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The Nitrogen Dayglow on Mars

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The ultraviolet dayglow spectrum arising from emission of N_2 in the Mars atmosphere is predicted. The intensities are such that a high-resolution spectrum should readily reveal the presence of N_2 at the abundances suggested by the Viking experiments.

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], *Dalgarno 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 with a fractional abundance of nitrogen of 0.025. Diffusive separation then leads to the observed fractional abundance of 0.06 at 135 km. The assumption of diffusive equilibrium is probably inappropriate, but the peak of the N_2 emissions occurs near 140 km and the calculated column intensities are insensitive to the assumed density and temperature profile in the region outside the altitude range studied by Nier et al.

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 [*Hinteregger*, 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 *Dalgarno and Lejeune* [1971], *Cravens et al.* [1975], *Victor et al.* [1976], and *Fox et al.* [1976], and the emission spectrum resulting from electron impact excitation of N_2 was then computed by using absorption and emission Franck-Condon factors and transition probabilities [*Benesch et al.*, 1966*a*, *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 $A^2\Pi$–$X^2\Pi$ system of CO_2^+. There is no sign of it nor of any other N_2 emissions in the Mariner 9 spectrum of *Barth et al.* [1969, 1972]. Our calculations suggest that the N_2 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 N_2 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.

TABLE 1. Calculated Overhead Intensities of N_2 Emission Features in the Mars Ultraviolet Dayglow Spectrum

Band v'-v''	Band Origin, Å	Intensity, R	Band v'-v''	Band Origin, Å	Intensity, R
		Vegard-Kaplan $A^3\Sigma_u^+ \rightarrow X^1\Sigma_g^+$			
0-4	2462	8	0-5	2604	14
0-6	2762	18	0-7	2936	17
0-8	3132	13	0-9	3353	7
1-8	2998	11	1-9	3199	16
1-10	3426	15	1-11	3684	10
2-11	3502	10	2-12	3760	11
2-13	4072	8	3-13	3856	7
3-14	4170	7			
		Second Positive $C^3\Pi_u \rightarrow B^3\Pi_g$			
0-0	3370	10	0-1	3576	7
1-0	3158	5	0-2	3804	3
1-2	3536	2	1-3	3754	2
2-1	3135	2			
		Lyman-Birge-Hopfield $a^1\Pi_g \rightarrow X^1\Sigma_g^+$			
3-0	1354	5	2-0	1384	4
4-0	1325	4	1-1	1464	3
0-2	1555	3	5-0	1299	2

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