Coupling 3D Simulations to Study Stellar and Planetary Atmospheres

What makes the study of exoplanetary atmospheres so hard is the extraction of its tiny signal from observations, usually dominated by telluric absorption, stellar spectrum and instrumental noise. The High Resolution Spectroscopy has emerged as one of the leading techniques for detecting atomic and molecular species (Birkby, 2018), but although it is particularly robust against contaminant absorption in the Earth's atmosphere, the non-stationary stellar spectrum — in the form of either Doppler shift or distortion of the line profile during planetary transits — creates a non-negligible source of noise that can alter or even prevent the detection. Recently, significant improvements have been achieved by using 3D, radiative hydrodynamical (RHD) simulations for the star and Global Circulation Models (GCM) for the planet (e.g., Chiavassa&Brogi 2019, Flowers et al. 2019). However, these numerical simulations have been computed independently so far, while acquired spectra are the result of the natural coupling at each phase along the planet orbit. With my work, I aim at generating emission spectra of G,F, and K-type stars and Hot Jupiters and coupling them at any phase of the orbit. I will present the unprecedented precise synthetic emission spectra obtained with the upgraded 3D radiative transfer code Optim3D (Chiavassa et al. 2009), showing the impact that they have on the detection of a sample of molecules (e.g., CO, H2O, CO2, CH4) for a grid of mock observations. This approach is expected to be particularly advantageous for those molecules that are present in both the atmospheres and form in the same region of the spectrum, resulting in mixed and overlapped spectral lines.