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Escape of Hydrogen from HD209458b

Justin Erwin (1,2), Roger Yelle (2), and Tommi Koskinen (2)

(1) The Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium, (2) LPL, University of Arizona, Tucson, Arizona, USA

Recent modeling of the atmosphere of HD209458b has been used to interpret the Lyman-α line and other observations during transits. Koskinen et al. (2010) used a hydrostatic density profile in the thermosphere combined with the Voigt profile to estimate the Lyman-alpha transit depths for an array of model parameters. A detailed photochemical-dynamical model of the thermosphere was developed by Koskinen et al. (2013a) and used to again estimate model parameters to fit not only the Lyman-alpha transits, but also the transits in the O I, C II and Si III lines (Koskinen et al., 2013b). Recently, Bourrier and Lecavelier (2013) modeled the escape of hydrogen from the extended atmospheres of HD209458b and HD189733b and used the results to interpret Lyman-alpha observations. They included acceleration of hydrogen by radiation pressure and stellar wind protons to simulate the high velocity tails of the velocity distribution, arguing that the observations are explained by high velocity gas in the system while Voigt broadening is negligible.

In this work we connect a free molecular flow (FMF) model similar to Bourrier and Lecavelier (2013) to the results of Koskinen et al. (2013b) and properly include absorption by the extended thermosphere in the transit model. In this manner, we can interpret the necessity of the various physical processes in matching the observed line profiles. Furthermore, the transit depths of this model can be used to re-evaluate the atmospheric model parameters to determine if they need to be adjusted due