EPSC Abstracts
Vol. 5, EPSC2010-595, 2010
European Planetary Science Congress 2010

Are magnetospheres really protectors of early planetary atmospheres?

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Abstract

The aim of this presentation is to discuss the evidence that early planetary atmospheres should be exposed to high solar/stellar X-ray, SXR and EUV radiation which can result in effective thermospheric expansion of the upper atmosphere, even above a possible magnetopause. If true, magnetospheres cannot act as a protection for the atmosphere. This results in a question who planets may keep their nitrogen inventories during the active epochs of their host stars? Observations of Sun-like stars with various ages indicate an early active phase including continuous flare events and X-ray, SXR and EUV radiation (XUV) much more intense than that of the present Sun [1]. After this very active stage, the solar XUV flux quickly decreases with time following a power law relationship. Early low mass stars appear to stay at high activity levels even as long as about 1 Gyr, and then their luminosity decrease in an analogous way to Sun-type G and K-type stars. Early K-type stars and early M stars may have XUV emissions of about 3 - 4 times and about 10 - 100 times higher, relative to their total luminosity, respectively, than solar-type G stars of the same age [1,2]. The longer lasting short-wavelength exposure of the upper atmospheres of such planets will experience an expansion [3,4,5] and corresponding large thermal and non-thermal loss rates [6,7]. We present recent modeling results for nitrogen and CO2-rich atmospheres of terrestrial planets under extreme solar EUV conditions where the exobase may expand above the magnetopause and the magnetosphere had not been able to protect the upper atmosphere against strong non-thermal erosion by the solar wind. These studies indicate that the composition of an early planetary atmosphere, including the planets water-inventory after its origin is most likely more relevant during the active young star epoch for the stability of the main atmosphere (e.g. nitrogen inventory, etc.) than a magnetosphere. Since lower mass M-type stars show a higher level of stellar activity compared to Sun-like stars, and because of the closer orbital distance of their habitable zones compared to that of the Solar System, terrestrial exoplanets within M-type habitable zones are expected to be much stronger influenced by stellar winds and dense plasma ejected from the host star by coronal mass ejections. The consequences of atmosphere-magnetosphere-plasma interaction related to the habitability of terrestrial planets within active M star environments are also discussed.

Acknowledgements

This research is supported by the Helmholtz Association through the research alliance "Planetary Evolution and Life" and through the joined Russian- Austrian project under the RFBR grant 09-02-91002- 215-ANF-a and the FWF grant I199-N16.

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