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AIRGLOW ATMOSPHERIC IMAGER ON BOARD THE 'IK-BULGARIA-1300' SATELLITE

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ABSTRACT

This paper shows the possibilities of the optical scanning imager for investigation of the structure of the auroral,SAR and tropical arcs and in this way to study the particle precipitation,neutral winds across the magnetic equator,drifts,electric fields and the current systems in the ionosphere.

INTRODUCTION

The main part of the basic aeronomic and dynamical phenomena in the upper atmosphere of the Earth and particularly of the ionized part is connected with the intensification of the optical emissions.The intensities at mid and low latitudes are comparatively low and except for hydroxyl and some oxygen emissions in the D and E regions,don't show clear spatial structure. For oxygen,the sructure is clearly expressed at high geomagnetic latitude and in the region of the geomagnetic equator.

The structure and the dynamics of the SAR-arc and of the discrete arcs in the aurora are of considerable interest for the magnetospheric-ionospheric relations.In the last few years it became clear that in the region of the geomagnetic equator there are discrete optical ionospheric structures (arcs),which have comparatively high values of the emissions in the visible and in the UV part of the spectrum [1,2,3] .The tropical and the equatorial arcs which are observed,are closely related to the equatorial anomaly,transequatorial plasma transfer and with the electrostatic field, generated in the region of the geomagnetic equator.

A number of satellite experiments have been devoted to the problem of the structures in the glowing atmospheric regions and of aurora.On board OGO-II there was a scanning optical photometer[4] ,but since the insrument optical axis was directed toward the horizon,vertical profiles were measured,but not the horizontal spatial structure of the airglow.The observations with OGO-4 used to produce space maps for the global distribution of the main optical emissions were analogous [5] .

Many successful observations of SAR- arcs and of the discrete aurora structures and of the cusp structures were made by the scanning photometer and by the red-line photometer on board ISIS-II.The resolution of the instruments was 0,4° [6,7,8,9] .VAE-the instrument on board "Atmospheric Explorer" [10] also made it possible to study the structure of the optical atmospheric emissions,but essentially in a vertical direction.

The DMSP-satellite [11] gave the possibility to obtain not only the auroral fine structure,but also a number of different observations and possibilities of comparison with different satellites and ground-based data.A new possibility of investigation of the discrete structures and of the polar oval is given by Dynamics Explorer.

The global auroral imaging instrument on board DE-A allows a continued observation of the whole picture of the polar oval in a number of spectral lines [12] but with comparatively low spacial resolution.

Further we'll describe the Airglow imager on board the satellite "IK-Bulgaria 1300".

"IK-BULGARIA 1300" SATELLITE

The satellite "IK-Bulgaria 1300" was launched in a near circular orbit 905/824 km, inclination 82,5° on 7-th August, 1981. The main scientific goal is the investigation of the complicated nature of magnetospheric-ionospheric phenomena and relations. For this purpose the following parameters are measured on board: Thermal plasma, electric fields, magnetic field, electron and proton spectrum in the range of 200 ev to 1Mev, drift, and optical glow in a large spectral range including UV emissions [13]. Further we'll dwell in particular on one of the optical instruments on board-the two channel scanning photometer EMO-5 which works in the visible part of spectrum. Both optical channels of the instrument look to the nadir (the satellite is three axis stabilized with an accuracy of stabilization better than ± 1°). The channels have 8 interference filters to measure the intensities of the following optical emissions in the subsatellite region: λ 6300 Å (OI), λ 5577 Å (OI), λ 4278 Å (I Neg. N_2^+), λ 4861 Å (H β), λ 7320 Å (O II) and in the line λ 6345 Å by which the spectral background is determined. At the seventh and the eighth position of the wheel are measured the dark current and the intensity of the radioactive source. The wheel with the filters makes a full revolution every 16 sec. The necessary time for measurement in each position is 1,5sec. One microcooler (Peltier effect) gives the possibility to lower the photomultiplier temperature to 35° below the temperature of the case. The optical protection of the channal is achieved by a shutter. The instrument is described in more detail in [14].

