A 6.7-S QUASI-PERIODIC FLUCTUATION OF AURORAL X-RAYS OBSERVED AT ROCKET ALTITUDES

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Abstract: A quasi-periodic variation of auroral X-rays was observed by a rocket-borne detector launched from Syowa Station, Antarctica. It is shown that a 6.7-s periodic variation was found for about 200 s in a diffused auroral region between two bright arcs near the midnight.

1. Introduction

So far, quasi-periodic fluctuations of auroral X-rays in the 1- to 10-s period range have been observed occasionally at balloon altitudes in conjunction with pulsating aurora (*e.g.* ANGER *et al.*, 1963; PARKS *et al.*, 1968). A similar fluctuation of precipitating energetic electrons in an early morning pulsating aurora was obtained directly by rocket-borne electron detectors (WHALEN *et al.*, 1971). Fluctuations of X-ray fluxes having time scales of the order of seconds or so should provide an important information of electron injection, bouncing, and acceleration. Now there are two interpretations of the X-ray pulsations as follows; the periodic injection of energetic electrons into the ionosphere due to pitch angle diffusion in the equatorial plane region (KENNEL and PETSCHEK, 1966), and the local electrostatic acceleration of electrons trapped in the geomagnetic field (LYONS, 1974).

Rocket-borne X-ray detectors can survey over a wider sky region for a moment than by means of balloons, particularly for lower energies of the order of keV undetectable at balloon altitudes. In this paper we present the results of temporal and spatial variations of auroral X-rays with energies of greater than 4 keV measured by the sounding rocket S-310JA-7 launched from Syowa Station (69°00′S, 39°35′E) at 2215: 50 LT on March 27, 1978. The X-ray detector consists of a NaI(Tl) crystal, of 1-inch diameter and 2 mm thickness, and an RCA 2060 photomultiplier tube. This scintillation counter was mounted perpendicular to the rocket axis. One of the aims of the present X-ray measurement was to try to determine the absolute flight aspect of the rocket, after the S-210JA-3 rocket experiment in which the flight aspect was decided using two X-ray counters (KODAMA and OGUTI, 1976). From this situation the field of view of the present counter was focused as small as $\pm 5°$. The period when the rocket was flying coincides with the substorm expansion phase of $\Delta H \simeq 740\gamma$. Riometer records of 30

MHz cosmic noise absorption at Syowa Station showed intense absorption of 3.9 dB in maximum at 2217 LT. Also, the auroral 5577 Å line intensities observed on the ground revealed about 30 kR and 10 kR in the ascending and descending phases of the flight, respectively.

2. Results

Figure 1 shows the entire intensity-time profile of auroral X-rays, where 1-s count-

