THE OBSERVATIONS OF THE SUBAURORAL NONTHERMAL RADIO EMISSION BY AKR-X RECEIVER ON BOARD OF THE INTERBALL SATELLITE

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Abstract

Since the operational function of the INTERBALL (Tail Probe) satellite in August-December 1995 the spectrum-analyzer AKR-X registered about 80 events of the subauroral nonthermal radio emission (SANE) at a specifically installed frequency 1463 kHz. Because of the peculiarity of the highly eccentric orbit of the satellite (it was launched in the morning sector and its apogees were changing in this period from 7 to 21 hours local time) the observations of SANE present a complete set of events in a defined sector of generation and emission.

For the first time SANE was observed in the AKR-2M experiment on board of Prognoz-10 satellite in 1985 at a frequency of 1486 kHz. The observations of the present AKR-X narrow-band and beamed emission, recorded from August through December 1995 is an important confirmation and addition to the results of Prognoz-10. Some SANE emission characteristics and future perspectives are briefly addressed.

1 Introduction

On board of the satellite INTERBALL, launched in August 3, 1995, the Russian-Slovak experiment AKR-X investigates the radio emission in the range of hectometric and kilometric wavelengths. One of the most important aims of this experiment is the confirmation and further investigation of the subauroral nonthermal radio emission observed earlier on the Prognoz-10 satellite.

In Table 1 the orbital elements of the INTERBALL (Tail Probe) satellite are summarized. The satellite orbit is highly eccentric, and the apogee moved from 7 hours LT to 21 hours LT, within the period of August through December 1995.

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Table 1: Elements of INTERBALL orbit.

Semimajor axis:	103276.5 km
Eccentricity:	0.93053
Argument of perigee:	314.0 °
Inclination:	62.8 °
True anomaly:	5.3 °
Period:	91.7 hours
Apogee height:	796.7 km
Perigee height:	193000.3 km

Among other instruments, the AKR-X experiment enables the measurement of electromagnetic waves with fixed frequencies over a broad frequency range. The spectrum-analyzer AKR-X is a 6-channels receiver with fixed frequencies 100, 252, 500, 749, 1463 and 1501 kHz. The frequency bandwidth is 10 kHz with a dynamic range of 80 dB and a time resolution of 0.2 sec. The antenna magnetic loop (area of 1.5 m^2) is electrostatically screened and only electromagnetic modes of the emission can be recorded. The maximum sensitivity of the receiver is about 10^{-19} W m^{-2} Hz^{-1} at a frequency of 749 kHz. The AKR-X receiver consists of two blocks, one for the receiver and the other for the antenna preamplifier (see Figure 1).

The telemetric information can be registered with a time interval of 1 or 2 sec and is transmitted at the time of transfer sessions after data accumulation in the memory system of the satellite. More detailed information about the receiver AKR-X can be obtained in Fischer et al. [1985], and Grigor'eva et al. [1995].

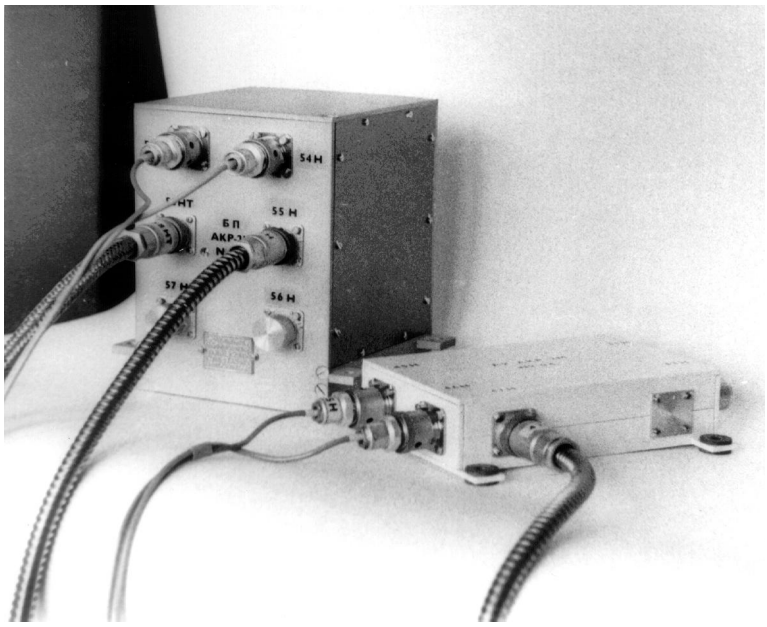

Figure 1: Receiver and antenna preamplifier of the AKR-X experiment.

