UPPER ATMOSPHERE TEMPERATURE MEASUREMENTS USING AN AIRGLOW PHOTOMETER ON BOARD A ROCKET

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ABSTRACT

One of the most useful techniques to observe neutral atmosphere temperature in the mesopause region, between 80 to 100 km, is to measure the molecular rotational temperature of the oxygen emission, $O_2(0,0)$ atmospheric band at 762.0 nm and the OH vibration-rotation band, for example OH(8,3) band at 732.0 nm. Ground based observations in these emissions have been carried out from various stations around the globe and their nocturnal and seasonal variations have been studied. The ground-based observations, however, can not provide information regarding the height of the emission layer. Photometers on board a rocket, measuring in situ the emission spectra makes it possible to observe the height profile of the emissions and their rotational temperatures. The scientific background for carrying out these measurements from an equatorial and/or mid-latitude region and instrumentation to be used will be discussed.

INTRODUCTION

Observations of the atmospheric neutral temperature in the upper mesosphere and in the lower thermosphere by optical methods have mainly been carried out by measuring (1) the Doppler broadning of the emission line of excited atoms, such as atomic oxygen at OI 557.7 nm (Hernandez, 1976), and (2) the rotational temperature of the excited molecules, such as $O_2(0,1)$ Atmospheric band at 864.5 nm and the OH vibration-rotation band emissions (Noxon, 1978). Fabry-Perot type interferometers are normally used for the

TABLE 1

COMPARISON BETWEEN $O_2A(0,0)$ BAND AND OH(8,3) BAND EMISSION SPECTRA IN THE NIGHT AIRGLOW

	OH(8,3)	$O_2A(0,0)$
Spectral lines to be measured	$P_1(2)$ and $P_1(4)$	P branch
Wavelength	732.0 nm	763.0 nm
Scanning range	5.0 nm	2.0 nm
Band intensity	350 R*	6000 R
Line intensity	~15 R	~300 R

In order to get the rotational temperature from the $O_2A(0,0)$ P branch, is necessary to measure its spectral intensity distribution which is 2.0 wide. For this purpose, it is proposed to use a Charge Coupled Device (CC imaging detector, instead of using the mechanical wavelength scanni technique. The required photometer specifications are listed in the Table and a simplified diagram of the photometer is shown in Figure 1. T wavelength dependent sky image is focused on the focal plane with circul fringes corresponding to the individual rotational lines of the P-branc This annular pattern will be detected and stored by the CCD imaging detecto and subsequently transmitted by the Telemetry System.

former measurement because it requires very high spectral resolution, which is of the order of 10^{-12} m. In the case of rotational temperature measurements, case (2), a grating spectrophotometer or a narrow band interference filter photometer, with a spectral resolution of a few tenths of nanometers are used (Takahashi et al., 1986).

These optical measurements of the atmospheric temperature have been carried out from ground based stations. The measurement from the ground, however, can not provide informations on the height profile of the emission layer and its rotational temperature. Observations on board a rocket are required to get the profiles. Solheim (1985) tried to measure the O_2 Atmospheric (0,0) band rotational temperature by a spectrophotometer on board a rocket; this is the only measurement published so far.

In this document, we propose in situ measurement of the $O_2A(0,0)$ band rotational temperature using an imaging spectral photometer on board a rocket.

INSTRUMENTATION

In order to measure the rotational temperature, the $O_2A(0,0)$ band is chosen instead of the OH bands because of its strong intensity and the relatively narrow wavelength distribution of the rotational lines. The characteristics of the O_2 spectra are shown in Table 1. Also shown for comparison are those of the OH(8,3) band. The $O_2A(0,0)$ band is one of the most intense emissions in the night airglow. The rotational lines of the P-branch are distributed over 4.0 nm, with line intensities of about 300 Rayleighs, which is 20 times stronger than those of the OH(8,3) P lines.

TABLE 2

IMAGING SPECTRAL PHOTOMETER SPECIFICATIONS (PRELIMINARY)

Photometer type:	- Interference filter photometer
Filter:	- λ peak at 765.0 nm - Δλ ~0.3 nm - Diameter ~50 nm
Objective lens:	- Diameter ~45 nm - short focus to make a small image on the focal plane
Detector:	- CCD imager, 5 x 7 mm rectangular

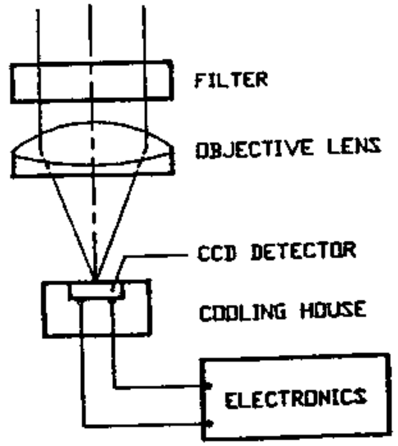

Fig. 1 - Diagram of the Imaging Spectral Photometer.

SUMMARY

This proposed project is still in a preliminary phase. Critical and quantitative discussions are needed before finalizing the proposal. Laboratory experiments also should be carried out to develop the optical system.

- **Objective of the Project:** Design and construction of an imaging spectral photometer to be launched on board a rocket to observe the vibration-rotation spectra of the $O_2A(0,0)$ band at 761.9 nm in the night airglow.

- **Scientific Goal:** To observe, in situ, the atmospheric temperatures between 80 to 100 km, by measuring the rotational temperature of the $O_2A(0,0)$ band emission.

- **Future work:** This type of photometer could be applied to any other optical measurement which needs a short range of wavelength scanning. The photometer should be space qualified, so that it would be possible to include it in a satellite payload to observe the atmospheric temperature on a global scale.

REFERENCES

Hernandez, G. (1976) Lower thermosphere temperatures determined from the line profiles of the OI 17.924K (5577 Å) emission in the night sky. 1. Long-term behaviour. J. Geophys. Res., 81, 5165.

Noxon, J.F. (1978) Effect of internal gravity waves upon night airglow temperatures. Geophys. Res. Lett., 5, 25.

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PLASMA PHYSICS

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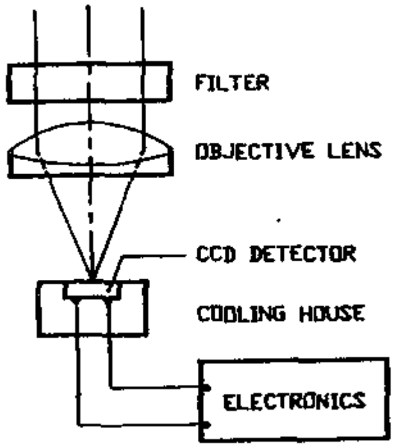

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