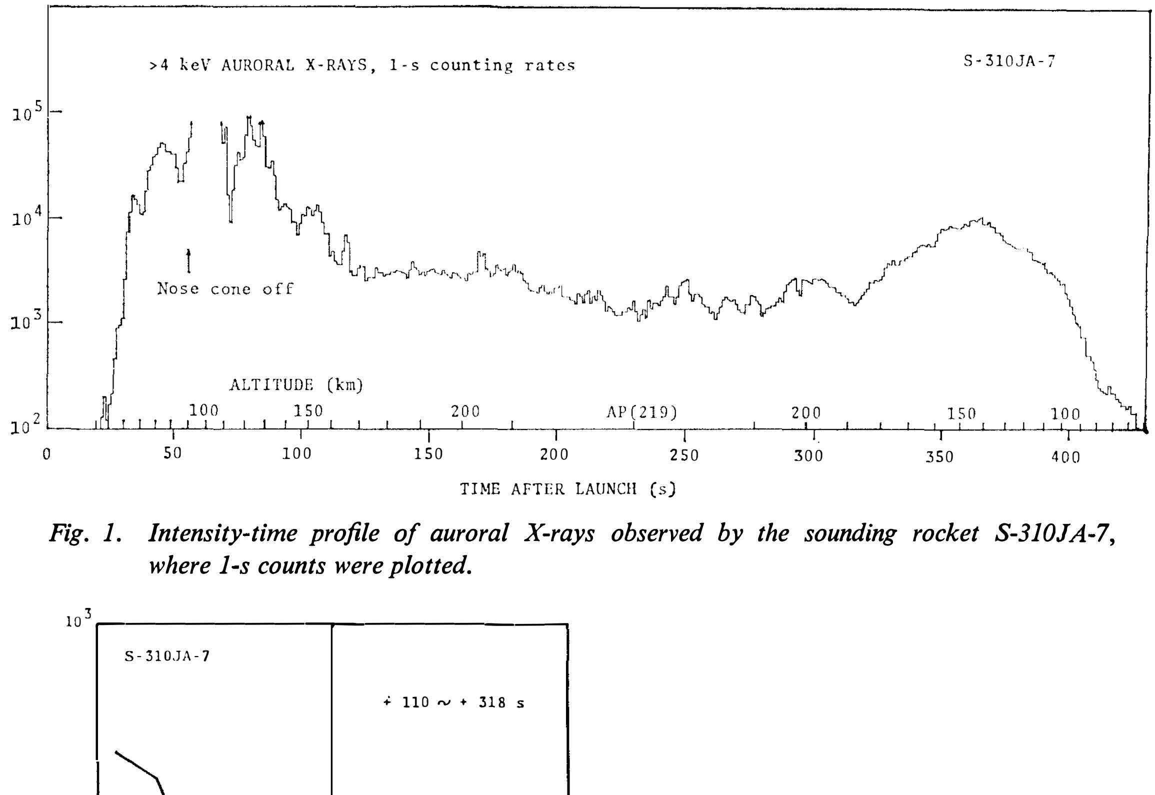

Fig. 1. Intensity-time profile of auroral X-rays observed by the sounding rocket S-310JA-7, where 1-s counts were plotted.

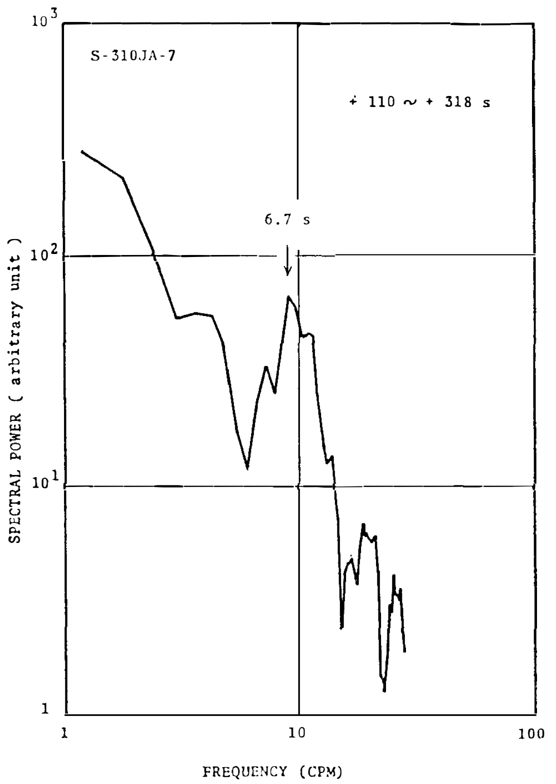

Fig. 2. Power spectrum computed for 208-s interval of pulsating X-rays. Only the peak around the frequency of 0.9 CPM is statistically significant.

ing rates are plotted to represent the gross feature of variations free from the spinning modulation. X-ray fluxes became saturated three times immediately after taking off the rocket nose cone, due to the limited telemeter response; during 56–68 s, 78–79 s, and 83–84 s after launch. The greatest enhancement of fluxes as these was followed by somewhat moderate intensities during the period from about 110 s to about 310 s, and thereafter the second dull hump was recorded. It is evident from Fig. 1 that there are quasi-periodic fluctuations of X-rays during this intermediate time interval. In Fig. 2 is shown the result of power spectrum analysis carried out using 0.1-s counting rates for the time interval from 110 s to 318 s. The enhanced spectral power is found around the frequency of about 0.9 CPM, corresponding to 6.7-s period, beyond the general form of approximately f^{-2}, f being frequency. During this time interval the rocket altitude changed from 160 km to 185 km *via* the maximum height of 219 km.

