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PRELIMINARY RESULTS OF OBSERVATIONS OF ATMOSPHERIC ULTRAVIOLET TWILIGHT EMISSIONS BY THE TD1-A SATELLITE

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Preliminary data collected by the UV telescope on board the ESRO TD1-A satellite in its winter spinning mode are described and analysed. They consist of angular scans parallel to the terminator plane, near the dusk meridian, in four ultraviolet channels covering the spectral range 1350—2200 Å. The main twilight emissions are identified as well as the altitude-latitude intensity dependence. The Mg II resonance doublet near 2800 Å appears to be present in one of the channels, in agreement with previous high altitude observations. The altitude distribution of magnesium ions obtained by comparison between the northern and southern scans at a given latitude is illustrated.

1. Introduction

Satellite TD1-A [1] was launched into a polar sun-synchronous orbit in March 1972. Among the seven experiments on board, S2/S68 [2] was designed to scan the sky and has provided spectrophotometric data for several thousand hot stars. In accordance with the astronomical aims, the telescope is permanently pointing towards the zenith.

When extended sources are observed, the instrument works as a sensitive four-channel photometer in the following spectral bands:

Channel	A1	2750 ± 150 Å (at half maximum)
	A2	1330—1780 Å
	A3	1730—2180 Å
	A4	2130—2580 Å

The data recorded during the first scan immediately showed an unexpected signal in channel A1, which appeared sporadically near the evening crossings of the magnetic dip equator. It was recognized by Boksenberg and Gérard [3] that this signal was to be attributed to a resonance scattering of Mg^+ ions lifted up by the well-known "fountain effect" in the ionosphere [4]. Maps of the observations were drawn up by Gérard and Monfils [5], who were able to localize the phenomenon, which is limited to a narrow region north and south of the dip equator. A longitudinal effect has also been detected by the same authors.

During the winter period, the spacecraft is kept stabilized in a fast spinning mode about the sun-satellite axis. This mode of observation has been used to scan the plane perpendicular to the spin axis, thus parallel to the terminator. Measurements of the altitude profiles of the emissions situated in the spectral ranges of the four channels, and particularly of the last one, were expected as a function of latitude.:

Channel A2	N_2 (Lyman-Birge-Hopfield)
	[O] λ 1356 Å
Channel A3	NO γ system (mainly (1, 0) band)
Channel A4	NO γ system
Channel A1	Mg II λ 2800 Å
	residual NO (γ system)

The preliminary results presented here are based on the few "quick look data" available in January 1974. The profiles investigated have been recorded between 60° and 15° geographic north latitude. Owing to the orbital properties of the satellite, the earth below was then in darkness. The intersection of the sunlit limit of the atmosphere and of the scanning plane tends towards zero altitude when the satellite approaches the equator.

2. Description of the Observations

In the considerations which follow, emphasis has been put on the mid-latitude scans, because, for the northern ones, the atmosphere is in darkness up to 300 km altitude and in the southernmost ones, the Rayleigh scattering complicates the analysis and cannot be readily subtracted quantitatively. Apart from some high latitude profiles, obviously influenced by auroral activity, all the northern profiles corresponding roughly to the same latitude are almost identical. The same is true for the southern profiles. Fig. 1 shows a typical recording of the southern

