EPSC Abstracts
Vol. 13, EPSC-DPS2019-1399-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Sub-Alfvénic Stellar Wind Interaction with the Upper Atmosphere and Magnetosphere of the Hot-Jupiter HD 209458b

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Abstract

Close-in exoplanets, i.e. planets orbiting their central stars within $0.1\,\mathrm{AU}$, are exposed to intense stellar radiation and the powerful influence of the flow of dense stellar wind plasmas. A very prominent example of such a close-in exoplanet, is the 'hot Jupiter' HD 209458b orbiting its host star at a radial distance of $\sim\ 0.047\,\mathrm{AU}$. UV observations revealed strong hydrogen absorption signatures at the Ly-α line suggesting that the atmosphere possess a gigantic outer coma and is subject to enormous mass loss rates. The absorption was mainly detected within the Ly-α spectrum at wavelengths corresponding to Doppler-shifted velocities between $\sim\ 100\,\mathrm{km/s}$ away and towards the observer. This absorption feature can be explained by the generation of Energetic Neutral Atmos (ENAs) due to a sub-Alfvénic stellar wind interaction with the upper atmosphere of the exoplanet. We performed self consisting MHD simulations with a 3D code 'ZEUS MP' modeling the stellar wind interaction with the upper atmosphere and magnetosphere of the exoplanet combined with a model for its hydrogen mass loss. We performed multiple model runs for different stellar wind conditions and magnetic field geometries. We show that various assumptions of the atmospheric, plasma and magnetic field environments of HD 209458b can lead to UV absorption spectra consistent with the observations, i.e., we show that the interpretation of its UV spectra is non-unique. Through comparison with the UV observations we derive new constraints on plasma and magnetic field environment around HD209458b.