EPSC Abstracts
Vol. 10, EPSC2015-307, 2015
European Planetary Science Congress 2015

Modelling the ionosphere of gas-giant exoplanets irradiated by low-mass stars

J. Chadney (1), M. Galand (1), Y. Unruh (1), T. Koskinen (2) and J. Sanz-Forcada (3)
(1) Department of Physics, Imperial College London, UK, (2) Lunar and Planetary Laboratory, University of Arizona, USA, (3) Centro de Astrobiologia (CSIC-INTA), Madrid, Spain
(joshua.chadney10@imperial.ac.uk)

Abstract

The composition and structure of the upper atmosphere of Extrasolar Giant Planets (EGPs) are affected by the high-energy spectrum of the host star from soft X-rays to Extreme UltraViolet (EUV) (0.1-10 nm). This emission depends on the activity level of the star, which is primarily determined by its age [1]. In this study, we focus upon EGPs orbiting K- and M-dwarf stars of different ages. XUV spectra for these stars are constructed using a coronal model [2]. These spectra are used to drive both a thermospheric [3] and an ionospheric model, providing densities of neutral and ion species. Ionisation is included through photo-ionisation and electron-impact processes. The former is calculated by solving the Lambert-Beer law, while the latter is calculated from a supra-thermal electron transport model [4]. Planets orbiting far from the star are found to undergo Jeans escape, whereas close-orbiting planets undergo hydrodynamic escape. The critical orbital distance of transition between the two regimes is dependent on the level of stellar activity. We also find that EGP ionospheres at all orbital distances considered (0.1-1 AU) and around all stars selected (eps Eri, AD Leo, AU Mic) are dominated by the long-lived H^+ ion. In addition, planets in the Jeans escape regime also have a layer in which H_3^+ is the major ion at the base of the ionosphere. For fast-rotating planets, densities of short-lived H_3^+ undergo significant diurnal variations, their peak value being determined by the stellar X-ray flux. In contrast, densities of longer-lived H^+ show very little day/night variability and their value is determined by the level of stellar EUV flux. The H_3^+ peak in EGPs in the hydrodynamic escape regime under strong stellar illumination is pushed to altitudes below the homopause, where this ion is likely to be destroyed through reactions with heavy species (e.g., hydrocarbons, water). Infrared emissions from H_3^+ shall also be discussed, as well as the impact of stellar variability.

References

[1] Chadney, J., Galand, M., Unruh, Y., Koskinen, T., and Sanz-Foracada, J.: XUV-driven mass loss from extrasolar giant planets orbiting active stars. Icarus, 250, 2015.

[2] Sanz-Forcada, J., Micela, G., Ribas, I., Pollock, A., Eiroa, C., Velasco, A., Solano, E., and Garcia-Alvarez, D.: Estimation of the XUV radiation onto close planets and their evaporation. A&A, 532, 2011.

[3] Koskinen, T., Lavvas, P., Harris, M., Yelle, R.: Thermal escape from extrasolar giant planets. Phil. Trans. R. Soc. A., 372, 2014.

[4] Galand, M., Moore, L., Charnay, B., Mueller-Wodarg, I., and Mendillo, M.: Solar primary and secondary ionization at Saturn. JGR, 114, 2009.