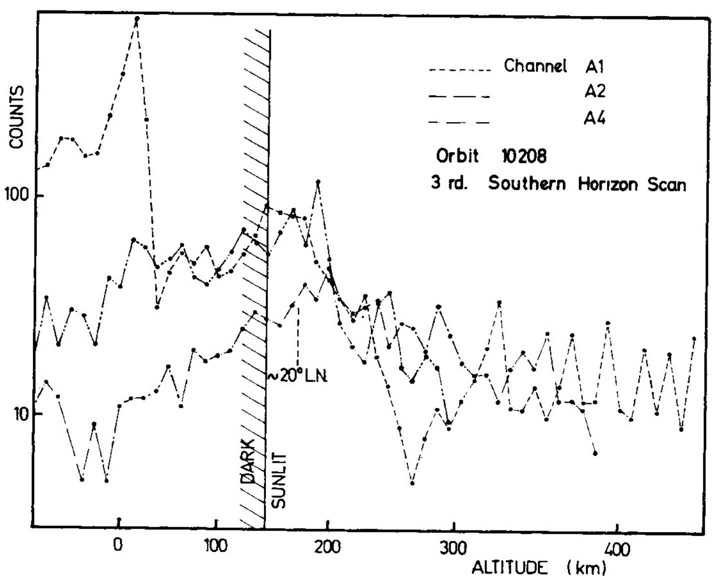

Fig. 1. Southern horizon scans recorded around 35° N by channels A1, A2 and A4.

horizon recorded around 35° N. The value of the impact parameter, which is closely related to the altitude of the emitting layers, has been calculated by simple trigonometric formulae. The most conspicuous feature of channel A1 is alsmost certainly due to Rayleigh scattering. It corresponds to an altitude of ~10 km which can hardly be distinguished from the ground owing to the measuring error. The intensity is low: 650 counts, i.e. 30 rayleighs/Å. At higher altitudes a new maximum is observed around 150 km, with an intensity of 0.5 kR situated in the sunlit part of the atmosphere. This may correspond to the signal observed during normal satellite operations, i.e. the Mg II fluorescence. In the present case, the intensity drops to the background at a little over 250 km and consequently no emission is to be seen by looking upward. The intensity maximum corresponds, through the Van Rhijn effect, to a latitude of approximately 20° N.

The two other channels drawn are A2 and A4, showing probably [O] λ 1356 Å in the first case, and NO bands in the second. In the first, a distinct maximum at high altitude (200 km) can be seen. This seems too high for the Lyman-Birge-Hopfield system, which is the only other obvious possibility. The intensity is low, (250 R at peak), but the maximum is very broad (250 km at half height). As far as channel A4 is concerned, a very broad asymmetrical maximum is observable, with a peak near 200 km, immediately above the limit of the sunlit part of the atmosphere; it is present down to very low altitudes. It should be pointed out that the latter limit has been computed without taking into account either the refraction effect or any screening heights.

Fig. 2 corresponds to an observation which has been made around 25° N, which is 10° closer to the equator than in the case of Fig. 1. It can be seen that the A1 profile shows a high altitude Mg II emission, although the intensity is not very

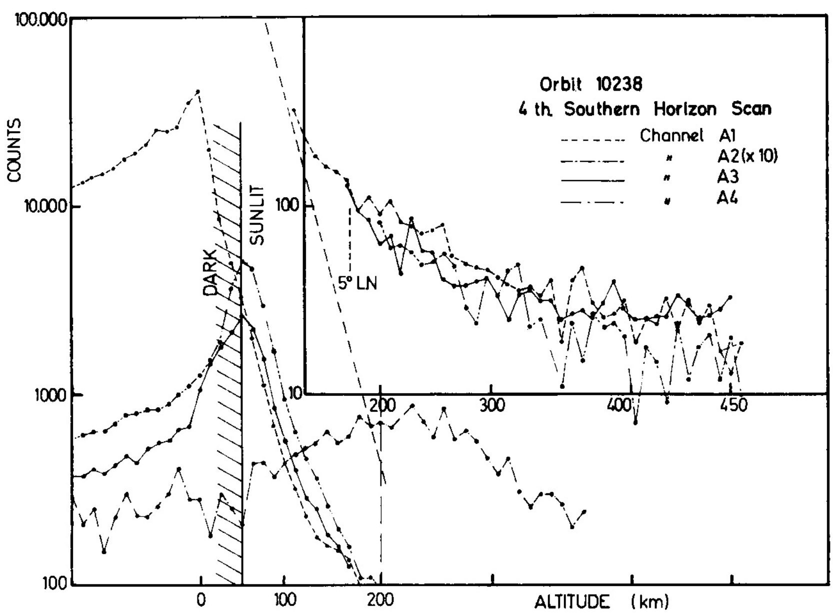

Fig. 2. Southern horizon scans by all four channels around 25° N. The similarity of the channels A3 and A4 is apparent.

