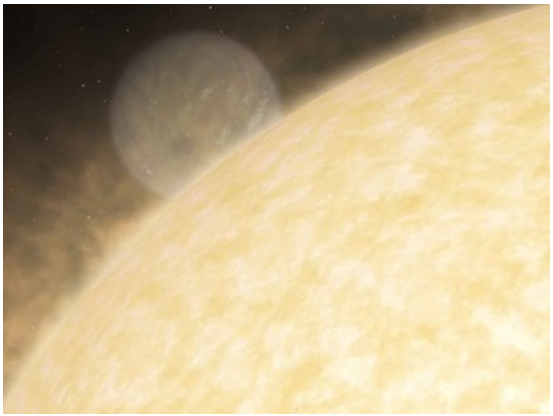
Atmospheres of exoplanets and stars



SUMMARY.
The largest information content from astrophysical objects comes from their spectra. Particularly, stellar and exoplanet spectra allow us to measure stellar and exoplanet atmospheres' thermal, chemical and dynamical properties.
We will first learn the fundamental physical processes that shape stellar and planetary atmospheres' temperature and chemical structure. Then we will learn how spectra are formed in planetary atmospheres and how their observations can be used to determine physical and chemical state of the atmospheres.
The METEOR will be divided into coursework, homework, practical and project. At the end the students will be able to use numerical codes to produce stellar and planetary spectra that can be directly compared to ground- and space-based observations.

— OBJECTIVES

- *Undersand the thermal strucutre, the chemical properties and the formation of spectra in stellar and planetary atmospheres.*
- *Use numerical codes to calculate the thermal structure and spectra of stellar and planetary atmospheres and compare them to space-based (JWST) and ground-based (VLT) telescope observations.*

— PREREQUISITES

- ☒ S2. Stellar physics
- ☒ S2. Dynamics & Planetology

— THEORY

by Vivien Parmentier, Andrea Chiavassa, Julia Seidel

- Radiative/convective equilibrium
- Equilibrium and disequilibrium chemistry
- Opacity
- Formation of emission and transmission spectra for exoplanets and stars
- Confounding factors (stellar contamination, 3D effects, instrumental effects)

— APPLICATIONS

Then the students will pick a project with a focus on exoplanet or stellar spectra.

by Vivien Parmentier

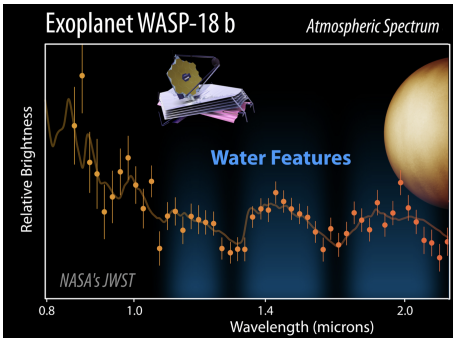
Estimate the chemical abundance and thermal structure of an exoplanet based on its observed spectrum by the James Webb Space Telescope using a 1D radiative/convective code.

by Julia Seidel

Extraction and study of the atmospheric signal of the sodium line fro high-spectral observation from the HARPS spectrograph

by Andrea Chiavassa

Interpretation of stellar spectra with a grid of state-of-the-art 3D stellar models.



— MAIN PROGRESSION STEPS

- `Tier 1`: Theory of atmospheres: radiative transfer, hydrodynamics, chemistry.
- `Tier 2`: Formation of emission and transmission spectra and tools to observe them.
- `Tier 3`: project

— EVALUATION

- `Theory grade [30%]`
  - Written exam on coursework
- `Practice grade [30%]`
  - Presentation of an article relevant for the project (30%)
  - Project (70%): initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

— BIBLIOGRAPHY & RESOURCES

- WASP-18b JWST observation
- TOI-1518b Gemini/MAROON-X observation

— CONTACT

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