λ 6300 Å SCANNING IMAGER

In the second optical channel of the instrument EMO-5 is an interference filter peaked at λ 6305 Å with bandwidth 15 Å, τ_{max} =40%, and a scanning optical system. The scanning is perpendicular to the satellite motion. The optical scheme of the imager is shown in Fig. 1. The instrumental field of

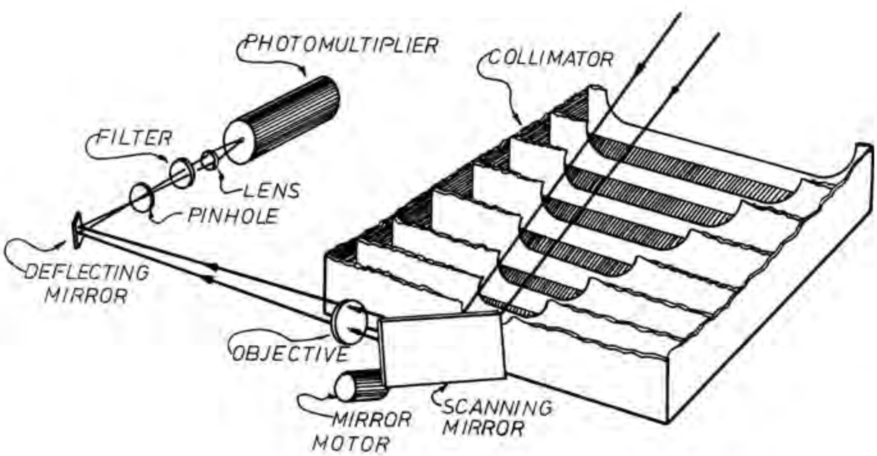

Fig. 1 The optical scheme of the scanning channel

view is 3°. After the optical baffle with a coefficient of attenuation better than 5.10^4 is an entrance plane mirror. By moving this scanning mirror, the optical axis, which is oriented to the nadir, can be moved to ± 15°. The block scheme for the scanning mirror control is shown in Fig. 2. A vacuum stepping motor and worm drive is used. One single scan of the instrument (from -15 to +15°) is made in 1 sec. The motion of the mirror is continuous with markers at seven different positions. When the comparator for a logical and optical protection gives a signal, the scanning mirror is automatically fixed at a middle position (looking to the nadir). The logic of the motion control besides the program, can also use supplementary ground command for switching on and switching off.

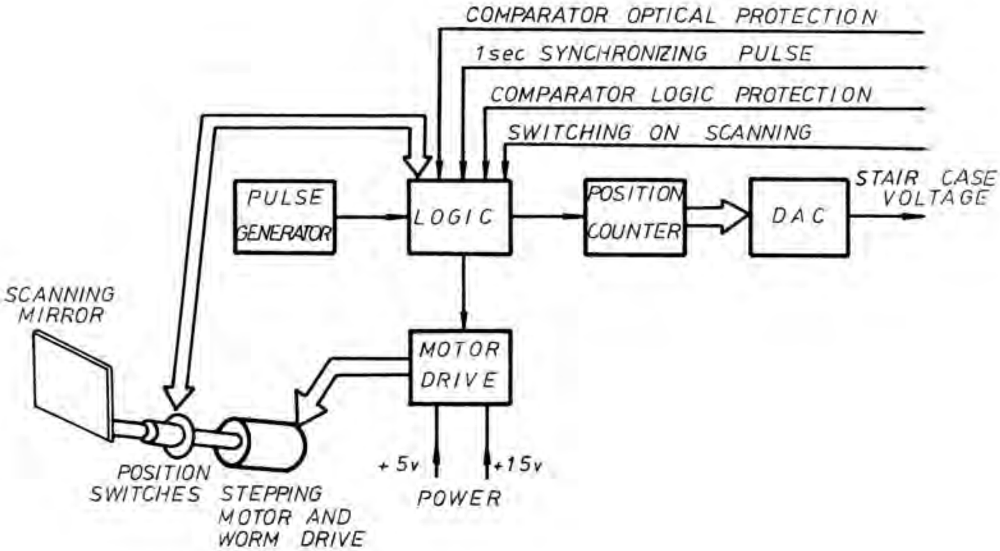

Fig.2 The block diagram of the scanning mirrór control

In a normal mode of operation one single scan contains 7 pixels. The pixel dimensions at the level of F max (we assume 270 km) are 8x52 km. The first value is obtained by some overlap of the field of view in the direction of satellite motion. In this way we have a better opportunity to investigate zonal structures.