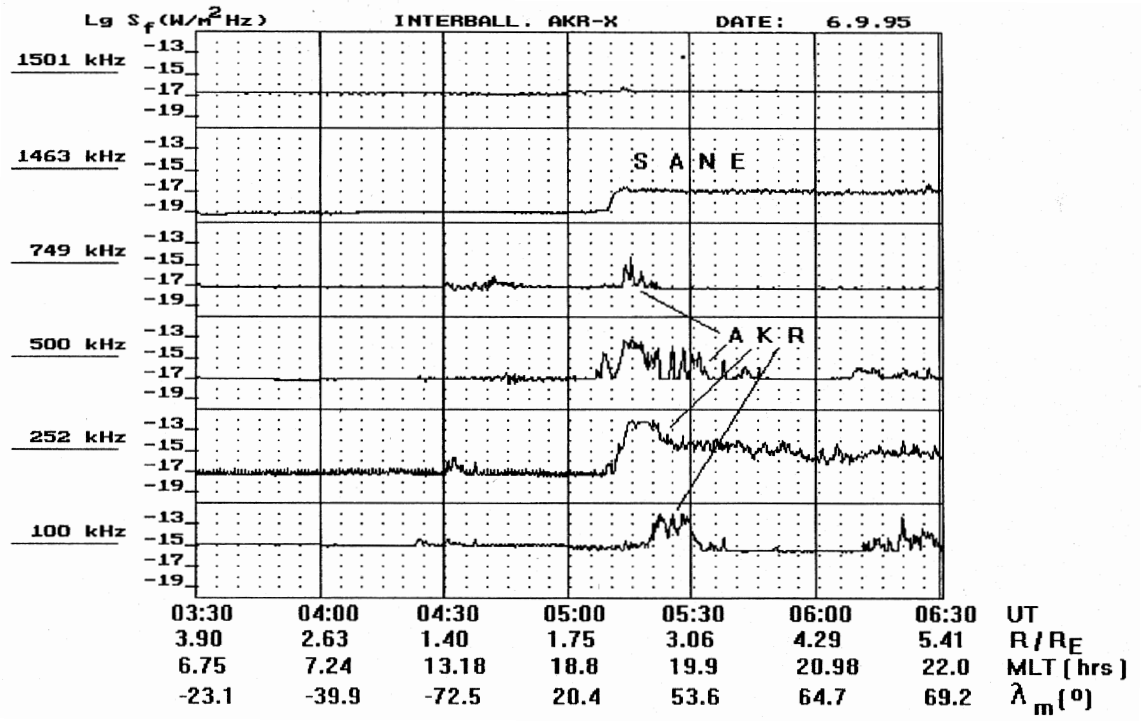

Figure 2: The registration of the Auroral Kilometric Radio emission (AKR) and SubAuroral Nonthermal Emission (SANE) after the passage of the perigee September 6, 1995.

Especially for the investigation of the subauroral nonthermal emission (SANE) apart the channel with frequency 1501 kHz, an additional channel with the frequency 1463 kHz has been installed. Corresponding observations and interpretations are subsequently described.

2 Subauroral Nonthermal Emission (SANE)

The observations are a prolongation of corresponding observations of SANE in the experiment AKR-2M on board of the satellite Prognoz-10 (Project INTERSHOCK) in 1985, when radio emission was discovered at the frequency 1486 kHz. First results were published by Kuril'chik et al. [1988]; more detailed consideration of the observations and general characteristics of SANE are given by Kuril'chik et al. [1992a,b,c].

