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THE OCCURRENCE OF THE NII 4176 Å EMISSION LINE IN CONNECTION WITH TYPE-B AURORAS

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INTRODUCTION

The presence of the allowed transitions of NI and NII atoms is a general feature of the auroral spectrum (Chamberlain, 1961). This note deals with the occurrence of the NII 4176 Å line, its relationship with the low altitude character of the auroras involved, and its implication on the shape of the energy spectra of secondary electrons.

THE INSTRUMENTATION

The instrument used was a Littrow type scanning spectrometer in the spectral range 4150–4294 Å with a resolution of 4·5 Å. Spectra were recorded last Winter every night on a pen recorder with one scan per minute. The photon counting equipment was provided with an integrating count ratemeter ranged with 10^3 counts/sec full scale value. Calibration with a standard source allowed us to deduce the absolute brightness of the emissions.

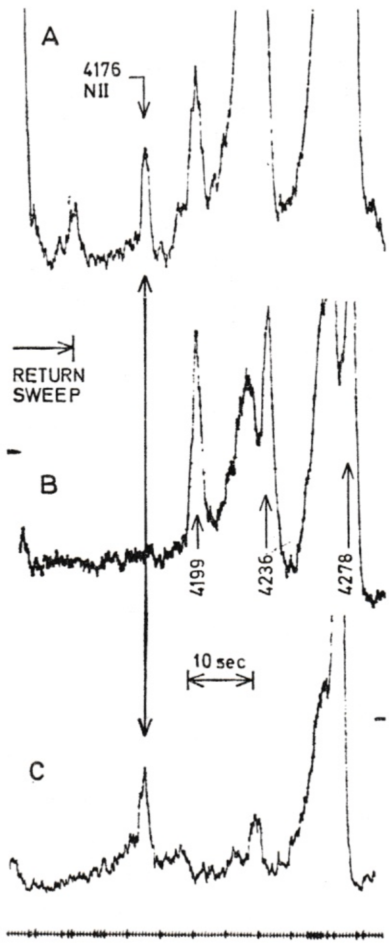

FIG. 1. SAMPLES OF SPECTRA TAKEN: (A) JAN. 18 AT 20.07–20.08 MET; (B) JAN. 18 AT 20.12–20.13 MET; (C) MAR. 17 AT 21.24–21.25 MET.

THE MEASUREMENTS

Generally the recorded spectra only showed the first three bands of the $\Delta v = -1$ sequence of the N_2^+ first negative system with bandheads at 4278, 4236 and 4199 Å.

On two occasions one additional feature appeared at 4176 ± 1 Å, associated with the occurrence of a type-B aurora. Samples of spectra are shown in Fig. 1A and 1C where the 4278 band is saturated. It must be stressed that the intensity of the aurora changed rapidly over a large range as can be judged from the anomalous profiles of the N_2^+ bands. Figure 1B shows an example of a strong spectrum without the 4176 line recorded few minutes after spectrum 1A. According to Chamberlain, this line is the NII multiplet: 3d $^1D^0 - 4f^1F$ at 4176·16 Å, originating from a level which is about 26 eV above the NII ground state.

This line appeared in spectra of the aurora of the 11th February 1958 (Wallace, 1959) and is also quoted by Vegard (1951). As these spectra had been recorded on films with limited dynamical range, little knowledge of absolute intensity and of the specific temporal occurrence of this emission has been obtained.

Because of the intensity fluctuation of the aurora during the scan, any estimation of the intensity ratio between this emission and the N_2^+ bands is uncertain.

Using the recordings of the two evenings in question, the 18th January and 17th March, the measured intensities were 0·7 and 0·4 kR, and the corresponding intensities of the N_2^+ 1st Neg. bandhead at 4199 were 1·5 and 0·5 kR, respectively. The latter intensities should then imply a 3914 Å brightness of 225 kR and 75 kR, if intensity ratios of 100:33:0·7 for the (0, 0), (0, 1) and (2, 3) transitions are used. The intensity ratio $I(4176)/I(3914)$ is then for the two occasions 0·03 and 0·05.

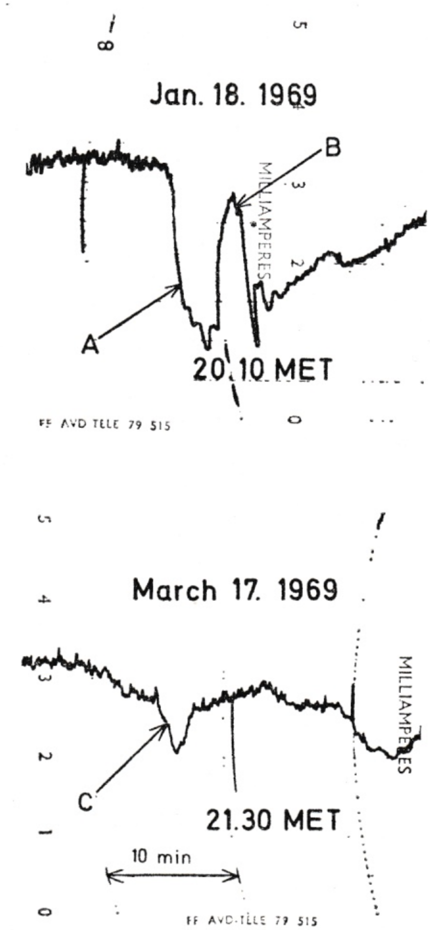

FIG. 2. RECORDINGS OF RIOMETER ABSORPTION AT 27·6 MHz.

The observed phenomenon was of a very transient nature. At the very moment when this emission line was observed, the riometer showed a sharp increasing cosmic noise absorption at 27·6 MHz (see Fig. 2).

DISCUSSION

The mechanism to produce the 1st Neg. bands, is

$$N_2(X^1\Sigma g^+) + e \xrightarrow{\sigma_1} N_2^+(B^2\Sigma^+) + 2e \quad (1)$$

and the mechanism for the NII transition is, according to Bates (1960):

$$N_2(X^1\Sigma^+ g) + e \xrightarrow{\sigma_2} (N^+)^* + N + 2e \quad (2)$$

where the two formed atoms can be in an excited state. It has been showed by Brown (1968) that even in auroral enhanced conditions, direct excitation of atomic nitrogen does not contribute significantly to nitrogen line intensity.

The cross section σ_1 for the first reaction has been measured (McConkey and Latimer, 1965, Srivastava and Mirza, 1968), and shows a maximum at 95 eV and a threshold energy close to 20 eV as expected by energy considerations.

The energy necessary to dissociate and cause a NII(4176) emission is about 50 eV. The cross section for this reaction does not seem to have been measured, but one could guess a cross section curve of σ_2 similar to σ_1 but displaced towards a threshold energy of about 50 eV.

The energy spectra of the secondary electrons has been measured on few occasions in ordinary aurora (Ulwick, 1968) and it has been computed theoretically by Stolarski (1967) who showed that for a fixed atmospheric composition the shapes of the energy spectra were independent of the energies of the primary particles. The fact that there is an enhancement of the NII-line compared to the N_2^+-bands should imply a hardening of the secondary energy spectrum. This contradicts Stolarski's results unless his model is sensitive to the change in atmospheric composition connected to this low altitude type aurora. This is unlikely as atomic oxygen seems to play a minor role in degrading the primary particles.

A reduction of the N_2^+-band intensities by charge transfer processes with molecular oxygen cannot be considered because of its low reaction rates. A knowledge of the absolute cross section σ_2 would enable us to give some indications of the hardness of this electron spectra, as direct measurements by rockets would be impracticable due to the infrequency of the phenomenon and its limited time duration.

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