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The radiation pattern of Auroral Kilometric Radiation

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Abstract

The radiation pattern has been determined on the basis of the comparative analysis of auroral kilometric radiation (AKR) received in the space-diversity mode simultaneous by two satellites, Interball-2 and Polar. The radiation propagates in a cone with an opening angle ~± 25° and the axis aligned with the local magnetic field. The results confirm the theoretical estimates that the source boundaries play a significant role in the generation of the auroral kilometric radiation and in the formation of the radiation pattern.

1. Introduction

Auroral kilometric radiation (AKR) detected for the first time by the Electron satellite is the most intense radio radiation generated in the Earth's magnetosphere. Wu and Lee proposed a mechanism for generating AKR through the development of the cyclotron maser instability in the auroral regions of the magnetosphere with a low plasma density (in the Calvert cavity), where the condition $\omega p/ \omega_B$ <<1 is satisfied (here, ωp and ω_B are the plasma frequency and electron gyrofrequency, respectively). This mechanism provides an explanation of a number of AKR features, in particular, the dependence of the AKR intensity on the geomagnetic activity,
the polarization, the frequency spectrum, etc. According to the proposed mechanism, the radiation flux should be maximal in the direction outward from the Earth at angles of 60 °–80 °
with respect to the local magnetic field.
The problem of the generation of AKR in a spatially bounded region and the effect of the cavity boundaries on the formation of the AKR spectra was considered by P.Loarn and T.Burinskaya. The general dispersion relation for waves propagating at an arbitrary angle to the magnetic field was derived by T.Burinskaya for a source whose transverse size exceeds the wavelength of the excited radiation. Analysis of the numerical solution of the dispersion relation revealed the presence of a distinct propagation angle for which the increment is maximal in the plane perpendicular to the magnetic field, while a sufficiently large wave vector projection onto the magnetic field direction ensures a sufficiently large time of wave propagation inside the source and, correspondingly, a significant increase in the gain. Thus, the AKR propagates from the source in a cone whose generatrix makes a sufficiently large angle with the plane perpendicular to the magnetic field. The cone-opening angle is to a certain extent governed by the source size.

2. Results of measurements

Was used the results of observations of the AKR in two experiments, POLRAD on the Interball-2 satellite and PWI on the Polar satellite to experimentally test the effect of the boundaries of the generation region. The analysis was done for the time interval of simultaneous measurements by two satellites when the Interball-2 satellite was located equatorward an extended polar auroral arc at altitudes ~15000–18900 km from the ground and the Polar satellite was poleward this arc at altitudes ~45000–47000 km. Both satellites moved in such a way that they were located for a long time on the same geomagnetic meridian. This makes it possible to consider the two-dimensional problem and, thereby, to simplify experimental data processing.
Using the difference in the AKR spectra detected by two satellites, we calculated the radiation pattern of the AKR source. The radiation pattern was calculated under the following assumptions: (i) the radiation pattern is symmetric with respect to the local magnetic field in the polar and equatorial directions and (ii) the radiation pattern source extended over the longitude: (i) the AKR radiation pattern is directed along the magnetic field in the source and (ii) the full width of the radiation pattern of the stationary AKR source amounts to ~± 25°. The feature of our approach in comparison with the methods used earlier is the possibility of determining not only the radiation pattern boundary, but also the spatial position of the AKR source. Therefore, we conclude

that the boundaries of the generation region play the crucial role in the formation of the AKR flux.

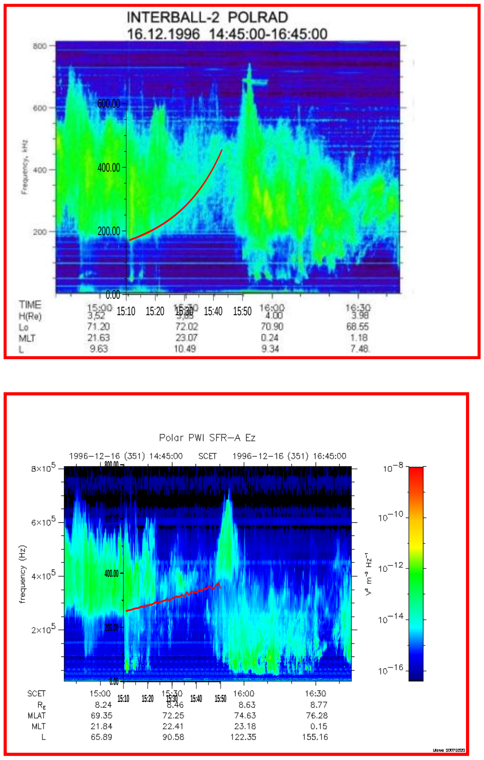

Figure 1: Comparison of the INTERBALL-2 and Polar satellites AKR measurements with the result of calculation (superposed red curve). Was found good agreement between variation of AKR low cut-off frequency and results of calculation.

3. Conclusions

Stable AKR source was located on the magnetic field line, conjugated with visible aurora and its position was shifted to the polar side from the middle of arc.
The longitudinal dimension of stable source was significant greater then latitudinal (hundreds and tens km respectively).
Life time of stable source was more then 30 minutes.
The opening of emission pattern at the frequency 260 kHz was about $\pm 25^0$ relative to the local magnetic field direction.

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