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Can one infer the presence of an hydrogen corona around CO_2-dominated exoplanetary atmosphere?

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Abstract

More and more Earth size and super Earth exoplanets are found every week. Now, one of the more challenging problem is to characterize their atmosphere (if they have one). There are many evidences that sustain the presence of huge hydrogen atmospheres around these exoplanets. In a recent paper, we showed how difficult it would be to detect an H atmosphere around an Earth-like exoplanet by studying Lyman Alpha emission. Here, we investigate the possibility to infer the presence of an hydrogen corona around a CO_2-dominated secondary atmosphere, by studying its impact on EUV induced emissions of CO_2 by-products.

1. Introduction

Numerous exoplanets in the Earth/Super Earth regime have already been found, and more and more are found every month. One of the most challenging issue is now to characterize their atmosphere when they have one.

The mean density of some of them, like the Kepler-11 system [5] tend to show that they are surrounded by a huge hydrogen atmosphere [4, 6]. On the other hand, recent simulations sustain the idea that an hydrogen-dominated atmosphere can last for long time in the case of terrestrial planets, even after the establishment of secondary atmospheres (Tian et al., 2005; [2], [3].

In a recent paper (Bernard et al., submitted), we showed that the contrast between the Young Sun and an hydrogen dominated Early-Earth is bad for detection. In the present work, we investigate the possibility to infer the presence of a huge hydrogen corona around a CO_2 atmosphere of an Earth-like planet.

2. Method

We use a 1D photoionization - kinetic transport code to calculate the emissions of CO_2 by-products induced by extreme UV (EUV) and primary photoelectrons. We also use a 1D radiative transfer code to calculate the Lyman Alpha emission of the hydrogen corona.

3. Results

Although CO_2 itself has no luminous transition induced by EUV photons, we propose two interesting reactions that could lead to detectable emissions : the ionization of CO_2 in the ($B^2\Sigma_u$) state with a doublet à 289 nm, and its dissociation with $O(^1S)$ production, with the green line emission at 557 nm.

Not surprisingly, the contrast is unfavorable for Earth-like planets in the habitable zone of Sun-like stars, especially because of a strong black body emission of the star in the visible region. As for other characterization methods, the most promising targets are planets in the vicinity of M-dwarfs, which present the double advantage to exhibit a strong EUV flux (for active stars) and a weaker flux in the near-UV and optical range, compared to warmer stars.

4. Summary and Conclusions

Until now, only a few exoplanetary atmospheres have been partially characterized. Both techniques are currently used : primary and secondary transit. Another one that has not been used yet is the search for emission lines, which could provide useful information on upper atmospheres, even for non-transiting planets. In this scope, we investigated the possibility to infer the presence of an hydrogen corona around a CO_2-dominated atmosphere, by studying its influence on some emission lines of CO_2 by-products.

The most promising targets are exoplanets close to active M-dwarf, where the contrast is close to the detection limit of current instruments, and will certainly be in the capabilities of future ones.

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