M2 IRT
Radiative Transfer
2021-2022

Project - Atmospheric diffusion on exoplanets

The goal of the following project is to develop a numerical tool to compute the diffusion of the light emitted by a nearby star by the atmosphere of a planet. The tool will provide an image of the sky as seen by an observer on the planet surface as well as spectra along lines of sight selected by the user. The diffusion of the star light across the atmosphere will be solved with a Monte Carlo method. As a test example, the tool will naturally be applied to Earth and Mars atmospheres. However, the tool will be built to be applicable to various kind of atmospheric composition, densities and diffusion processes and to account for the possibility that the planet orbits in a binary star system.

1 Step 1 - report and code expected on October the 20th, 2021.

- Build a function that computes the spectrum of a star based on its surface temperature.
- Build a function that computes the trajectory of the star across the sky depending on the position of the observer on the planet and the rotation axis of the planet.
- Build an interactive tool that displays (1) intensity maps integrated over a frequency range that can be changed by the user and (2) the spectrum along a specific line-of-sight selected by the user.
- Allow the interactive tool to show the time dependent evolution of the sky over one day.

2 Step 2 - report and code expected on November the 20th, 2021.

- Modify the code to allow for the selection of a planetary atmospheric composition, density, and depth, and the corresponding diffusion processes.
- Solve the scattering across the planet atmosphere with a Monte Carlo method by following the path of packets of photons emitted by the star. Quantify the number of photons packets required to obtain a reliable result as a function of the parameters of the problem.
- Configure the tool to display the sky as it would be seen by human eyes. Apply it to the atmosphere of the Earth and the atmosphere of Mars.

3 Step 3 - report and code expected on December the 20th, 2021.

- Add the possibility to include a binary star gravitationnally bound to the first star but with different surface temperature, size, and distance to the planet.
- Modify the solver to account for scattering of photons emitted by both stars.
- Explore the code, find its limits, and propose solutions to broaden the application.