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Hydrogen Coronae around Mars and Venus

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Abstract

We present Monte-Carlo simulatios of the hydrogen corona around Mars and Venus for various possible photochemical sources of hot (energetic) hydrogen atoms. The aim of this study is to investigate those possible sources which may significantly contribute to the hydrogen corona and to compare the obtained densities with observations. The model includes the initial energy distribution of hot atoms, elastic, inelastic, and quenching collisions between the suprathermal atoms and the ambient cooler neutral atmosphere, and uses energy dependent total and differential cross sections for the determination of the collision probability and the scattering angles.

1. Monte-Carlo Modell

The simulations are based – if available – on the most recent data for both the atmospheric input and the collision cross sections. The model is limited by various circumstances: (a) the background atmosphere is represented by 1D ion and neutral density profiles, (b) the hot particles are treated as test particles, i.e. their influence on the background gas is neglected, (c) due to the lack of data, some types of collisions are simulated by using approximate values of the parameters.

The simulation of the hot particle corona is initiated by calculating for a specific reaction the corresponding velocity distribution of the products at discrete altitudes. The motion of these products through the thermosphere up to the exobase and beyond is followed by means of a Monte-Carlo model. On their way the hot particles can interact with the background neutral atmosphere via elastic, inelastic and quenching collisions and will loose on average part of their initial energy. For those particles which cross the exobase, the energy distribution function is determined which in turn serves as input for the exosphere density calculations. A more detailed description of the Monte-Carlo model can be found in [4], [2], and [3].

2. Hydrogen Simulation

Possible sources of hot hydrogen atoms due to dissociative and radiative recombination, photodissociation as well as charge exchange and chemical reactions are included in the model and listed in Table 1. In the course of this study other reactions may be considered. An additional task is to find proper cross sections for specific collisions. Currently only proper total and differential cross sections for H-H and O-H collisons, published by [6] and [7], respectively, are used in our model.

Table 1: Possible sources of hot hydrogen atoms due to dissociative and radiative recombination, photodissociation as well as chemical reactions.

Reactions
Dissociative recombination
$H_2^+ + e \longrightarrow H + H$
$OH^+ + e \longrightarrow H + O$
$HCO^+ + e \longrightarrow H + CO$
Radiative recombination
$H^+ + e \longrightarrow H + h\nu$
Photodissociation
$H_2 + h\nu \longrightarrow H + H$
Chemical reaction
$H_2 + O^+ \longrightarrow H + OH^+$
$H_2 + CO^+ \longrightarrow H + HCO^+$
$H_2^+ + O \longrightarrow H + OH^+$
$H_2^+ + CO \longrightarrow H + HCO^+$
$H_2 + CO_2^+ \longrightarrow H + HCO_2^+$
Charge transfer
$H^+ + O \longrightarrow H + O^+$
$H^+ + CO_2 \longrightarrow H + CO_2^+$

3. Results

Preliminary results of the hydrogen corona simulations at Venus are shown below for the reactions listed in Table 1. The obtained production rates for high and low solar activity are shown in Figure 1. The prelim-

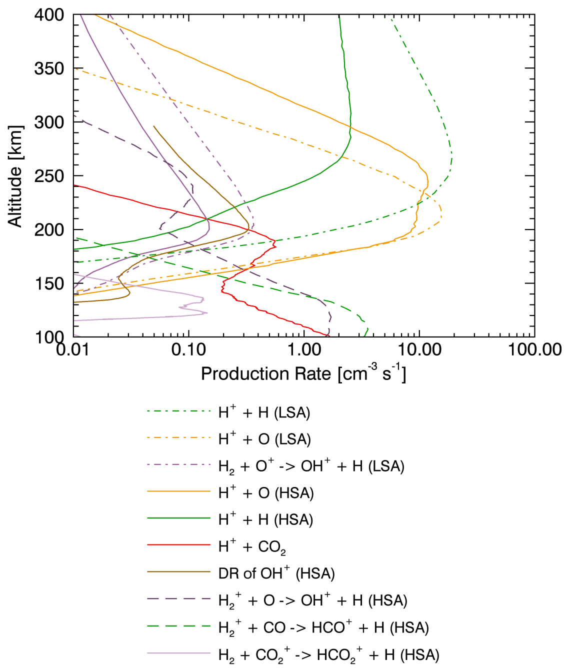

Figure 1: Production rates at Venus for high (solid lines) and low (dashed-dotted lines) solar activity of the reactions listed in Table 1.

inary number densities for high and low solar activity of reactions which show a significant contribution to the total density are illustrated in Figure 2. The black solid and dashed-dotted lines taken from [5] and [1], respectively, are in agreement with our preliminary results.

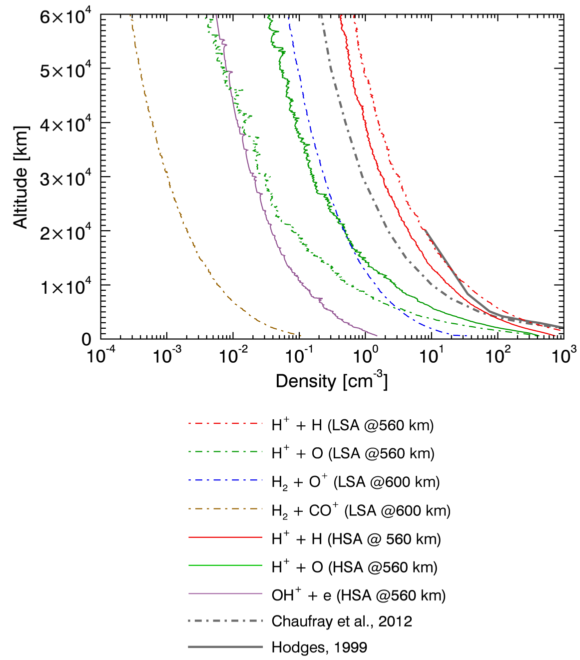

Figure 2: Calculated number densities at Venus for high (solid lines) and low (dashed-dotted lines) solar activity as well as the densities from [1] and [5].

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