The observation of the beamed SANE on board of Prognoz-10 at large distance from the Earth (up to 32 R_E) was terminated in November 1985 when the apogee of this satellite was located at about 6 hours local time (LT). Thus, the character of the spreading of SANE at LT $<$ 6 hours could not be studied. But from the observations close to the Earth (in the perigees) it was clear that the source of SANE is extended sometimes from 19–20 hours to 7–8 hours magnetic local time (MLT) [Kuril'chik et al., 1992a,b].

The INTERBALL satellite exhibits a very eccentric orbit (apogee 42° N at the distance of about 31 R_E), but this initial apogee had a location of about 7 hours LT. In the period August–December 1995 the apogee moved from 7 to about 21 hours LT, i.e., in the sector

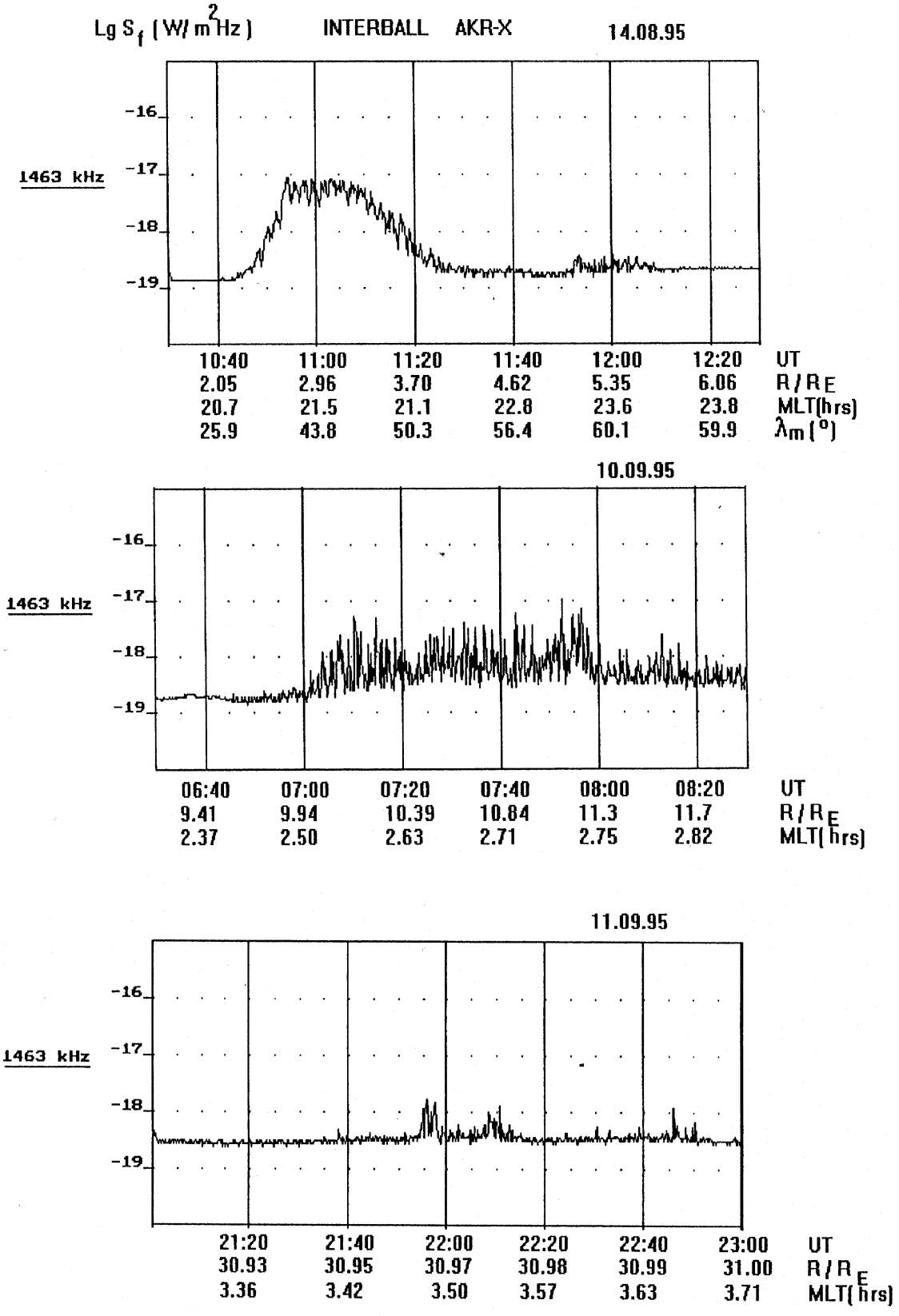

Figure 3: Examples of the recording of beamed SANE at frequency $f = 1463\,kHz$ at different distances from the Earth in the Northern hemisphere.

