Indian J. Met. Geophys. (1972), 23, 3, 393-394

527.7 : 523.43 : 551.510.42 : 546.

Day time emission of CO third positive bands in martian atmosphere

S. K. GUPTA, A. N. SRIVASTAVA & R. V. SHUKLA* and R. D. SRIVASTAVA†

University of Allahabad, Allahabad

(*Received 1 November 1971*)

ABSTRACT. The excitation of (0, 2) band of CO third positive system in the dayglow of martian atmosphere is considered. It is found that the intensity of this band should be several kilorayleighs, the major contribution coming from 115-145 km region of the atmosphere of mars. Simple calculations show that the intensity of the band is too small to be observed from the surface of the earth, but becomes observable at a distance less than 4000 km from mars.

1. Introduction

Recent spectroscopic investigations and radio occultation measurements by Mariner IV on planet mars reveal that CO_2 molecules are main constituent of its atmosphere (Kaplan *et al.* 1964; Belton and Hunten 1966; Spinard *et al.* 1966 Kilore *et al.* 1965). It is expected that solar ultraviolet rays falling upon the martian atmosphere should excite, dissociate and ionise CO_2 molecules and its products (CO, CO_2^+, O etc). The spectral features in the martian dayglow should, therefore, be composed of CO, CO_2^+, O etc Jain. (1970) had dealt with the daytime photochemistry of O atoms in the martian atmosphere and predicted the presence of 5577A and 6300A lines of atomic oxygen. The presence of CO fourth positive bands in the ionosphere of mars has also been reported (Gupta 1970). Its excitation is attributed due to the following reaction —

$$CO_2^+ + e \rightarrow CO^* + O \tag{1}$$

These bands may also be excited in the martian dayglow. Due to lack of data on collisional deactivation by atmospheric constituents of mars, it is not possible to estimate theoretically the intensity of these bands. Recently, Gupta (1970) has determined experimentally the value of quenching coefficient for (O, 2) band of CO third positive system by CO_2 molecules. It is interesting to examine the possibility of excitation of CO third positive bands in the dayglow of martian atmosphere.

2. Production of CO ($b^3\Sigma$) molecules

Since $CO(b^3\Sigma)$ molecule is loaded with an energy of 10·4 eV (Herzberg 1950), ultraviolet radiation lying in the range 780—790 A will be required to dissociate CO molecules in the following manner —

$$CO_2\,(X^1\ \Sigma_g{}^+) + h_\nu \overset{J}{\rightarrow} CO\,(b\,{}^3\Sigma) + O(^3P), \tag{2}$$

where, J is the probability of dissociation of the CO_2 molecules and is given by —

$$J = \gamma\ \Sigma\nu\ n(h\nu)_\infty\ K\nu_z\ K\nu \tag{3}$$

In the above expression, $n(h\nu)_\infty$, $K\nu_z$ and $K\nu$ stand respectively for photon flux at the top of the martian atmosphere, transmission coefficient at an altitude z and the absorption coefficient for the frequency ν. γ is the ratio of dissociated molecule to absorbed quanta. In the absence of precise information, its value has been taken to be unity. The summation is to be carried over the wavelength region which is responsible for the dissociation of CO_2 molecules.

The transmission coefficient can be calculated from the relation—

$$K\nu_z = \exp\left[\,-N_z\,K\nu\,\right], \tag{4}$$

where N_z is the column density of CO_2 at an altitude z in the martian atmosphere.

Using the number density of CO_2 given by F_1 model of the martian atmosphere and value of $K\nu$ reported by Sun and Weissler (1955) for the range 780-790 A, $K\nu_z$ in the altitude range 110-210 km has been obtained.

For the calculation of J in Eq. (3), photon flux on the top of the martian atmosphere is estimated by multiplying the dilution factor†† with the photon flux data for the earth's atmosphere given by Hinteregger *et al.* (1965). Substituting

*J.K. Institute of Applied Physics and Technology, †Departent of Physics.

