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High-energy galactic cosmic rays in the magnetospheres of terrestrial exoplanets

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Abstract

Theoretical arguments indicate that close-in terrestial exoplanets may have weak magnetic fields, especially in the case of planets more massive than Earth ("super-Earths"). Planetary magnetic fields, however, constitute one of the shielding layers which protect the planet against cosmic ray particles. In particular, a weak magnetic field results in a high particle flux to the top of the planetary atmosphere. For the case of cosmic ray protons, we numerically analyze the propagation of the particles through planetary magnetospheres. We evaluate the efficiency of magnetospheric shielding as a function of the particle energy (in the range 64 MeV $\leq E \leq$ 500 GeV) and of the planetary magnetic field strength (in the range $0.05\mathcal{M}_E \leq \mathcal{M} \leq 3\mathcal{M}_E$). In order to illustrate possible effects of weak magnetic fields, we show the dependency of the penetration energy on the planetary magnetic field strength. We discuss implications of increased particle fluxes, including the modification of atmospheric chemistry, destruction of atmospheric biomarker molecules, and potential biological implications.