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INTERFEROMETRIC MEASUREMENTS OF THE λ7319 Å DOUBLET EMISSIONS OF OII

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Abstract—Fabry–Perot interferometer observations of the OII 7319 Å line made from College, Alaska are presented. Significant Doppler shifts corresponding to the ion drift motion, caused by the convection electric fields, were observed under special conditions, but no steady observations were possible due to the sporadic nature of this emission. Very preliminary results of the observed doublet separation (≈0·836 Å) are also presented.

INTRODUCTION

The emissions at λ7319 and λ7330, arising from the atomic oxygen ion metastable transition (^2D–^2P) were first observed in the Earth's atmosphere by Omholt (1957) in an extremely bright red aurora. Since that observation only minor attention has been directed toward this emission feature. However, recent developments in detection techniques, as well as increased interest in ionic motions in the auroral zone, have revived interest in this spectral feature of the aurora. (Rees *et al.*, 1974; Swenson, 1974). This paper is concerned with high resolution measurements of Doppler shifts observed in the λ7319 doublet in the aurora.

The observations reported here were carried out with the 15 cm Fabry–Perot interferometer of the Michigan Airglow Observatory (MAO) which has been situated at College, Alaska, ($L = 5{\cdot}6$; $\Lambda = 65°$) since October 1971. Details of this instrument was published previously (Roble, 1969; Hays *et al.*, 1969) and will not be given here except to mention that the finesse and the free spectral range, for a 1 cm spacer, were 10 and 0·268 Å, respectively. The choice of a 1 cm spacer, ideally suited for λ6300 line profile measurements (Roble, 1969), was somewhat unfortunate, as the quoted doublet separation of 0·8 Å (Chamberlain, 1961; Bowen, 1935; Edlen, 1934) is almost exactly three orders, so that an overlap of the two lines will occur. The λ7319 doublet appeared more suitable for study than λ7330 where the OH and N_2 1PG emissions would present a more serious contamination problem. Even so, the filter had to be carefully tilted so as to minimize the inclusion of the OH P_1 branch located at the nominal wavelength value of 7316·4 Å (Chamberlain, 1961). The transmission curve of the filter used was nearly gaussian with a half-width of 4 Å, and a peak transmission of 0·54; the transmission at the quoted OH wavelength was $\frac{1}{5}$ the peak value.

OBSERVATIONS

A number of attempts to observe λ7319 emissions were made during February 1972, however the intensity of this feature is erratic and is usually less than 100 R. Two nights of observations, namely 12–13 February and 18–19 February 1972 (AST), did provide approximately 16 fringes suitable for study. The night of 18–19 February was characterized by widespread low energy electron and proton precipitation (Degan *et al.*, 1972), and the intensity of λ7319 was considerably greater (Rees *et al.*, 1974) than that found on most occasions. The earlier night showed λ7319 to be more sporadic in occurrence, but more intense when observed. A detailed study of the morphology of λ7319 emissions and its relationship to the spectral hardness of the auroral forms will be given by Rees *et al.* (1974) and Swenson (1974).

Figure 1 presents two examples of λ7319 line profiles obtained on 12–13 February looking to the geomagnetic east and west respectively at an elevation of 45°. Lack of sufficient emission prevented the acquisition of a zenith reference to determine the zero, but assuming a symmetry in the flow with respect to the zenith, comparison of the two fringes indicates an ion drift of 1050 m/sec to the east with an implication of a southward electric field of about 50 mV/m. This result is consistent with the presence of a negative bay of 750 γ in H during the period of observations (0120–0140 AST). At the time of these observations,

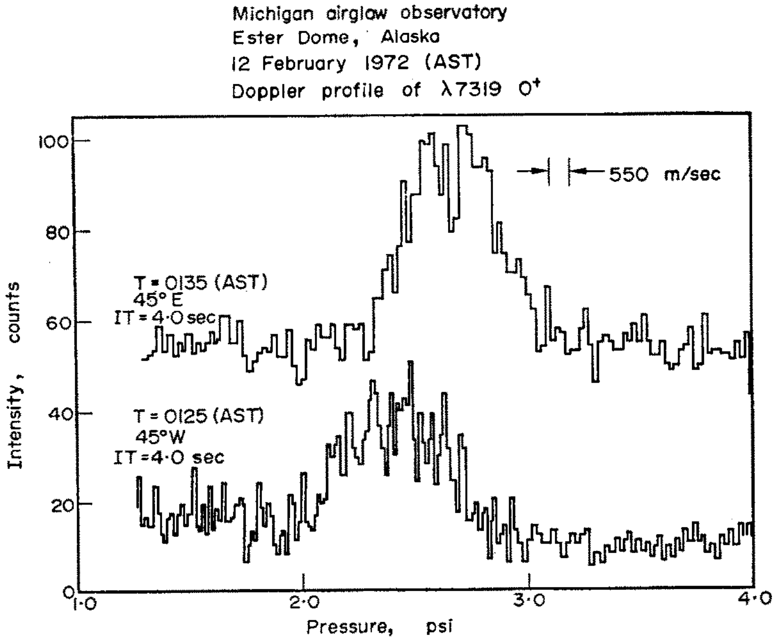

FIG. 1. DOPPLER PROFILES OF OII 7319 Å EMISSIONS OBSERVED DURING THE NIGHT OF 12 FEBRUARY 1972 AT ESTER DOME, ALASKA.
The two profiles were obtained by looking 45°E and 45°W, respectively.