The threshold sensivity of the channal is 50 R, and the upper limit-120kR, when the instrument protection circuity is activated.

DATA ANALYSIS

A map of intensity distributions, taken by the scanning imager on board "IK-Bulgaria 1300" on August 1981, orbit 213 is shown in Fig.3. The intensity distribution of I_{6300} is shown in 5 discrete levels with 100 R, 100-150 R, 150-200 R, 200-300 R, and more than 300 R. The regions of the North tropical arc ($\varphi \sim 5^{\circ}$, $\Lambda_0 \sim 18^{\circ}$) and of the South tropical arc (φ geogr. $\sim 7^{\circ}$, $\Lambda_0 = 24$ geogr.) are well outlined. The maximum intensities in the northern arc exceed 200 R and in the South they are about 150 R. We must note that on the picture 15 scan avaraging is used. In the lower part of the figure the intensity increase is related with the satellite approach to the sunlit atmosphere. On the other orbits the typical level for Appelton's airglow anomaly (tropical arcs) in 6300 Å is obvious. Some data show the assymetry in the arcs, probably related with the influence of neutral winds and drifts. The 6300 Å Scanner Imager possibilities, can be illustrated by Fig.4 referred to orbit No.203 (21 August, 1981). Here are shown the measured intensities from the first channel with the background from the sixth channel removed. The diffuse auroral region begins at $\Lambda_0 \sim 59^{\circ}$. The increase of intensity here agrees with the simultaneous soft particle measurements on board the satellite. The comparisons of the emissions allow one to outline different zones in the polar oval region. Let us now look at the structure of the atmosphere in the 6300 Å line in Fig.5 at the same time. Besides the tropical arc (in this case-one which is practically situated on the geomagnetic equator), the South oval position is well outlined. The fine structure of the oval, using the data without averaging is shown in Fig.6. The picture given there is only the area situated between 67 and 70 deg. inv. latitude in Fig 5 and it coincides with the maximal intensities in Fig 4. It is evident that in the oval there are separate regions with great intensity differences. Probably, they are related to the electrojet structure at that time [15], but for studying this phenomenon we need ground based magnetometer data.

