Calculation of H_β emission in aurora. Comparison with observation.

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Abstract. H_β emission in aurora is calculated by simplified model based on results of precise Monte-Carlo simulation of proton-hydrogen atom (p-H) transport in the atmosphere. Comparisons with rocket measurements [1] and with simultaneous satellite and groundbased observations [2] were made. It was found that both altitude profile of emission rate and spatial distribution of column emission rate observed from the ground agree well with values calculated by measured downgoing proton flux.

1. Introduction

It is well known, the hydrogen emission in the aurora is a sign of proton precipitation. A large number of experimental and theoretical papers have been published on investigation of this emissions. The complexity and insufficient study of interaction processes of particles with the atmosphere and the real composition of the Earth's atmosphere made the authors use various simplifying suppositions in these theoretical models. Therefore these early theoretical investigations had a large discrepancies.

Improvements of collisional cross sections and the atmosphere model that were made during last decade allowed to construct a precise Monte-Carlo transport model for p-H fluxes [3,4]. By this model the precision of different approaches that usually used for p-H transport problem was estimated. The simplified numerical algorithm based on this estimations was presented by [5].

In this paper we try to reconstruct theoretically the conditions of two experiments: (1) rocket measurements [1] and (2) simultaneous satellite and groundbased observations [2].

2. Rocket measurements [1]

The completed description of rocket-borne and groundbased equipment was presented in [1]. Here we only dwell on our viewpoint on the results.

We believed that reconstruction of proton differential energy spectrum made in [1] is not correct, because the low-energetic flux of charge particles was mainly the flux of electrons, but not protons. Therefore the proton differential energy spectrum in the range 2-200 keV may be approximated by Maxwellian distributions with parameters Q=1 erg/cm^{2}s, E_0 = 20 keV. This shape of energy spectrum agrees with typical parameters of proton precipitations presented by [6].

An additional reason of this our viewpoint is a measured ratio between N_2^+ (4278Å) and the H_β emissions. The ratio obtained by groundbased observations remained approximately about 8. According to [7] and our calculations, the ratio increases with the increasing of average proton energy, but ever for average energy 40 keV the ratio is about 2.5. So as intensity of the H_β observed was about 170 R, only about 425 R of N_2^+(4278Å) emission may be result of proton precipitation. Thus additional 1000 R of N_2^+(4278Å) emission must be result of electron incoming. The energy flux about 3 erg/cm^{2}s for electrons in range 0.5-10 keV is sufficient for excitation of this N_2^+(4278Å) intensity.

For calculation of altitude profile of the H_β emission rate we used simplified transport algorithm presented by [5]. As we have information about proton flux at altitude 220 km, we neglect a reflection of protons by magnetic field and a lateral spreading of the p-H flux. The excitation of H_β has been calculated by the cross sections presented by [8]. The measured intensity of protons in the energy range 24-37 keV as a function of altitude have been used to obtain of the local atmosphere density profile. Two forms of the initial proton differential energy spectrum have been used: step function according to rocket data and Maxwellian distribution with parameters Q=1 erg/cm^{2}s, E_0 = 20 keV. Fig.1 presents the comparison of calculated intensities of protons in several energy ranges with measured ones.

Calculated H_β intensity as a function of rocket altitude is shown on Fig.2. One can see that an altitude of maximum emission and a value of maximum emission rate agree well with measured values if we use the Maxwellian distribution. Measured emission rates (more than calculated one) at the altitudes >130 km may be explained by low-energy (<1 keV) tail in the initial proton flux. But the use of the proton differential energy spectrum presented by [1] lead to large overestimation of values of H_β emission rate.

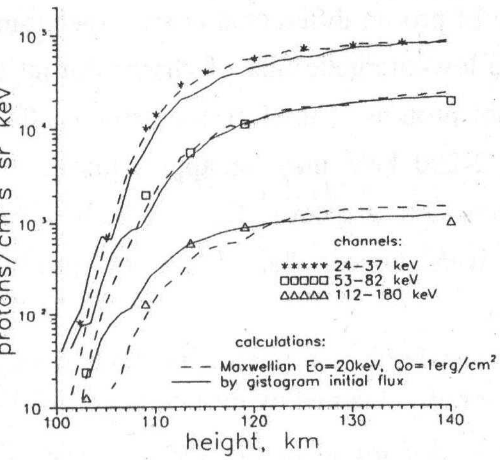

Fig.1. Comparison between measured and calculated proton differential intensities for three energetic channels.

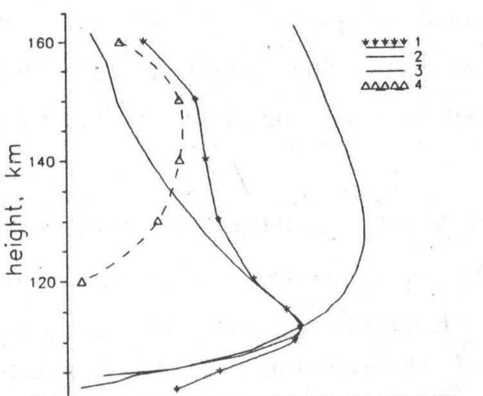

Fig.2. Comparison between measured (1) and calculated (2) volume H_β emission rates. Curve (3) has been calculated by initial differential energy spectrum in proton flux given by [1]. Curve (4) is an emission excited by low-energetic tail in proton energy spectrum.

