

## INFRARED OBSERVATION OF NON THERMAL EMISSIONS FROM SPACELAB

G. Moreels\* and C. Muller\*\*

\* Service d'Aéronomie du C.N.R.S. (France)

\*\* Institut d'Aéronomie Spatiale de Belgique.

Observations of the emissions of atmospheric ozone and nitric acid in the 10  $\mu\text{m}$  window have already been used for the monitoring of these constituents in the stratosphere. We propose to generalise these methods to the emissions of mesospheric constituents using non thermal emissions. Thermal emission  $E(\nu)$  can be expressed by the formula :

$$E(\nu) = A(\nu).B(\nu)$$

where  $A(\nu)$  is the absorption of the emitting gas and  $B(\nu)$  is the blackbody emission at frequency  $\nu$ .

We shall not consider the cases where self-absorption occurs and shall limit ourselves to the so-called optically thin approximation, taking into account the fact that we have to consider long optical paths, the previous expression could be rewritten

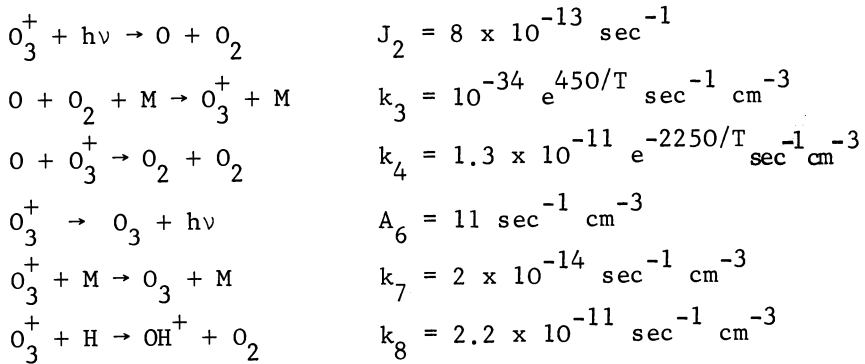
$$E(\nu) = \int_0^{\infty} A(\nu,s) B(\nu,s) ds$$

for an optical path  $s$  divided into differential segments  $ds$ . Infinity occurs when no more emission features can be detected ; for thermal emission, this limit is rather rapidly attained. In fact, the absorption spectrum  $A(\nu,s)$ , for zenithal paths, can be considered as nearly flat above 50 km with the exception of the 15  $\mu\text{m}$   $\text{CO}_2$  bands used for temperature soundings. If limb scanning is used in the stratosphere, the advantage of altitude resolution, still given by absorption

spectrometry, is lost because a large optical field is needed in order to have a detectable signal with light instrumentation.

Mesospheric non thermal emissions may, on the contrary, be observed with rather high precision as has been proved by the auroral observations of Stair et al. (1975). The process is always the same, a molecule is brought in an excited state and desexcites itself in one of its vibration modes. These emissions have no relation with the blackbody temperature emission of the unexcited gas. We shall not consider the purely rotational transitions which could be also observed from much higher altitudes (Simpson, 1976).

We propose to limit ourselves to the near infrared (1-15  $\mu\text{m}$ ) because of the availability of simple existing instrumentation (Ackerman et al., 1976). We shall discuss especially the emissions of excited ozone. The chemistry of excited ozone is governed by the equations compiled by Moreels (1975) :



This system leads to a photochemical equilibrium value of

$$n(\text{O}_3^+) = \frac{k_3 n(\text{O}) n(\text{O}_2) n(\text{M})}{A_6 + J_2 + k_4 n(\text{O}) + k_7 n(\text{M}) + k_8 n(\text{H})}$$

This amount of vibrationnally excited ozone leads to an emission process distributed among the different vibration rotation bands of the molecule.

These modes are usually the most intense in infrared absorption spectra. However, laboratory and theoretical studies are still needed in order to determine the relative emissions of the bands.

In the case of excited ozone, Von Rosenberg and Trainor (1974) show that the ozone structure in the 9.6  $\mu\text{m}$  band does not exactly correspond with the absorption pattern of the same band at room temperature : emissions tend to be stronger than expected at the longer wavelengths. This correspond to emissions from the hot bands  $\Delta v_3 = 1$ . It means that the ozone producing process corresponds to a much higher temperature than the atmospheric ambient air. According to Von Rosenberg and Trainor (1974), if every  $\text{O}_3$  formed by  $\text{O} + \text{O}_2 + \text{M}$  is in the  $\Delta v_3 = 1$  state, it means an equivalent temperature of 2160 K but if only one of 2 formed  $\text{O}_3$  turns to be vibrationally excited, the distribution is characterized by  $T_v = 1080$  K. These temperatures and the now well known ozone molecular parameters would permit to build a model if the emission in the considered bands.

The observed intensity will be, in any case, related to the concentration of excited ozone which, in its turn, is directly related to the atomic oxygen concentration by its formation process. As a result of chemical reaction with atomic oxygen above 80 km and collisional quenching below 60 km, the oxygen related ozone emission should peak between 65 and 75 km.

The main advantage of this kind of experiment is to be performed from space using light instrumentation and parts from other optical experiments when these are not in use. As an instrument, we propose a circular variable filter radiometer scanning the 10  $\mu\text{m}$  atmospheric window such as the one we have built for stratospheric monitoring.

In order to assess the variation of the  $v_3$  ozone emission related to sunset or sunrise, we intend to perform this year a balloon flight using the stratospheric monitoring radiometer above the ozone layer.

## REFERENCES

- ACKERMAN, M., LIPPENS, C. and MULLER, C., Emission features in the 10  $\mu\text{m}$  atmospheric window related to nitrogen and halo-carbon compounds, to be presented at the E.G.S. meeting, Amsterdam (1976).
- MOREELS, G., Oxygène atomique mésosphérique, Proposition au service d'aéronomie du C.N.R.S. (France) (1975).
- SIMPSON, J., Infrared emission from the atmosphere above 200 km., Nasa Technical Note TN D-8138, Ames Research Center (1976).
- STAIR, A.T., ULWICK, J.C., BAKER, K.D. and BAKER, D.J., Rocketborne observations of atmospheric infrared emissions

in the auroral region, Atmospheres of Earth and the planets, McCormac ed., Reidel, Dordrecht (1975).  
von ROSENBERG, C.W. and TRAINOR, D.W., Vibrational excitation of ozone formed by recombination, J. Chem. Phys., 61, 2442 (1974).