INSTANTANEOUS AKR EMISSION CONE

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Abstract

Simple model of AKR visibility based on the rectilinear propagation approximation has been applied to the data collected by Interball–2 spacecraft. For some cases lowest observed frequency on the AKR dynamical spectra coincides with rays azimuthal angles (with respect to the magnetic shell passing through the source) going across 0 or $180°$. In such cases only radiation produced on the same side of the magnetic shell can be observed.

1 Introduction

The problem of directivity and detailed form of AKR emission cone has not been solved until now. The classical paper by Green et al. [1977] takes into account values of AKR emissions averaged over many months washing completely out any individual characteristics of single AKR events. Their results suggest filled emission cone with opening angle changing with AKR emission frequency. On the other hand Louarn and Le Queau [1996] propose strongly anisotropic AKR directivity pattern. The situation is additionally complicated due to the departure of radiating AKR cavity walls from geometry of parallel planes taken practically as a de facto standard in AKR generation discussions. Such departures are strongly suggested by curled forms of auroral arcs.

2 Data

For the purpose of this paper the subset (32 cases) of data used in Hanasz et al. [2001] has been analyzed. Cases were chosen for simple and compact auroral structures seen on Polar UVI images. AKR data correspond to the AKR bursts - sudden, wideband emissions, well localized in time. There was no specific intention in choosing exactly that sort of data - the present paper can be regarded as a byproduct of the paper by Hanasz et al. AKR data were collected onboard Interball–2 s/c with POLRAD experiment - a step frequency analyzer, swept over one of 2 frequency ranges: 4 kHz - 1 MHz, or 4 kHz - 0.5 MHz, with repetition periods of 6 or 12 s and a frequency resolution of 4.096 kHz [Hanasz et al., 1998]. UV images were collected by UV Imager onboard Polar s/c [Torr et al., 1995].

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3 Method

The geometrical analysis proposed in the paper needs as input data the position of s/c in a given moment as well as the position of the AKR source. While the s/c positional data are easily accessible, the position of the AKR source must be measured using direction finding capabilities of the antenna system [Calvert, 1985; Huff et al., 1988] or must be deduced for instance from positions of bright auroral structures. It has been already shown by Huff et al. [1988] that magnetic field lines passing through the AKR source terminate at bright auroral structures. Hanasz et al. [2001] reported recently association of wideband AKR bursts with UV auroral bulges and Liou et al. [2000] discussed relative timing between sharp AKR enhancements and auroral breakups. It is the deduction of AKR source position from the localization of isolated bright structures seen in UV on the auroral oval which has been adopted in this paper. Invariant Latitude (InvLat) and Magnetic Local Time (MLT) of the center of bright structure define single field line on the magnetic shell labeled by InvLat. On that line one can determine positions corresponding to the AKR emission at a given frequency - assuming AKR generation is taking place at a frequency close to the local electron gyrofrequency. By introducing small MLT range it is possible to define for each frequency a vector normal to the surface element of the magnetic shell. Another normal vector we need, is perpendicular to the plane defined tangent to the local magnetic field line at the source and line from the source to the s/c. The angle between these two normal vectors is called azimuth - it equals 0° or 180° for rays tangent to the surface of the magnetic shell passing through the AKR source. The second angle used in the paper - between tangent to the local magnetic field line at the source and the line from the source to the s/c is called emission angle. Conventions used are as follows:

1. Azimuth angle for the Northern Hemisphere equals 0° for rays emitted toward the local West direction at the source and 180° for rays going East.

2. Emission angle for the Northern Hemisphere for the s/c hovering above the AKR source is smaller than 90°.

For all 32 cases azimuth and emission angle have been calculated as a function of AKR emission frequency providing that the sources were localized on single magnetic field lines (data corresponding to relatively compact auroral structures on UVI images have been selected). All the calculations were made for the centered magnetic dipole field approximation.

4 Results

The analyzed data sample incorporated 32 AKR bursts cases registered by POLRAD from December 1996 to March 1997. For 6 cases unusual coincidence has been detected - lowest frequency in the AKR dynamical spectra corresponded to the azimuth angles close to 0° or 180°. Three such cases are shown in Figures 1–3. Please note the numerical
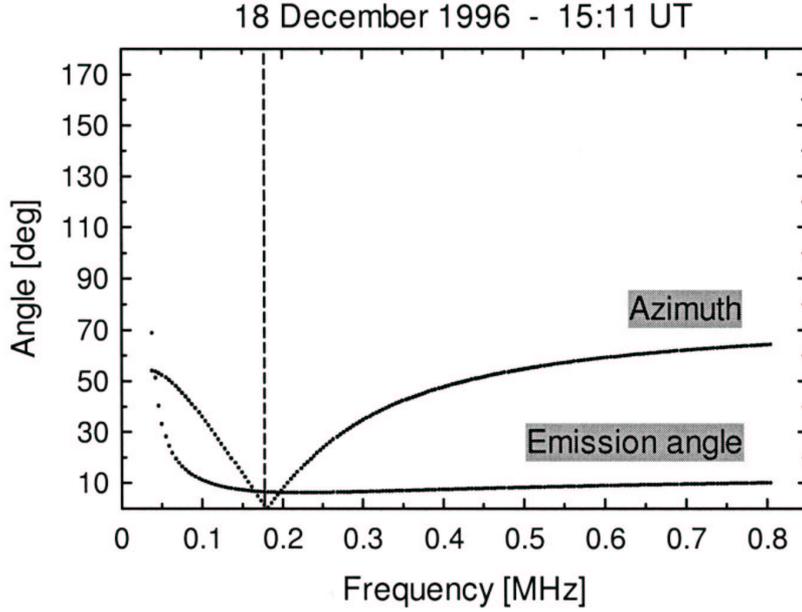
18 December 1996 - 15:11 UT

Figure 1: Example of azimuth and emission angles as a function of AKR emission frequency calculated for a magnetic field line passing through the AKR source. The dashed vertical line corresponds to the lower frequency AKR cutoff determined from the POLRAD dynamical spectrum. Azimuth angle passes the 0° mark.

artefact - close to 0° or 180° azimuth is continuous, the cusps result from the ACOS function implementation. For all 6 cases small emission angles (of the order of 10°) have been observed.