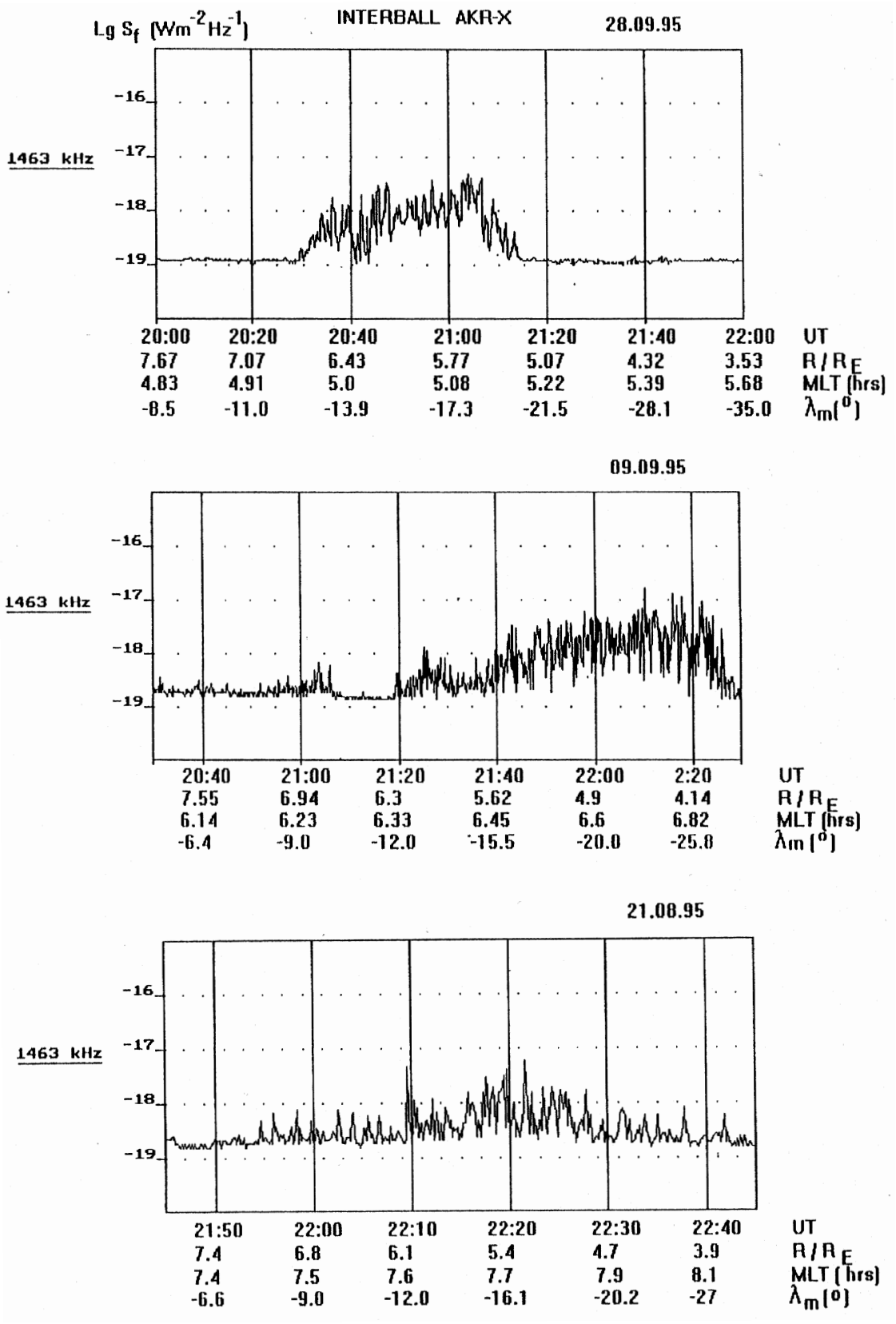

Figure 4: The beams of the SANE observed in the Southern hemisphere before the passage of the perigee.

