EPSC Abstracts
Vol. 6, EPSC-DPS2011-372-1, 2011
EPSC-DPS Joint Meeting 2011

Near-IR Auroral Processes in the Polar Regions of Jupiter

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Abstract

Recently, 3 micron auroral emission lines of CH_4, C_2H_2, and C_2H_6 from the south polar auroral region of Jupiter were detected [1]. In order to understand the auroral processes producing these emissions, we constructed an electron precipitation model for the auroral atmosphere including H_2, He, H, and the hydrocarbon molecules. We present preliminary results for the mixing ratios of these molecules in the stratosphere, which are consistent with the observed auroral emission intensities.

1. Electron Precipitation Model

We used a particle precipitation program previously developed [2]. This non-relativistic electron energy deposition program apportions the incoming electron energy in various excitations, ionizations, and dissociations of major constituents, H_2, He, and H, which account for the bulk of the energy loss of the precipitating electrons.

The original program calculated the vibrational excitation of H_2 and CH_4. For this work we updated the electron collision cross sections of vibrational states of CH_4 and temperature-pressure profiles, and added electron collision cross sections for the 3 micron bands of C_2H_2 and C_2H_6. The excitation rates for the various vibrational states are balanced by de-excitation processes, such as auroral radiation and collisional relaxation. For the latter we inserted into the program the vibrational deexcitation rates for C_2H_2 and C_2H_6 by collisions with H_2. We have compared our preliminary results to two widely differing theoretical vertical mixing ratio curves [3,4] for C_2H_2 and C_2H_6 available in literature.

2. Preliminary Results

The preliminary results of our calculations are notably closer to the predicted C_2H_2 and C_2H_6 mixing ratios [4] of 5×10^{-6} and 2×10^{-5}, respectively, near 10^{-5} bar than those [3] of 10^{-4} and 4×10^{-6}. Although the above excitation and deexcitation rates are somewhat uncertain and could significantly affect the band strengths, our results suggest that C_2H_6 is more abundant than C_2H_2 near 10^{-5} bar. We also find that the kinetic energies of auroral electrons which are capable of penetrating the hydrocarbon layers and causing the hydrocarbon line emission seem to be in the range of 30 - 100 KeV. On the other hand, most of the auroral electrons that cause the higher altitude H_3^+ and H_2 line emission seem to have energies less than 30 KeV.

Since the spectroscopic detection of H_3^+ on Jupiter two decades ago, there have been many detailed investigations of the morphology and excitation processes of that molecular ion. Similarly, additional observations and investigations for the CH_4, C_2H_2, and C_2H_6 emission are now needed to reach a clearer understanding of the Jovian hydrocarbon aurora.

Acknowledgements

S.J.K. acknowledges partial supports from the Korea Science and Engineering Foundation (R01-2008-000-20002-0) and a WCU Grant (No. R31-10016).

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