EGU21-936
https://doi.org/10.5194/egusphere-egu21-936
EGU General Assembly 2021

Modelling the influence of high-energy radiation on the atmospheric composition of the hot Jupiter HD 189733b

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Hot Jupiters provide valuable natural laboratories for studying potential contributions of high-energy radiation to prebiotic synthesis in the atmospheres of exoplanets. HD 189733b, a hot Jupiter orbiting a K star, is one of the most studied and best observed exoplanets. We combine XUV observations and 3D climate simulations to model the atmospheric composition and kinetic chemistry with the STAND2019 network. We show how XUV radiation, cosmic rays (CR), and stellar energetic particles (SEP) influence the chemistry of the atmosphere. We explore the effect that the change in the XUV radiation has over time, and we identify key atmospheric signatures of an XUV, CR, and SEP influx. 3D simulations of HD 189733b's atmosphere with the 3D Met Office Unified Model provide a fine grid of pressure-temperature profiles, consistently taking into account kinetic cloud formation. We apply *HST* and *XMM-Newton/Swift* observations obtained by the MOVES programmewhich provide combined X-ray and ultraviolet (XUV) spectra of the host star HD 189733 at 4 different points in time. We find that the differences in the radiation field between the irradiated dayside and the shadowed nightside lead to stronger changes in the chemical abundances than the variability of the host star's XUV emission. We identify ammonium (NH_4^+) and oxonium (H_3O^+) as fingerprint ions for the ionization of the atmosphere by both galactic cosmic rays and stellar particles. All considered types of high-energy radiation have an enhancing effect on the abundance of key organic molecules such as hydrogen cyanide (HCN), formaldehyde (CH_2O), and ethylene (C_2H_4). The latter two are intermediates in the production pathway of the amino acid glycine ($C_2H_5NO_2$) and abundant enough to be potentially detectable by *JWST*.

Ultimately, we show that high energy processes potentially play an important role in prebiotic chemistry.

P Barth et al., MOVES IV. Modelling the influence of stellar XUV-flux, cosmic rays, and stellar energetic particles on the atmospheric composition of the hot Jupiter HD 189733b, *Monthly Notices of the Royal Astronomical Society*, in press, DOI:10.1093/mnras/staa3989