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Influence of Suprathermal Atoms on the Escape and Evolution of Mars' CO2 Atmosphere

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Abstract

Loss rates of hot oxygen and hot carbon from Mars are presented for an EUV flux of 1, 3, 10, and 20 times the present one which correponds to different epochs in the past. Moreover, the contribution of different chemical processes to the loss rates at different times is shown and the evolution of the martian CO2 atmosphere is discussed.

1. Introduction

The escape of hot oxygen and carbon from the martian atmosphere for 1, 3, 10, and 20 times the present solar EUV, corresponding to different epochs in Mars' evolution, is studied. Based on simulated 1D profiles for neutrals and ions of the upper atmosphere for the various EUV fluxes [2], the stochastic motion of hot O and C produced via different chemical reactions is calculated by means of a 3D Monte Carlo modell [1]. From the obtained energy distribution of the suprathermal particles at the exobase, the escape rates of O and C corresponding to the different EUV fluxes can be estimated.

2. Results

We discuss different sources of hot oxygen and carbon atoms in the martian thermosphere and their changing importance with the EUV flux. The increase of the production rates due to higher densities resulting from the higher EUV flux competes against the expansion of the thermosphere and corresponding increase in collisions. We find that the escape due to photodissociation continuousely increases with increasing EUV level, while other processes show a different behaviour. E.g., the escape of particles due to dissociative recombination of O2+ reaches a maximum at the ~ 10 EUV level and starts to decrease again for higher values (Fig. 1).

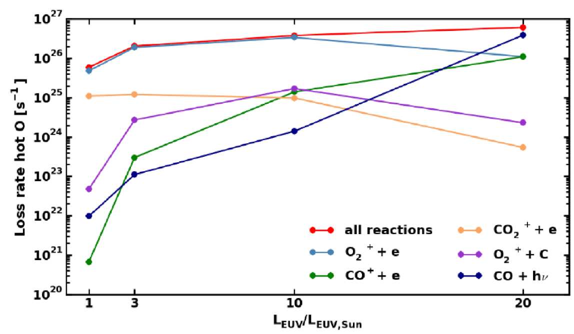

Figure 1: Loss rates of hot O as a function of EUV flux normalized to the present solar EUV flux for various production processes.

Depending on the initial rotation rate of the Sun and its rotational evolution, the different EUV fluxes can be related to different times in the past of the martian history by comparing a sample of solar like stars of different age and rotation rate [3]. If we assume that the Sun has been a slow rotator in the past, our findings show that Mars could not have had a dense atmosphere at the end of the Noachian epoch, since such an atmosphere would not have been able to escape until today. In the pre-Noachian era, most of a magma ocean and volcanic activity related outgassed CO2 atmosphere could have been lost thermally until the Noachian epoch, when non-thermal loss processes such as suprathermal atom escape became dominant. Assuming a 2:1 relation for lost hot O to lost hot C, our results suggest that not more than an equivalent of some hundred millibar of CO2 could have been removed since the Noachian epoch by suprathermal atom escape.

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References

[1] Gröller, H., V. I. Shematovich, H. I. M. Lichtenegger, H. Lammer, M. Pfleger, Y. N. Kulikov, W. Macher, U. V. Amerstorfer, and H. K. Biernat (2010), Venus' atomic hot oxygen environment, *J. Geophys. Res.*, *115*, E12017, doi:10.1029/2010JE003697.

[2] Tian, F., J. F. Kasting, and S. C. Solomon (2009), Thermal escape of carbon from the early Martian atmosphere, *Geophys. Res. Lett.*, *36*, L02205, :doi10.1029/2008GL036513.

[3] Tu, L., C. P. Johnstone, M. Güdel, and H. Lammer (2015), The extreme ultraviolet and X-ray Sun in Time: High-energy evolutionary tracks of a solar-like star, *Astron. Astrophys.*, *577*, L3, doi:10.1051/0004-6361/201526146.