Abstract
Upper atmospheric escape: H/He signature characterization with a 3D coupled thermosphere-exosphere model

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Atmospheres of exoplanets are our main observing window into the physical and chemical properties of these remote worlds. Spectacular progress has already been made on the atmospheric characterisation of exoplanets, highlighting a huge diversity compared to our Solar System planets. In particular, hot exoplanets found very close to their stars have been found to lose a substantial fraction of their atmospheres, because of the tremendous stellar irradiation they receive. It is surmised that such planets could be entirely stripped from their atmospheres, raising questions as to the possibility that gaseous planets in milder irradiation regimes could give birth to smaller planets with residual, Earth-like atmospheres. The study of atmospheric escape is thus essential to our understanding of exoplanet evolution, and the origins and stability of habitable worlds.

Upper atmospheres (thermosphere + exosphere) give rise to spectacular spectroscopic signatures in the UV and more recently in the IR. The metastable helium lines (10832.1, 10833.2 and 10833.3) represent recent tracers of escape in a wavelength range where the spectra of the star and of the planetary atmosphere are more easily observed than in the UV. Observations of exospheres in the UV only yield part of the information about the escaping gas which need to be completed by probing the thermosphere in the IR. It is thus essential to simulate self-consistently thermosphere and exosphere with the most relevant codes, to interpret accurately observations of these layers. The joint interpretation can be done using sophisticated simulations with the model of upper atmosphere that we developed to the description of both gaseous and ultra-hot rocky planets, EVaporation of Exoplanets (EVE). This model is a 3D model simulating the different atmospheric layers of exoplanets: the lower layers, described in a fluid regime, are modelled with a high-resolution Cartesian grid containing millions of cells. The upper atmospheric layers are modelled in a collisionless regime, with tens of millions of particles of gas. The main purpose of the EVE code is to calculate the absorption of stellar light across the simulated atmosphere. The better coupling of thermospheric and exospheric structure allow us to re-interpret and in greater details all available UV (HST) and IR (CARMENES, GIANO, SPIRou, Keck/NIRSPEC) observations of upper atmospheres. We will also be able to interpret and predict signatures of escape in near-infrared JWST spectra of small exoplanets, and in near-infrared and optical spectra respectively obtained by the GTOs of the NIRPS and ESPRESSO spectrographs.