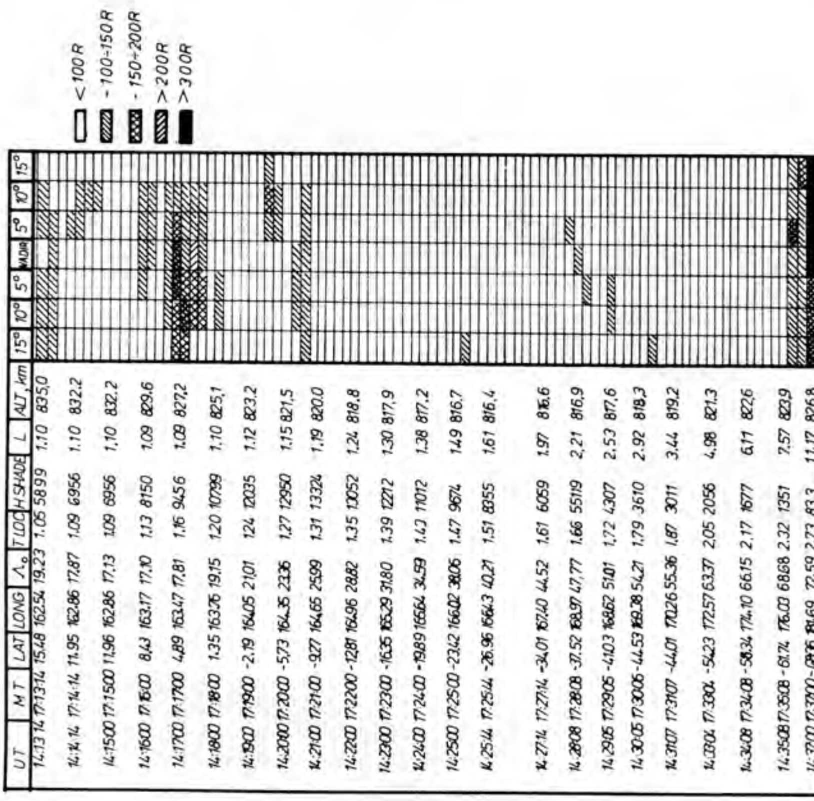

Fig.3 The I_{6300} imager picture, obtained on 213 orbit

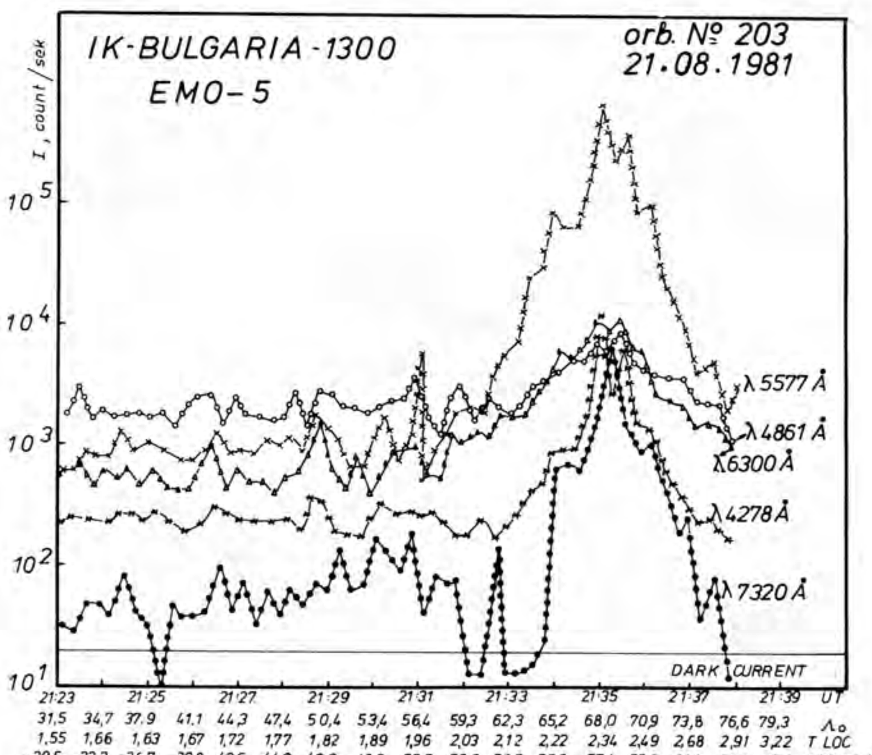

Fig.4 The intensities of λ 6300 Å, λ 5577 Å, λ 4278 Å, λ 4861 Å, and λ 7320 Å in polar oval (orbit.No203)