5 Discussion and conclusions

The simple model employed in this paper is purely geometrical, it does not depend a priori on details of AKR generation process. The simplest interpretation of the disappearance of AKR emission below some frequency exactly at the moment when the rays are parallel to the magnetic shell passing through the source is the supposition that we can see only ONE SIDE of the source. For all 6 cases where the s/c is located north with respect to the AKR source we see the southern part of the magnetic shell. In other words: The AKR emission may not cover a full range of azimuth angles, as it has been suggested by Louarn and Le Queau [1996]. The present study is very preliminary and should be extended in order to address the directivity question more properly. In particular some questions cannot be answered at the moment:

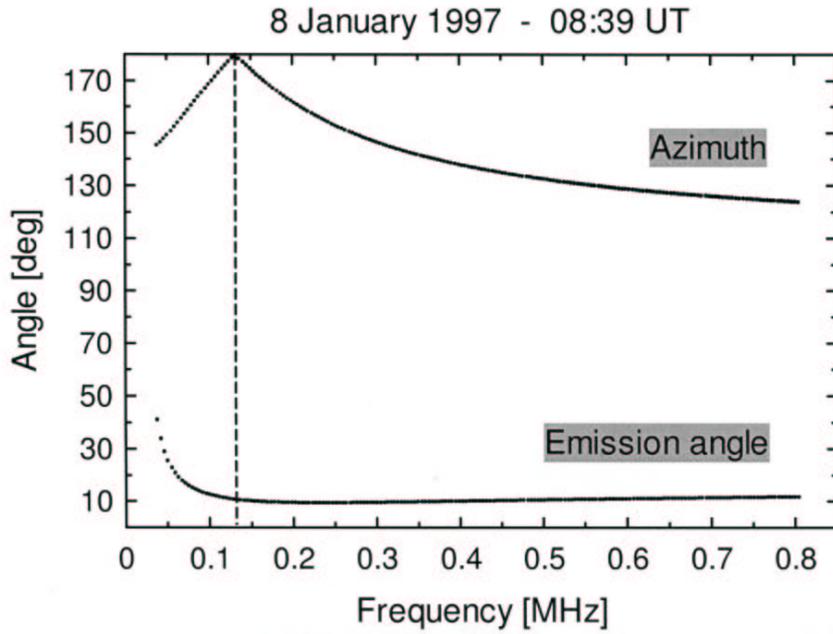1. Is the ∼ 10° emission angle a necessary condition for AKR cutoff when passing 0° or 180° azimuth angle?

8 January 1997 - 08:39 UT

Figure 2: Another example. Azimuth close to 180°.

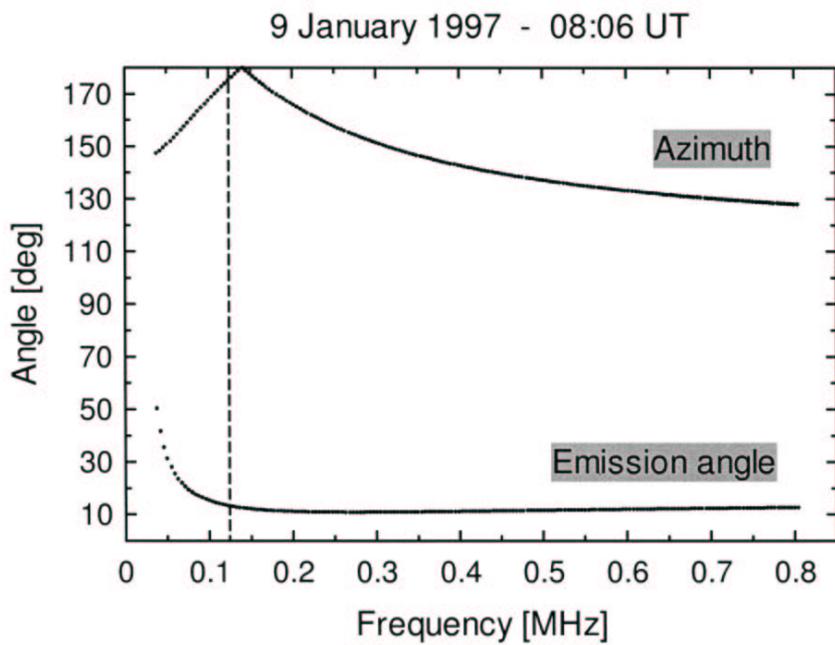**9 January 1997 - 08:06 UT**

Figure 3: Sometimes agreement is not so perfect....

2. What role plays the specific geometry of Interball–2 orbits, mostly parallel to the auroral oval with a well defined peak around 70° of InvLat?

3. What about passing 0° or 180° azimuth angle when AKR is still present - does it relate to curved walls of AKR generation cavity?

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