

Impact of Ionizing Radiation on exoplanetary habitability induced by Solar and Stellar Energetic Particles

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Ionizing radiation, resulting from the interaction between cosmic radiation and a planet's atmospheric boundary, has a profound impact on lifeforms. On planets with sufficient atmospheric depth, the direct exposure to radiation is significantly mitigated. However, our calculations suggest that some exoplanets classified as "habitable" may experience ionizing radiation doses at critical levels when considering atmospheric escape scenarios. Furthermore, the presence of harder radiation spectra on a broader scale, particularly from coronal mass ejections (CMEs) emitted by host stars, exacerbates this risk.

High-energy radiation due to exoplanetary space weather introduced by magnetic activity of a planet-hosting star can also play a crucial role in the definition of habitability in addition to the conventional factors (Airapetian et al. (2016) Airapetian et al. (2017a) Airapetian et al. (2017b) Lingam et al. (2017)). The potential impact into habitable planets has been evaluated quantitatively (Yamashiki et al. 2019), and in this case, we assumed that the Spectra of Stellar Energetic Particles is identical to that observed on the Earth.

Here we revised quantitative impact evaluation system of stellar activity on the habitability factors with an emphasis on Stellar Proton Events for several documented exoplanets examining the impact of CO₂, H₂, N₂+O₂ -rich atmospheres by introducing harder possible stellar impact generated by Hu et al. 2022

Results suggested that completely safe planets in the past survey orbiting K and G dwarfs (Kepler-283 c, Kepler-1634b) also may suffer fatal impacts from the central stars with larger scales of ICME events at 1/10 of terrestrial atmospheric pressure. Calculation into habitable planets orbiting M dwarfs (Proxima Centauri, TRAPPIST-1 e) also suffer severe or fatal doses when harder spectra attack the planets. On Ross-128b, it only receives a relatively small dose considering the maximum flare energy of the host star. We also extended our survey to other habitable planets orbiting other M dwarfs (Kepler-1652b, GJ163b and GJ3323b) where severe and critical doses were estimated at 1/10 of terrestrial atmospheric pressure.

By integrating these methods, we aim to refine our understanding of planetary habitability under varying cosmic radiation conditions and improve predictive models for future space exploration missions, for those planets listed as habitable planets.

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