the Chatanika Incoherent Scatter Radar Facility was not operating, therefore no direct comparisons can be made, but the magnitude and direction of the observed ion flows are in accordance with the general patterns observed with the radar (Doupnik *et al.*, 1972). The data obtained during the period of 2130–0130 AST on the night of 18–19 February which was magnetically quiet, indicated an ion drift of less than 200 m/sec ($\approx$ 10 mV/m).

In addition to the observations described thus far, some data were obtained with a $\frac{1}{4}$ cm spacer using SF_6 as the scanning gas. An attempt was made to evaluate the doublet separation and wavelength position with respect to the OH $P_1(2)$ branch. This series of measurements was unfortunately of low quality due to large temporal variation in the signal, but results obtained suggest the λ7319 doublet separation to be 0·836 Å ± 0·004 Å. The position separation of the doublet midpoint with respect to the OH component is (1·07 Ån + 0·75 Å or 1·07 Ån − 0·32 Å) ± 0·05 Å, where n is an unknown integer. It is stressed here that these values represent preliminary results and would be subject to subsequent adjustments upon acquisition of data of higher quality.

CONCLUSIONS

The interferometric observations presented here show that under special conditions the λ7319/7330 emissions from 0^+ can be used to measure ion temperatures and ion drifts (electric fields). However, these emissions are quite sporadic and exceed 100 R only in "bursts" (Rees *et al.*, 1974; Swenson, 1974). The sensitivity of the present interferometer system at these wavelengths is such that intensities in excess of 100 R are needed to obtain useful Doppler profiles in a reasonable period of 5–10 min.

The high resolution measurements reported here also indicate that there are significant uncertainties in the quoted wavelength of the λ7319 doublet. Further work using laboratory sources for a wavelength reference needs to be done to determine this value more accurately.

In summary then we found that although under ideal conditions the technique is capable of measuring ion temperatures and drifts, it is not a practical method at this time in the auroral belt. Useful measurements may be practical in the polar cusp region where the λ7319/7330 emissions are expected to be more intense and stable and, of course, new developments in 'red' sensitive photomultipliers would lead to improved system sensitivities making this technique useful even in the auroral belt, especially near the northern boundary where soft particle precipitation dominates (Eather and Mende, 1972).

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Department of Atmospheric and Oceanic Science,
The University of Michigan,
Ann Arbor,
Michigan 48105,
U.S.A.

J. W. MERIWETHER
P. B. HAYS
K. D. MCWATTERS
A. F. NAGY

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NON-DUCTED TWO-HOP WHISTLERS IN THE INNER MAGNETOSPHERE DEDUCED FROM ROCKET MEASUREMENT

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Abstract—The non-ducted whistler propagation in the inner magnetosphere is discussed using the broad-band VLF measurement on board the K-9M-26 rocket launched at 1703 hr JST on 24 August 1969 from Kagoshima Space Center (geomagnetic lat 20°N). A large number of whistlers which seemed to be two-hop whistlers originating in the northern hemisphere were observed. The main features of these whistlers are summarized: (1) their dispersion value is widely scattered in the range 55–75 $sec^{1/2}$, (2) their frequency spectra show a broad maximum in the frequency range 2–5 kHz and higher frequency components are likely to disappear. Attempts are made to interpret these properties in terms of ducted or non-ducted propagation. It is then found from the ray tracing studies that the measurements are satisfactorily explained by non-ducted propagation in the inner magnetospheric model with latitudinal density gradient such as the equatorial anomaly.

1. INTRODUCTION

There are two different types of whistler propagation in the magnetosphere, i.e. ducted propagation and non-ducted (Helliwell, 1969). The ducted propagations have long been investigated and are used to deduce the magnetospheric electron density profile (Helliwell, 1965). The existence of field-aligned ducts has been evidenced not only at high latitudes (Carpenter, 1968; Angerami, 1970) but also at low latitudes (Hayakawa, 1973; Hayakawa and Ohtsu, 1973; Iwai *et al.*, 1973).

The non-ducted propagations have been currently studied using the observations on board satellites (Smith and Angerami, 1970; Walter, 1969). This kind of propagation is also utilized to deduce the magnetospheric electron density profile. In addition the non-ducted propagations have revealed the importance of the presence of ions (Kimura, 1966; Smith and Angerami, 1970) and of the latitudinal dependence in electron density (Walter, 1969). At low latitudes Kimura (1971) has found a new phenomenon named 'whistler striations' on POGO satellites and suggested that they were the consequence of horizontal