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Thermospheric emissions of the early Earth

D. Bernard (1), M. Barthélémy (1), G. Gronoff (2), H. Ménager (1) and J. Lilensten (1)
(1) Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) (david.bernard@obs.ujf-grenoble.fr / Fax: +33 476514146) (2) NASA LaRC, Hampton Va, USA

Abstract

The aim of this work is to examine the thermospheric emission of the Earth over its history. In this first step, we adapt a kinetic transport code developed for different planets of the Solar System to the first atmosphere of the Earth. We take into account the possible changes in the solar emission spectrum to compute the diurnal ionizations, excitations and dissociations. We deduce a thermospheric spectrum averaged over the planet. The effect of solar wind electron precipitation is also considered.

1. Introduction

Within the search for exoplanets, the search for terrestrial type exoplanets has become an important topic. The main direct observable of an exoplanet is its atmospheric emission. The Thermospheric one is particularly important because it is often optically thin and therefore not reabsorbed in the upper atmosphere. Some bright emissions such as Lyman alpha are thick and request a radiative transfer. Most of these emissions are also in the UV range, distinct from the UV emission of the parent star, due to different emission sources.

In the other hand, the Earth experienced several types of atmosphere since it was created : from a primary Jovian-type atmosphere (H, H2, CH4) to the current state, its pressure and composition varied considerably.

Therefore, in order to determine whether an exoplanet thermospheric emission is the one of a terrestrial planet, it is necessary to take into account a large span of atmospheres.

2. The Early Earth atmosphere

In this first step of a larger work, we focus on the primary Earth atmosphere. This atmosphere was an inherited from the solar nebula. It was mainly composed of H and H2 [1]. There are little constraints for the modeling of this atmosphere. However, [1] suggest that the ground pressure was about 10 bars. As there is no model of this atmosphere, we rescaled a Jovian atmosphere model to the Earth conditions [2]. However, almost nothing is known about the temperature, which is therefore considered as a free parameter. The atmospheric density profiles are shown in figure 1.

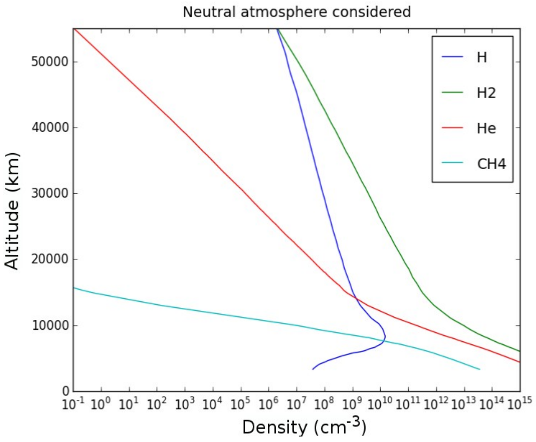

Figure 1 : Density profile of the atmosphere used

3. Method

We use a set of codes to compute the excitation and emission rates. The first one is a kinetic transport [3]. Its inputs are the solar EUV flux, the precipitated electrons, the atmospheric composition and the correlative cross sections. It solves a stationary Boltzmann equation and computes the electron stationary flux, the different ions states productions and excited neutrals. From these outputs, we compute the emission rates through spontaneous deactivation. Finally, we use a radiative transfer code [4] to compute the emission rate of Lyman alpha, which is optically thick.

In order to account for the solar emission, we use the prescription proposed by **Ribas et al.** [5] out of the Sun in Time program.

4. Results

In figure 2, we show the results of this approach for Jupiter as a test case [6]. We provide the emission rate of Lyman alpha photons, at low solar illuminance (F10.7 = 100, solar zenith angle of 70◦) and Maxwellian electron precipitation of 1 keV, 50 keV and 150 keV.

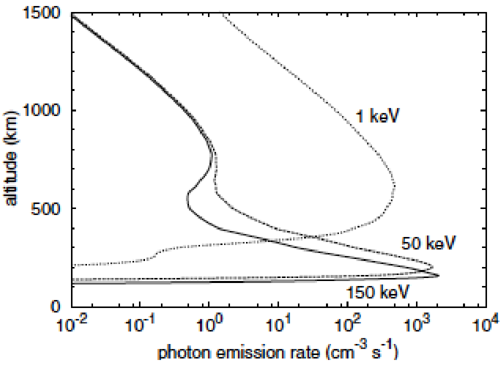

Figure 2 : Lyman alpha photon emission rate in the Jovian case. From [6].

In this poster, we will present the results of this modeling in the case of the Early Earth as described above.

References

[1] Sasaki, S. and Nakazawa, K. : Did a primary solar-type atmosphere exist around the proto-earth?, Icarus, Vol. 85, pp. 21-42, 1990.

[2] Grodent, D., Gerard, J.C. and Waite Jr, JH. : A self-consistent model of the Jovian auroral thermal structure, JGR, Vol. 106, pp. 12933-12952, 2001.

[3] Gronoff, G., Wedlund, C.S., Mertens, C.J. and Lillis, R.J. : Computing uncertainties in ionosphere-airglow models. I-Electron flux and species production uncertainties for Mars, JGR, Vol. 117,A04306, 2012.

[4] M. Barthélemy, C. Parkinson, J. Lilensten and R. Prangé : Modelling the Lyman β dayglow in the Jovian atmosphere. Astronomy and Astrophysics, Vol. 423, pp. 391–395, 2004.

[5] I. Ribas, E.F. Guinan, M. Güdel, and M. Audard. Evolution of the solar activity overtime and effects on planetary atmospheres. i. high-energy irradiances (1-1700 Å). The Astrophysical Journal, pp. 622-680, 2005.

[6] H. Menager, M. Barthélemy et J. Lilensten : H Lyman alpha line in Jovian aurorae : electron transport and radiative transfer coupled modelling. Astronomy and Astrophysics, 509:A56+, 2010.