Excitation of the LBH bands by proton precipitation

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1. Introduction

Our interest in the research of the LBH system is explained by a possibility to receive the information about atmospheric luminosity in the u.v. region by such satellites as DE and Viking. We extend the investigation of the LBH system developed in [1] for electron aurora to a proton case. Here we want to show our preliminary calculation results of the production rate and the photon yields for the LBH bands during proton precipitation.

2.Transport model

Calculations were carried out by the simplified transport algorithm described in [2] for three-component atmosphere. This algorithm is based on results of Monte-Carlo calculations and simple CSDA. Effects of both the reflection and the lateral spreading of the p-H flux have not been taken into account here. The numerical model of the luminosity of the Lyman-Birge-Hopfield bands presented in [1] and the atmospheric model MSIS-86 were used for the calculations. Cross sections for proton and H-atom collisions with the atmosphere gases were given by [3,4].

3.Excitation of the $a^1\Pi_g$ state

The excitation of the $a^1\Pi_g$ state may be caused in three ways: direct collisions with protons and atoms, collisions with secondary electrons and intersystem transitions. As Edgar et al. [5] we assume that all the hydrogen-induced excitation cross-sections are the three quarters of corresponding proton cross sections. Fig.1 presents the LBH production rates for various characterisic energies of the Maxwellian proton distribution. All incident fluxes contain 1 erg cm $^{-2}$ s^{-1}.

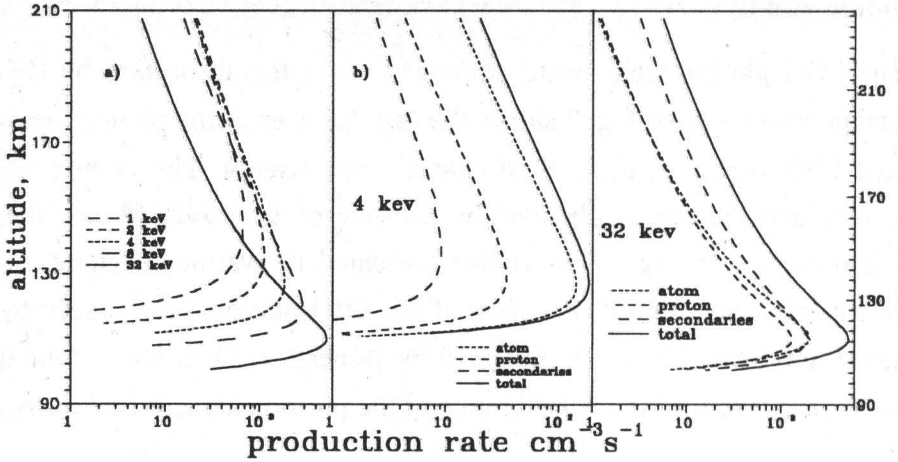

Fig.1.The LBH production rate.

An estimation of the secondary electron contribution into the excitation of the $a^1\Pi_g$ state was made. We used an analytic representation of the differential cross-section for proton and hydrogen ionisation given by [6]. Then the population of the "i" electronic state caused by the secondary electrons may be obtained from the expression :

$$I_s^i = \int_0^{T_{max}} \frac{n_p(E_p, T)T}{\zeta_i(T)} dT$$

where T is a secondary electron energy, ζ_i is energy cost of "i" electronic state. For the secondary electrons which have small energy, the energy cost depends on the electron energy. The dependence is satisfactory described by :

$$\zeta_i = \frac{\varepsilon_i T}{T - W_i}$$

where W_i is the threshold energy of the "i" state, ε_i is the asymptotic value of energy cost for electron energy >300 eV (see [7]). The production rates for various excitation ways are shown in Fig. 1 for two Maxwellian characteristic energies. It can be seen, the secondary electron contribution into the $a^1\Pi_g$ state excitation for small characteristic energy is weak, but for the energy >30 keV the secondary electrons are the main contributors in the LBH excitation.

4.Photon yield.

The LBH photon yields were computed when the absorption by O_2 had been taken into account. Fig. 2 shows the dependences of the photon yields for selected LBH bands on the proton characteristic energy. The comparison of our results and the results obtained by Jasperse et al. (1992) [8] for the 4-0 band is presented in Fig.3. The results presented for various excitation ways satisfactorily agree with the exception of the LBH photon yield caused by the secondary electrons. This yield obtained by Jasperse et al. is about four times greater than our result for 1-8 keV range of the proton characteristic energy.