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high. Due to the much lower shadow height, the Rayleigh scattering is much more intense, peaking to a value of 600 Rayleighs/Å for a layer that must be close to the ground if the Van Rhijn effect is responsible for the observed profile, the peak possibly being due to the ground itself. In order to find the Mg II fluorescence,

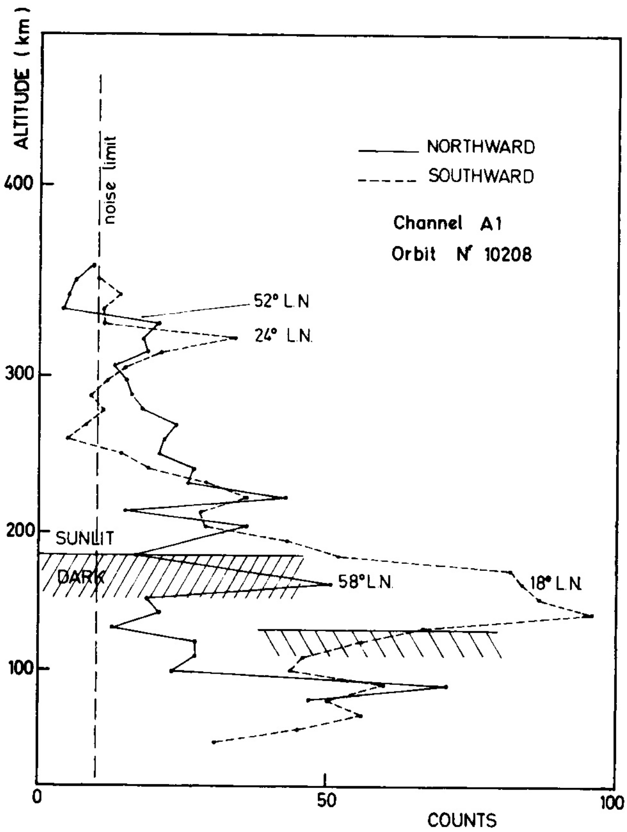

Fig. 3. Successive northward and southward altitude profiles from channel A1 recorded near 38° N.

we have to look at the tail of the curve which indeed shows a counting rate exceeding the 10 counts noise up to more than 450 km.

The other channels also show very interesting aspects. A3 and A4 channels exhibit a very similar profile which is readily accounted for by resonance scattering of the NO gamma bands. The peak altitude seems to be around 50 km. Channel A2 shows a peak around 220 km, which corresponds to an intensity of 400 raleighs provided the λ 1356 is the only contributing emission. The width is the same as for Fig. 1 (250 km), but the intensity is somewhat higher. The effect looked for is, by nature, irregular: only studies extending over many recordings can lead to a complete analysis of the altitude profile and its variations with time and latitude. It is, however, possible to derive some information on the problem from the comparison of consecutive scannings of the northern and southern horizons. Such profile comparisons have been drawn in Figs. 3 and 4. In the first case, the profiles have been recorded near 38° N. They illustrate the fact that we are very probably observing the expected fluorescence effect: due to the 75 sec-

