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Determination of the exospheric temperature of CO_2 and O_2 rich exoplanets

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The discovery of Earth-sized exoplanets orbiting in, or near, the so-called habitable zone leads to questions concerning the presence, the characteristics, and the evolution of their atmospheres. For giant exoplanets, the characterization of their atmosphere has already started, with major discoveries such as the observation of evaporation of hot-Jupiter atmospheres.

One technique to better understand these processes would be to determine the exospheric temperature of these atmospheres since it is the main parameter for atmospheric escape (both thermal and non-thermal). The exospheric temperature is highly dependent on the composition: CO_2-rich planets, Venus and Mars, are known to have a small exospheric temperature (200 - 300 K), compared to other planets like Earth (800 - 1600 K) or Jupiter (700 - 1000 K). The determination of the exospheric temperature on exoplanets is therefore an important step to determine the stability and the evolution of their atmospheres, and to help understand how our own solar system evolved.

To reach this goal, measurements have to be done in the UV, because the emission/absorption of lower layers of the planet may mask the infrared features of the upper atmosphere. Currently, several UV absorption techniques are proposed to determine the atmospheric composition, but rely on several hypotheses concerning the composition of the planetary atmosphere. The CO_2 and O_2 molecules have an uncommon feature in the 150-200 nm region: their UV absorption is strongly temperature (in addition to wavelength) dependent. In this work, we present the theoretical calculation of the UV absorption by several planetary atmospheres rich in O_2 or CO_2, taking into account the temperature dependence, and we show that this feature allows to decorrelate the scale height of the thermosphere from the temperature of its neutral species. It means that it is possible to determine the exospheric temperature and to check whether the atmosphere is in hydrostatic equilibrium or in hydrodynamical escape. Finally, we stress the necessity for adequate instrumentation in order to test this technique.