

## 恒星フレアによる太陽系外惑星ハビタビリティ評価 Impact of Stellar Superflares on Planetary Habitability

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Environmental factors of crucial importance for exoplanetary habitability include the presence of bodies of liquid surface water, a dense atmosphere, planetary global magnetic field, and internal planetary dynamics. In addition, 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.

Here, we present the first 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 CO<sub>2</sub>, H<sub>2</sub>, N<sub>2</sub>+O<sub>2</sub> -rich atmospheres by introducing starspots of their hoststars, estimated using their rotational periods and lightcurves.

Simulations suggest that the estimated ground level dose for each planet, assuming a terrestrial-level atmospheric thickness, does not exceed the critical dose for complex (multi-cellular) life to persist, even for the planetary surface of Proxima Centauri b, Ross-128b and TRAPPIST-1 e. However when we consider the possible maximum flare for those host stars, at the terrestrial lowest atmospheric depth, the estimated dose reaches fatal levels on TRAPPIST-1 e and Ross-128 b. Continuous XUV radiation higher than that experienced by the Earth induces rapid atmospheric escape for those planetary systems, meaning the atmospheric depth might be substantially less than the Earth. In a scenario where the modelled planetary systems have 1/10 the atmospheric thickness of Earth, the radiation dose at Proxima Centauri b and TRAPPIST-1 e reaches near fatal levels just from relatively minor annually occurring flares from their hoststars.

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