EPSC Abstracts
Vol. 5, EPSC2010-635, 2010
European Planetary Science Congress 2010

Modeling FUV emissions of a hot Jupiter

H. Menager (1), M. Barthelemy (1), C. D. Parkinson (2), J. Lilensten (1), H. Abgrall (3) and E. Roueff (3)
(1) Laboratoire de Planétologie de Grenoble, France, (2) University of Michigan, MI, United States, (3) LUTH, Observatoire de Paris, France (helene.menager@obs.ujf-grenoble.fr / Fax: +33-476-51-41-46)

Abstract

To date, there have been no detection of FUV emissions from the atmosphere of a hot Jupiter. However, in the absence of any precise computation, it is generally agreed that the contrast with the parent star FUV emissions is not very favorable to this detection. We propose here to estimate these emissions using a kinetic code to model the absorption of the stellar flux and the transport of superthermal electrons for a model atmosphere of a hot Jupiter. The kinetic code provides excitation rates of H and H_2. We then perform radiative transfer calculations to calculate the intensity of the H Lyman-α line and H_2 bands between 900 and 1650 Å. We calculate both the dayglow and the auroral emissions. These calculations are carried out for different hot Jupiter model atmospheres, computed by making perturbations around an initial reference model. This will allow a determination for the best conditions to make a future detection.

1. Introduction

In the solar system, the giant planets Jupiter and Saturn have bright emissions of hydrogen in the FUV. The most intense line is H Lyman-α. Besides that, between 900 and 1650 Å, molecular hydrogen has a wide spectrum dominated by the Lyman and Werner bands, whose total intensity is comparable to that of the H Ly-α line. On the day side of the planets, these emissions are excited by the absorption of the solar EUV/FUV flux. At auroral latitudes, they are due to plasma which precipitates into the atmosphere where it ionizes or excites atmospheric particles.

Since they are mostly composed of hydrogen, hot Jupiters are likely to produce the same kind of FUV emissions. Their emissions are expected to be very intense because the planets, which are very close to their parent stars, receive intense stellar fluxes. Detecting these planetary emissions is a challenging issue : although they are very bright, they remain much fainter than the star's emissions.

2. Calculation of planetary FUV emissions

2.1. Excitation of atmospheric particles

We calculate the intensity of the emissions of the H Ly-α line and of the H_2 bands of hot Jupiters. To do so, we first use a kinetic transport code to calculate excitation rates of H and H_2 in the atmospheres. The code accounts for both the absorption of the solar EUV/FUV flux and the collisions between auroral electrons and atmospheric particles. This multi-stream code, which solves the Boltzmann equation, has been described in [1].

Calculations are done for several hot Jupiter model atmospheres. To simulate the effect of different temperatures and background compositions, adapted atmosphere models are computed with the Caltech/JPL KINETICS model, by making perturbations around an initial hot Jupiter atmosphere model.

2.2. Ly-α emission

Since the atmospheres are optically thick at Ly-α, the excitation rates calculated by the kinetic code are included in radiative transfer calculations. By also taking into account the absorption of resonant Ly-α photons, we calculate the intensity and the profile of the emergent Ly-α line. Details on the radiative transfer at Ly-α can be found in [2, 3, 4]. Eventually, we are able to estimate the contrast between the planetary emission and that of the star, for both the dayglow emission and the auroral contribution.

We are thus able to designate a hot Jupiter for which the contrast is the most favorable. By also taking into account the Doppler shift between the planetary emission and that of the star, we designate a hot Jupiter gathering the best conditions for a detection.

2.3. H_2 emission

A feature has been detected at 1582 Å in a spectrum of HD209458b, but could not be attributed unambiguously to H_2 [5]. Making a clear detection of some H_2

emission from an exoplanet still has to be done.

Using the excitation rates of H_2, radiative transfer calculations allow us to calculate line-by-line spectra of H_2. We account for self-absorption and cascades from the upper $gerade$ levels.

As for Ly-α, we can point out the best candidates to detect their H_2 planetary emissions.

3. Summary and Conclusions

By modeling the emission of the H Ly-α line and of the FUV H_2 bands of hot Jupiters, we designate planets gathering the best conditions to detect these emissions and we make recommendations for future observations.

References

[1] H. Menager, M. Barthélemy, and J. Lilensten, "H Lyman α line in Jovian aurorae: electron transport and radiative transfer coupled modelling," *Astronomy and Astrophysics*, vol. 509, pp. A56+, Jan. 2010.

[2] E. Griffioen, "A pseudo three-dimensional resonance line radiative transfer model with overlapping lines," *Journal of Geophysical research*, vol. 105, pp. 24613–24620, Oct. 2000.

[3] C. D. Parkinson, J. C. McConnell, L. Ben Jaffel, A. Y.-T. Lee, Y. L. Yung, and E. Griffioen, "Deuterium chemistry and airglow in the jovian thermosphere," *Icarus*, vol. 183, pp. 451–470, Aug. 2006.

[4] M. Barthélemy, C. Parkinson, J. Lilensten, and R. Prangé, "Modelling the Lyman β dayglow in the Jovian atmosphere," *Astronomy and Astrophysics*, vol. 423, pp. 391–395, Aug. 2004.

[5] K. France, J. T. Stocke, H. Yang, J. L. Linsky, B. C. Wolven, C. S. Froning, J. C. Green, and S. N. Osterman, "Searching for Far-ultraviolet Auroral/Dayglow Emission from HD 209458b," *Astrophysical Journal*, vol. 712, pp. 1277–1286, Apr. 2010.