3. Discussion

First, let us examine the relation between the gross time variation of X-rays and the auroral luminosity. Figure 3 illustrates a contour map of auroral 5577 Å line intensities which was composed by the meridian scanning-photometer measurement at Syowa Station, where one scan needs 30 s and a lower border of auroral height is assumed to

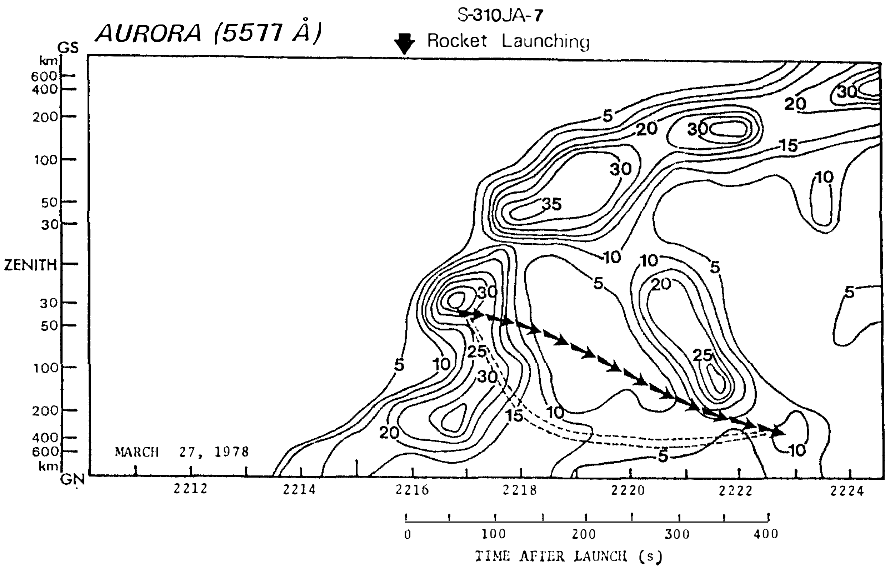

Fig. 3. Auroral intensity at a wavelength 5577 Å observed by the meridian scanning photometer at Syowa Station during the S-310JA-7 rocket experiment (after T. HIRASAWA). The rocket trajectory is projected onto the 100 km height along the geomagnetic field line, shown by successive arrows. Also traces of viewing-fields of the X-ray counter on the 100 km height level are shown by parallel dashed lines.

be 100 km altitude. Also is plotted the trace of viewing-fields of the X-ray counter projected on the 100 km height plane. As clearly seen in the figure, the ascending rocket happened to encounter with the 25–35 kR arc region during the flight time of about 60–90 s, when the first extremely intense hump of X-rays was recorded. After the split of this arc into two arcs, southward and northward, the descending rocket again encountered with the northward-moving 10 kR arc, when the second X-ray hump was observed. There is, therefore, a very good correlation between the gross profile of auroral X-ray fluxes with energies of greater than 4 keV and the 5577 Å line intensities. This means that the gross profile is not temporal but spatial.

The 6.7-s periodic fluctuations of X-rays were found in a diffused auroral region with brightness of less than 5 kR. We note that no spinning modulation of X-rays appeared during the period when the quasi-periodic fluctuations were observed. In other words, the spatial distribution of X-rays was not directional but rather uniform during this time interval. It is of interest to note that 5–330 Hz electron density fluctuation simultaneously measured on board is pronounced during the same time interval (OGAWA *et al.*, 1981), as well as the AC electric field fluctuation (YAMAGISHI *et al.*, 1981). Precipitations of energetic electrons associated with pulsating aurora occur in early morning sector and energetic electrons with energies of a few tens of keV are predominant in individual peaks of the fluctuations (SANDAHL *et al.*, 1980). Though the present pulsating X-ray event occurred near the midnight, it seems a typical example of auroral pulsations observed at rocket altitudes.

The authors wish to express their hearty thanks to all members of the 19th Japanese Antarctic Research Expedition wintering party for their efforts in performing the rocket experiment.

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(*Received August 2, 1982*)