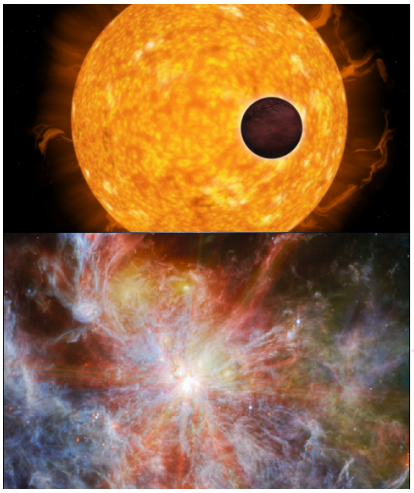
High resolution spectroscopy from planets to stars



SUMMARY.

Understanding the chemical composition of the stars unlocks information about how the star may have been formed and the environment of the star system for potential planet formation processes.

This module will teach you how to analyse the stars and use the information to make statements on the environment the star is found in, like in super-dense clusters at the centre of our galaxy, or exoplanet host-stars.

OBJECTIVES

- *Understanding the theories behind the origin of chemical species in the Universe and how these theories can be understood/challenged through observations.*
- *Learn to perform abundance analysis on stars based on spectroscopy of the light escaping through their atmospheres.*
- *Understanding the difficult task to obtain precise chemical abundances.*

PREREQUISITES

- ☒ S1. Data Sciences
- ☒ S1. Numerical methods
- ☒ S2. Stellar physics

Stellar Physics (in particular: stellar evolution) and General Astrophysics (Milky Way Structure, the Centre of the Milky Way, stellar populations). A detailed course on analysing stellar atmospheres will be provided.

THEORY

by Brian Thorsbro

All elements heavier than helium, denoted as metals by astronomers, were not present in the universe at the time of the Big Bang, and has over time been produced mostly by the stars. Understanding this evolutionary path of nuclear synthesis makes predictions on what type chemical species should be found in stars today. The theory of this will be taught.

Looking at the light emitted from a star it is possible to determine the chemical abundances of a given star. The theory of of how the emitted light of stars are affected by their chemical composition will be taught.

When a planet transits in front of a host star, part of the light is blocked by the planet. Comparing in-transit observations with out-of-transit observations is thus possible to isolate the light coming from behind the planet. This means detailed analysis of a small part of the star can be carried out. How the light differ in this scenario compared to the scenario of observing the entire star at once will be taught.

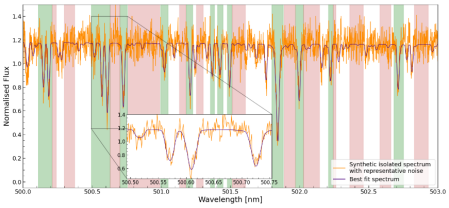
by Mathias Schultheis

The Center of our Milky Way is the only nucleus of a Galaxy which we can study in detail as we can resolve there individually the stellar populations. Together with the existence of the supermassive black hole of Sgr, this part of our Galaxy is one of the most extreme environment where star formation can happen. High-resolution spectroscopy in the Infrared allows to measure chemical abundances of cool M giants and to trace back the chemical evolution of the center of the Milky Way, an unsolved puzzle.*

APPLICATIONS

by B.Thorsbro and M. Schultheis

Using modern computational tools that physically models atmospheres of stars, the process to decode the spectrum (see figure) of a star will be taught. The tools we will use are PySMe and for some projects StarRotator. PySMe will be the major tool to derive chemical abundances such as alpha-elements and/or heavy iron-peak elements. Stellar parameters for these stars will be derived in parallel and used as an input for PySMe.



Spectrum of a star. Decoding this will provide information on the chemical composition of the star.

MAIN PROGRESSION STEPS

- `Weeks 1-2`: Theory and introduction to PySME
- `Weeks 1-2`: Courses on stellar atmospheres and the galactic Center
- `Weeks 3-4`: Theory and exercices
- `Weeks 5-7`: project

EVALUATION

- `Theory grade [30%]`
  - Written exam (70%): theoretical questions,
  - Presentation of an article (30%): critical spirit
- `Practice grade [30%]`
  - Exercices (30%): thought-process and results
  - Project (70%): initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

— BIBLIOGRAPHY & RESOURCES

- Thorsbro2020
- Hoeijmakers2018
- Github PySME
- Github StarRotator

— CONTACT

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