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Comparative aeronomy of HD209458b and HD189733b

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Abstract

Transit observations at UV wavelengths probe the hot, extended and highly ionized upper atmospheres of close-in extrasolar planets. HD209458b and HD189733b both orbit their host stars within 0.05 AU and are loosing mass due to intense heating by stellar XUV radiation. However, their surface gravities differ by a factor of ∼2 and while HD209458 is a solar-type star, HD189733 is a K type star. Consequently, the X-ray and EUV flux received by HD189733b is expected to be significantly higher than that received by HD209458b. Therefore, the upper atmospheres of the planets should have different characteristics. Here we discuss the interpretation of the UV transit observations and show how they can be used to obtain information about the thermal structure, composition and escape rates in the upper atmosphere. Based on the results, we highlight the differences and similarities between HD189733b and HD209458b.

1. Introduction

UV transit observations have revealed the presence of H I, O I, C II [6, 7], and Si III [4] in the upper atmosphere of HD209458b and H I in the upper atmosphere of HD189733b [5]. The interpretation of these observation is not straightforward and has been discussed extensively in many modeling studies [1, 2, 3]. However, the observations and practically all of the modeling studies point to one solid conclusion – these planets possess an extended thermosphere with a temperature close to or exceeding 10,000 K.

Koskinen et al.[3] showed that the H I and O I transit depths depend on the level where H_2 is dissociated, the mean temperature of the thermosphere and the ionization state of the upper atmosphere. The interpretation of the C II and Si III observations is more difficult because, contrary to the neutral species, the detectable distribution of the ionized species is not necessarily constrained to the thermosphere of the planet. Due to uncertainties in the emission line profiles detected during transit, the observations do not constrain mass loss rates directly and their interpretation is thus model-dependent.

2. Results and conclusions

We fit the observations with an empirical model and also present results from a numerical, one-dimensional escape model that includes realistic heating rates, photochemical calculations and hydrodynamic escape. We obtain density profiles for H I, O I, C II, and Si III on HD209458b and for H I on HD189733b that agree roughly with the existing observations. The results reveal differences in the ionization state and thermal structure of the upper atmospheres. Surprisingly, the mass loss rate from HD189733b is comparable or lower than the escape rate from HD209458b.

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