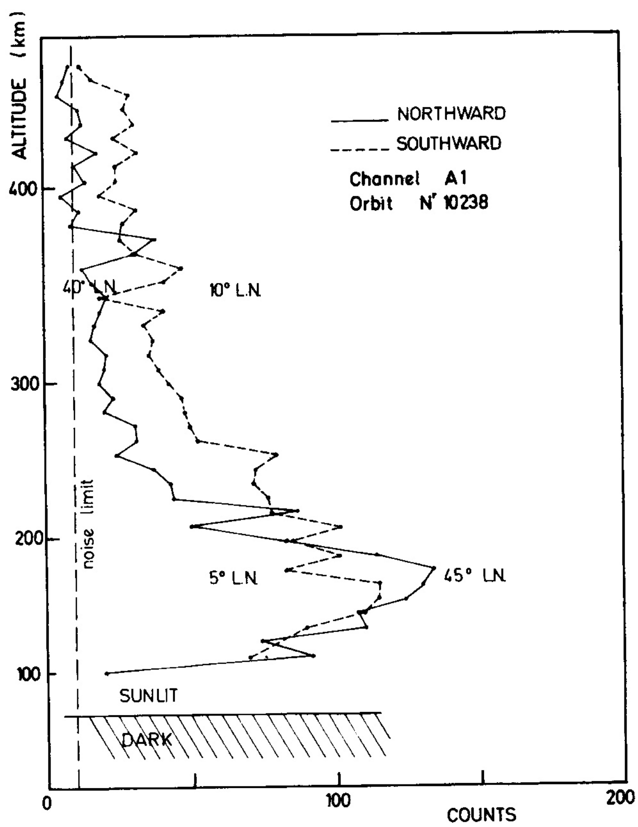

Fig. 4. Successive northward and southward horizon scans recorded from around 25° N by channel A1.

onds separating the recordings, the shadow height has decreased from 180 km to 130 km, crossing the altitude of the maximum which then appears around 170 km in the sunlit part of the atmosphere. Higher up, there is not much difference. In Fig. 4, the lower latitude of the observations (~26° N) appears much more favourable, although the presence of a low-altitude superposed emission makes it necessary to subtract it before plotting the data. This was done by extrapolating to higher altitudes the exponential decrease. The two profiles obtained by looking north and south show the expected effect: in the northern direction, an important maximum (675 R) is observed around 170 km, and corresponds to a latitude of 45° N. Above 170 km, the decrease is fast, the intensity falling to the noise level at about an altitude of 380 km. The southern profile, on the contrary, shows a lower intensity for the (160 km altitude) maximum (575 R) but the intensity does not drop as fast as a function of altitude as in the first case: an altitude of 450 km is necessary for a drop to the noise level. By easy calculation, it can be seen that the latitude region covered around 350 km is situated around 10° N, which is the geographic latitude of the geomagnetic dip equator, where the ionospheric fountain effect should be maximum.

3. Conclusion

By using the fast spinning mode of satellite TD1 several hundreds of horizon profiles have been observed. The preliminary analysis of the quick-look data has shown (i) that they do not correspond to days where the high altitude Mg II fluorescence effect is noticeable, and (ii) that the same effect as the one invoked for the explanation of the preceding observations is, in fact, likely to be effective. The analysis of the complete data will proceed in the future and will cover the whole of the experimental material.

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References

[1] B. TILGNER, ELDO-CECLES/ESRO-CERS Scient. and Tech. Rev. **3**, 567 (1971).
[2] A. BOKSENBERG, R. G. EVANS, R. G. FOWLER, I. S. K. GARDNER, L. HOUZIAUX, C. M. HUMPHRIES, C. JAMAR, D. MACAU, D. MALAISE, A. MONFILS, K. NANDY, G. I. THOMPSON, R. WILSON and H. WROE, Mon. Not. R. Astr. Soc. **163**, 291 (1963).
[3] A. BOKSENBERG and J. C. GERARD, J. Geophys. Res. **78**, 4641 (1973).
[4] W. W. HANSON, D. L. STERLING and R. F. WOODMAN, J. Geophys. Res. **77**, 5530 (1972).
[5] J. C. GERARD and A. MONFILS, J. Geophys. Res. **79**, 2544 (1974).