5.Intensity ratio

Fig. 5 illustrates the I_{LBH}(1838Å)/ $_{LBH}$(1464Å) ratio for two LBH bands with different degrees of O_2 absorption in proton aurora. The LBH 1464Å band has a maximum of the absorption cross section, while the LBH 1838Å band is not absorbed by O_2. The intensity ratio weakly depends on the characteristic energy of proton, while for electron case this dependence is stronger (see Fig.4). The value of the ratio for a proton case begins to increase when the secondary electrons are the main contributors in the excitation of the $a^1\Pi_g$ state.

The dependences of the I_{1NG}(3914Å)/I_{LBH}, $I_{H\beta}/I_{LBH}$. on the proton characteristic energy are present in Fig. 5. It is seen that the dependences of the $I_{H\beta}/I_{LBH}$ ratio are strong. The ratio of the intensities of the 1NG 3914Å and the LBH 2025Å band which has no O_2 absorption is weakly sensitive to variations of the characteristic energy. But for the LBH 1383A band for which the O_2 absorption cross section is close to a maximum, the ratio I_{1NG}/I_{LBH} varies by factor of about 4 within 1-65 keV range of the proton energy.

6.Results

The result of our report may be summarized as follows.

H-atoms include main contribution into the LBH excitation for 1-10 keV region of proton characteristic energy. The contribution of the secondary

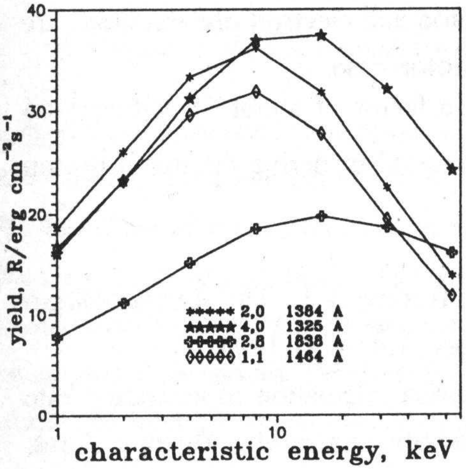

Fig.2. Dependences of the photon yields for selected LBH bands on the proton characteristic energy

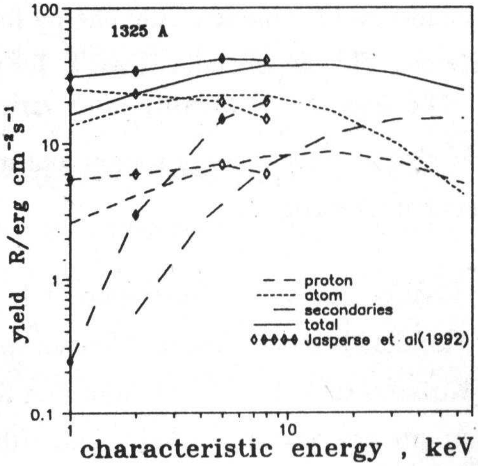

Fig.3. Photon yield of 4–0 LBH band. Comparison of our results and results obtained by Jasperse et al. (1992) [8]

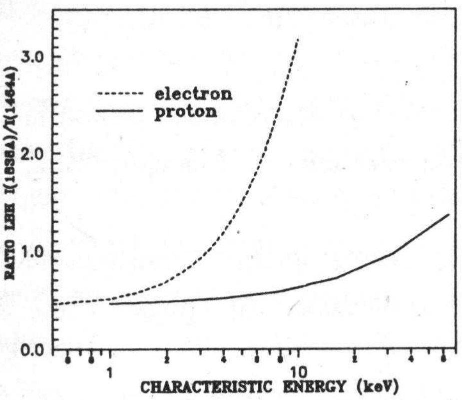

Fig.4. The intensity ratio of two LBH bands.

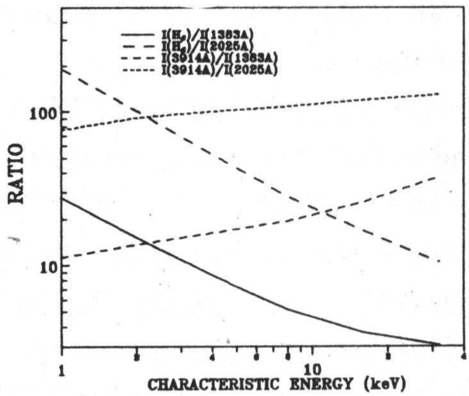

Fig. 5. Dependences of the intensity rations on the proton characteristic energy

electrons into the LBH excitation rapidly increases with the increase of the proton energy and becomes principal at proton energy > 20 keV.

The shapes of the dependences of the $I_{LBH}(1838Å)/I_{LBH}(1464Å)$ intensity ratio on the characteristic energy for proton and electron precipitations are different. This dependence is weak for the proton case.

The $I_{H\beta}/I_{LBH}$ intensity ratio varies by a factor of about 10 within 1-64 keV characteristic energy region and may be used to derive the initial proton flux characteristic.

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