1977

The Nitrogen Dayglow on Mars

Jane L. Fox
Wright State University - Main Campus, jane.fox@wright.edu

Alexander Dalgarno

E. R. Constantinides

G. A. Victor

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INTRODUCTION

With the assumption that an emission feature with an overhead intensity of 50 R would not have gone unrecognized in the Mariner 9 observations of the Martian dayglow [Barth et al., 1969, 1972], Dalgaro and McElroy [1970] concluded from the absence of any features that could be attributed to molecular nitrogen that the fractional abundance by volume of molecular nitrogen in the Martian atmosphere does not exceed 0.05. The Viking 1 data indicate a fractional abundance between 0.02 and 0.03 at the surface [Owen and Beimann, 1976] and of 0.06 at an altitude of 140 km [Nier et al., 1976]. We have carried out a more comprehensive study of the expected dayglow emission spectrum which incorporates the growth in our knowledge of the excitation processes for both nitrogen and the major constituent carbon dioxide.

CALCULATIONS

We constructed a model atmosphere of Mars that approximately reproduces the Viking data. The model atmosphere has a surface pressure of 7.3 mbar [Nier et al., 1976] and a temperature that increases from 130°K at an altitude of 100 km through 180°K near 135 km toward an exospheric temperature of about 315°K. The turbopause is taken to be at 111 km and the temperature increases from 315°K at an altitude of 100 km to 345°K at 140 km. A high-resolution spectrum of the Mars dayglow should provide a ready confirmation of the results of the Viking 1 neutral mass spectrometer experiment [Nier et al., 1976] that sampled the composition of the Martian upper atmosphere.

The initial energy distribution of the photoelectrons produced by the absorption of solar radiation at a zenith angle of 45° was calculated with the Atmosphere Explorer solar flux values [Hintergger, 1976] and photoabsorption cross sections compiled from the laboratory measurements of Nakata et al. [1965] and Samson and Gardner [1973]. A detailed accounting of the energy degradation was made following the discrete energy loss procedures of Dalgaro and Lejeune [1971], Crawfens et al. [1975], Victor et al. [1976], and Fox et al. [1976], and the emission spectrum resulting from electron impact excitation has been computed by using absorption and emission Franck-Condon factors and transition probabilities [Benesch et al., 1966a, b; Cartwright, 1970; Covey et al., 1973; Vallance Jones, 1974]. Cascading effects were included by procedures similar to those described by Cartwright et al. [1971].

The predicted zenith intensities of the Vegard-Kaplan, the second positive, and the Lyman-Birge-Hopfield band systems are presented in Table 1. The 1-9 band of the Vegard-Kaplan system has a predicted intensity of 16 R. It lies near 3200 Å between the 2-0 and 3-0 bands of the A'II-X'II system of CO₂⁺. There is no sign of it nor of any other N₂ emissions in the Mariner 9 spectrum of Barth et al. [1969, 1972]. Our calculations suggest that the N₂ dayglow emission features must be close to the limits of detectability if the Viking 1 data are correct in showing a 6% fractional abundance of N₂ at 140 km. A high-resolution spectrum of the Mars dayglow should provide a ready confirmation of the results of the Viking 1 neutral mass spectrometer experiment [Nier et al., 1976] that sampled the composition of the Martian upper atmosphere.

Acknowledgments. One of us (J.L.F.) is a National Science Foundation predoctoral fellow in the Department of Chemistry, Harvard University. This work was supported in part by the Atmosphere Sciences Section of the National Science Foundation.

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(Received November 11, 1976; accepted December 13, 1976.)