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Thermospheres of Extrasolar Giant Planets

T. T. Koskinen, A. D. Aylward, S. Miller

Department of Physics and Astronomy, University College London, London

tommi@apl.ucl.ac.uk

We have used a three-dimensional, hydrodynamic model to study the temperature variation, composition, ion densities and circulation in the thermospheres of Extrasolar Giant Planets (EGP) at different orbital distances from a solar type host star. Provided that the thermosphere is composed of hydrogen and helium, we find that the upper atmospheres of EGPs should be relatively stable at orbits further than 0.2 AU from the host star. The intense heating of the thermosphere by stellar XUV radiation is effectively balanced by infrared emissions from H_3^+ ions. Also, thermospheric circulation cools the dayside of the planet and distributes heat evenly around the planet, although on tidally locked EGPs, notable diurnal temperature differences persist at the top of the thermosphere.

For close-in EGPs or "Hot Jupiters", this situation is altered by thermal dissociation of H_2, which prevents the formation of H_3^+. This process becomes significant at temperatures above $\sim$3000 K, which are reached by the model between 0.1 AU and 0.2 AU. If the temperatures are high enough, dissociation happens rapidly and the entire upper thermosphere is converted into atomic hydrogen. Consequently the thermosphere heats up and expands and significant atmospheric loss may take place. If radiative cooling by H_3^+ is ignored altogether, the upper atmosphere reaches temperatures well above 10 000 K within 0.6 AU from the host star and the entire upper atmosphere should be converted into atomic hydrogen further out from the host than if radiative cooling is included.

We have calculated infrared emission rates from various vibrational transitions of H_3^+ based on the thermal state and composition of the model at different orbital distances. Observing these faint signals could prove challenging for any existing observing programs.