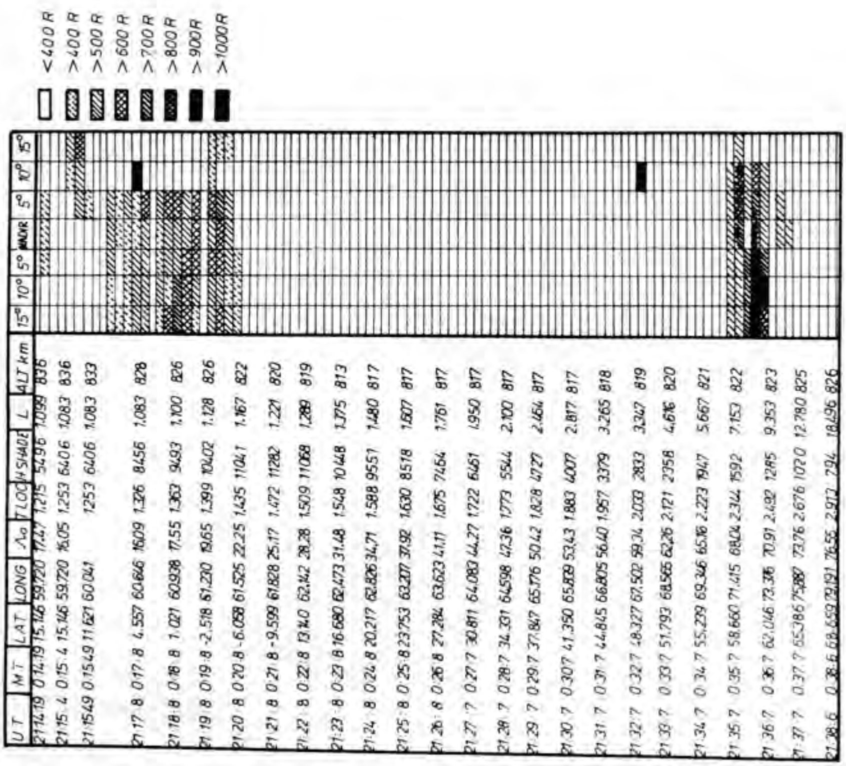

Fig.5 The I_{6300} imager picture, obtained on 203 orbit

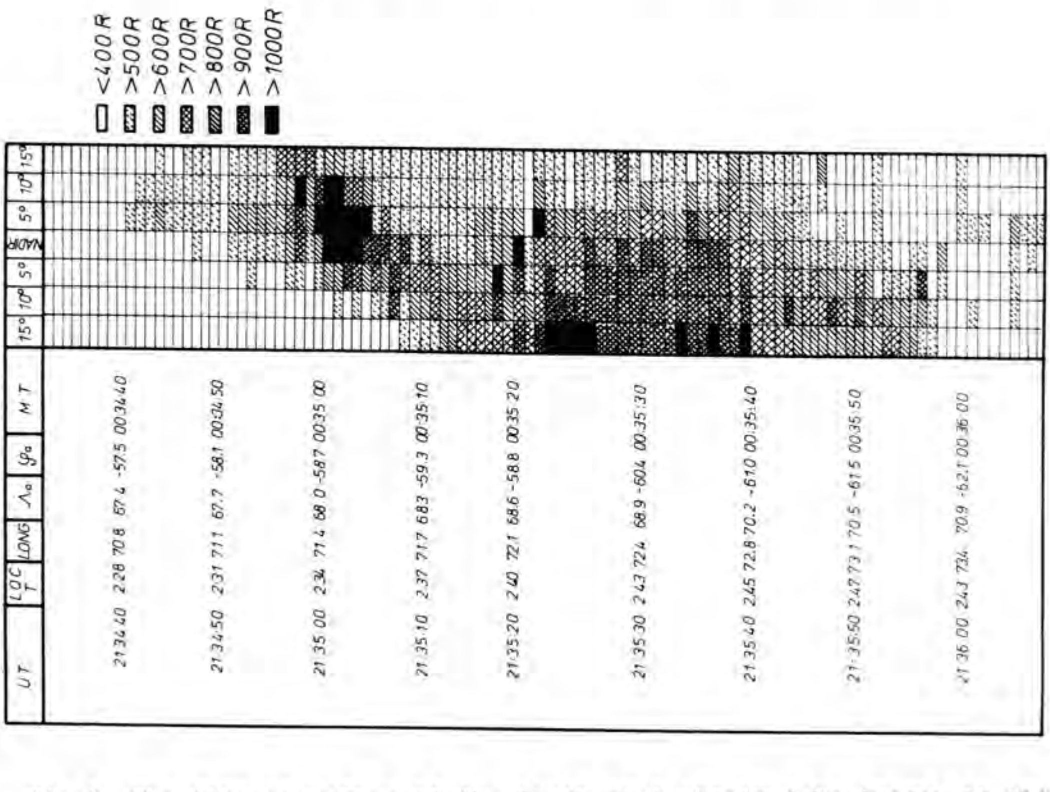

Fig.6 The fine structure of the South oval, obtained by imager on 203 orbit

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