of the terrestrial magnetosphere where SANE is generated within the inner magnetosphere and then spread off the Earth. Indeed, only at this specific period of time SANE was regularly observed by the experiment AKR-X at a frequency of 1463 kHz, close to the Earth and far away from the Earth, up to a large distance of 31 R_E.

Figure 2 shows an example of the registration of different radio emissions in all 6 channels at the perigee on September 6, 1995. First, immediately after 4 : 30 UT, one can see weak emissions observed at frequencies 252 kHz and 749 kHz within the plasmasphere and then, after 5 : 05 UT, powerful AKR and SANE emissions appear. Regretfully, the channel 1501 kHz is strongly and steadily influenced by interference of other devices and service systems and, therefore, cannot be used for SANE registration.

Figure 3 displays some examples of the registration of SANE at different distances from the Earth in the Northern hemisphere. Figure 4 represents the comparatively rare events of beamed emission registered in the Southern hemisphere close to the Earth before the passage of the perigee ($-42°$). One can easily see from both figures that the SANE emission has a pulse-noise bursty character. But at times of large intensification of emission these pulses are superposed in a practically steady flux of emission (see Figure 2, SANE channel with frequency f = 1463 kHz).

The subauroral emission was regularly registered from August through December 1995, and showed the same dependence from universal time (UT) (from the position of the magnetic pole of the Northern hemisphere in relation to the tail of the terrestrial magnetosphere) as the emission discovered earlier on board of Prognoz-10 [Kuril'chik et al., 1992a,b,c]. The observations on board of INTERBALL satellite covered all local times of SANE generation and spreading. Figure 5 shows the occurrence and intensity of the beams of the SANE emission in September 1995. At the left side of Figure 5 the diurnal sum of the K_p-index of geomagnetic activity can be seen. The occurrence and intensity of the emission is correlated with this activity as also evidenced by Prognoz-10. Analogous dependencies occur in August and October 1995. In November 1995 only 5 weak events have been observed due to very low geomagnetic activity during this month. In December 1995 the number of events was again large, but because of the gradual shift of the satellite apogee outwards from the sector of the spreading of SANE only traces of very weak scattered emission were registered.

Figure 6 presents the intensity histogram of the occurrence of SANE in UT for all periods of observations from August through December 1995. Most of the events, the more intense have been observed between 6–12 hours UT. *This is approximately the time interval*

Figure 5: (plate, next page) SubAuroral Nonthermal Radio Emission (SANE) in September 1995 (INTERBALL, AKR-X).

Figure 6: (plate, following page) The dependence of the probability of SANE appearance from UT in August - December 1995. N denotes the number of events, and the coded areas represent different total flux S_f for the frequency $f = 1463$ kHz.

when the magnetic pole of the Northern hemisphere passes into the nightside of the magnetosphere. A second maximum between 21 and 24 UT consists of very weak and narrow beams.

3 Conclusion and Future Perspectives

This preliminary study of AKR-X experiment results provides evidence of similar observations as performed by PROGNOZ-10. The subauroral nonthermal emission (SANE) apparently differs from AKR emission features, apart from the high frequency well above usual AKR frequencies. SANE occurrence, specifically its intensity, is obviously correlated with magnetic storm activity.

The tailprobe AKR-X experiment is still fully operational and will be prolonged two more years (probably until 1999). The inclusion of measurements performed by the AURORAL Probe will definitely improve the data analysis, as well as the comparison with appropriate Wind/WAVES data.

One important investigation which has to be done is the direction finding of the SANE emission for the determination of its source location. This implies the consideration of the frame antenna directivity, emission intensity variation due to the spinning satellite and possible radio horizon constraints. Further studies should also include investigations on the influence of external control (e.g. solar wind, internal magnetospheric dynamics) on SANE for providing clues to the energy input and generation mechanism.

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