3. Observations [2]

The data concerned the proton aurora observed on July 27, 1984 was presented by [2, 9]. Number and energy fluxes of precipitating electrons and protons observed by the DMSP F6 satellite we used as a parameters for the Maxwellian distribution in proton flux. The H_β intensity in column along satellite trajectory has been calculated by simplified algorithm presented by [5]. The MSIS-86 atmosphere model has been used.

Fig.3 (bottom panel) shows the calculated H_β intensities and measured ones. The background

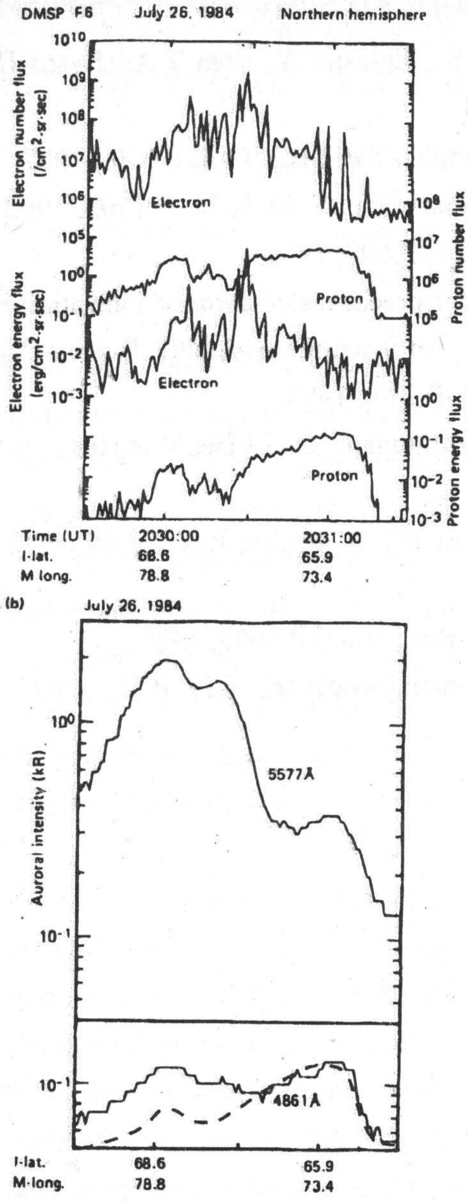

Fig.3. Number and energy flux of precipitating electrons and protons observed by the DMSP F6 satellite (a), and 5577Å and 4861Å auroral intensities along the satellite conjugate trajectory (b). Dashed line on the bottom panel has been calculated by observed characteristics of proton precipitation.

continuum emission 55 R has been added to calculated results. One can see that calculated values agree well with observation for latitudes 64^{o}-67^{o} where protons was the most part of precipitation particles. Unfortunately, the bandwidth for H_β observation was very large (70Å) [9] and the H_β emission was blended by other emissions in case of combined electron-proton precipitations. This is an explanation of smaller calculated values of H_β emission in comparison with observed at the latitudes 67^{o}-69^{o}

4. Conclusion

The H_β emission in aurora is calculated by the simplified model based on results of precise Monte-Carlo simulation of the proton-H atom transport in the atmosphere. Comparisons with rocket measurements [1] and with simultaneous satellite and groundbased observations [2] were made. It was found that both the altitude profile of emission rate and spatial distribution of the column emission rate observed from the ground agree well with values calculated by measured downgoing proton fluxes.

References

1. Söraas F., Lindalen H.R., Maseide K., Egeland A., Sten T.A., Evans D.S. J.Geophys.Res., V.79, P.1851, 1974
2. Ono T., Hirasawa T., Meng C.I., Geophys.Res.Let., V.14, P.660., 1987.
3. Kozelov B.V., Ivanov V.E., Planet.Space Sci., V.40, N.11, P.1503, 1992.
4. Kozelov B.V., Ann.Geophysicae, V.11, P.697, 1993.
5. Kozelov B.V. Simplified algorithm for precise calculation of ionization rate in proton aurora. Abstract. IAGA'93, 7th Scientific Assembly, Buenos Aires, Argentina, IAGA Bulletin 55, Part B, P.234., 1993.
6. Hardy D.A.,Gussenhoven M.S., Brautigam D., J.Geophys.Res., V.94, P.370, 1989.
7. Van Zyl B., Gealy M.W., Neumann H., J.Geophys.Res., V.89, P.1701, 1984.
8. Van Zyl B., Neumann H., J.Geophys.Res., V.85, P.6006, 1980.
9. Ono T., Ejiri M., Hirasawa T., J.Geomag.Geoelectr., V.39, P.65, 1987.