††The dilution factor is about 0·431 and is obtained by using inverse square law for intensities of light,

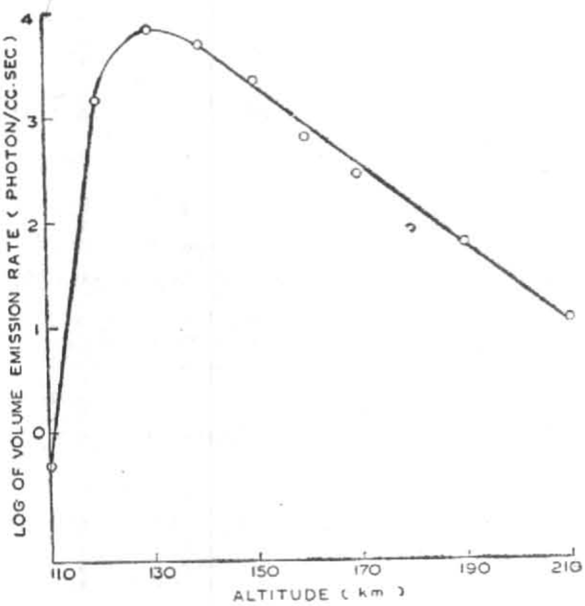

Fig. 1

Variations of volume emission rate of (0,2) band of CO third positive system with altitude in the day time martian atmosphere

the values of photon flux, transmission coefficient and absorption coefficient in Eq. (3), J is calculated. The rate of production of $CO(b^3\Sigma)$ molecules at different altitudes of martian atmosphere during daytime has been computed by multiplying J with the particle density of CO_2.

3. Loss of CO (b^3 Σ) molecules

$CO(b^3\Sigma)$ molecules produced in martian atmosphere may be lost through radiative transitions—

$$CO(b^3\Sigma) \overset{A}{\rightarrow} CO' + h\nu \quad (5)$$

where, A is the probability of transition ($b^3\Sigma$—$a^{3\pi}$) and $h\nu$ is the emitted radiation. In addition, these molecules may also suffer collisional deactivation through the reaction—

$$CO\ (b^3\ \Sigma) + M \overset{K}{\rightarrow} CO' + M' \quad (6)$$

where, K is the quenching coefficient and M, the quenching agent which may be taken to be CO_2 molecules. As other gas species like H_2O, O_2, O etc present in martian atmosphere are in traces, their quenching effect will be negligibly small.

4. Volume emission rate of (0,2) band of CO third positive system

Equating the production and loss rates of CO ($b^3\Sigma$) molecules at equilibrium, the volume emission rate of CO third positive (0.2) band is given by—

$$I = \frac{R_o}{1 + \frac{K}{A}[CO_2]} \quad (7)$$

where, R_o is the rate of production of CO ($b^3\Sigma$) molecules. From Section 1, one finds that the value of K/A for the (0, 2) band of CO third positive system is available (Gupta 1970). Out of all the bands in the above system, the volume emission rate of only (0, 2) can be computed here.

In the martian atmosphere, from where (0, 2) band is emitted, CO_2 concentration is less than 10^{12} cm^{-3}. The value of K/A for this band as reported by Gupta (1970) is of the order 10^{-16} cm^3/sec molecule. Taking these values, one can see that the quenching is ineffective in the region where this band is emitted. Hence, the volume emission rate becomes equal to the rate of production of CO ($b^3\Sigma$) molecules (Eq. 7). The variation of the volume emission rate with the altitude in the atmosphere of mars is shown in Fig. 1. From the figure, it is obvious that the major contribution in the intensity of this band comes from the altitude range 115-150 km and that the maximum emission is around 130 km.

A simple estimation will show that the dayglow intensity of the (0, 2) band of the third positive system in the martian atmosphere is about 17 kR. Even this intensity is too small to be detected on the surface of earth. However, it could be observed at a distance less than 4000 km from the surface of mars.

REFERENCES

Belton, M. J. S. and Hunten, D. M. 1966 *Astrophys. J.*, **145**, p. 454.
Gupta, S. K. 1970 D. Phil. Thesis, Univ. Allahabad,
Jain, S. K. 1970 D. Phil. Thesis, Univ. Allahabad,
Herzberg, H. 1950 Molecular Spectra and Molecular Structure, D. Van Nostrand Inc., New York.
Hinteregger, H.E., *et al.* 1965 *Space Res.*, **5**, p. 1175.
Kaplan, L.D. *et al.* 1964 *Astrophys. J.*, **139**, p. 1.
Kilore, A. *et al.* 1965 *Science*, **149**. p. 1243.
Spinard, H. *et al.* 1966 *Astrophys. J.*, **146**, p. 331.
Sun, H. and Weissler, G. L. 1955 *J. Chem. Phys.*, **23**, p. 1627.