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Modelling of Hot Jupiter thermospheres and ionospheres under irradiation from active stars

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Abstract

Upper atmospheres of Hot Jupiters are subject to extreme radiation conditions that can result in atmospheric escape. The composition and structure of the thermosphere and ionosphere of these planets are affected by the high-energy spectrum of the host star. This emission depends on stellar type and age, which are thus important factors in understanding the behaviour of exoplanetary atmospheres. In this study, we focus on Hot Jupiter planets orbiting K and M dwarf stars. As an example, XUV spectra for three different stars – ε Eridani, AD Leonis and AU Microscopii – are constructed using a coronal model. Neutral density and temperature profiles in the thermosphere of hypothetical, Hot Jupiters orbiting these stars are then obtained from a fluid model of the upper atmosphere, incorporating atmospheric chemistry and taking atmospheric escape into account. Using these models of both the host star and the planetary atmosphere, we have derived a method to scale the X-ray and EUV regions of the solar spectrum to produce a very similar outcome in terms of the planet's neutral thermosphere as using a detailed coronal model of the host star. We also calculate ion production rates and densities in the ionospheres of such planets, considering ionisation through both photo-ionisation and electron-impact processes. We find that in planets subjected to radiation from more active stars, the transition to a regime of hydrodynamic escape from the top of the atmosphere occurs at larger orbital distances. A greater X-ray to EUV flux ratio in these stars compared with the solar case also produces ionospheres that extend to lower altitudes and are significantly more pronounced.