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Two coordinate systems - two visibility diagram types for AKR directivity determination

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Abstract

The concept of visibility maps for Auroral Kilometric Radiation (AKR) introduced by Mutel et al. [2] and based on Tangent Plane coordinates can be refined and extended to maps based on spherical coordinates. Spherical coordinate system permits to easily identify AKR beams deflected significantly from Mutel's Tangent Plane and in a natural way completes Tangent Plane coordinates.

Introduction

In the recent paper Mutel et al. [2] presented direct measurements of Auroral Kilometric Radiation (AKR) beaming pattern for individual AKR bursts using direction finding capabilities of WBD receivers located on four CLUSTER mission satellites. For description of strongly beamed AKR radiation authors proposed a Tangent Plane (TP) coordinate system: *an orthonormal 3-dimensional coordinate system with origin at the source, $\vec{x}$ aligned outward along the magnetic field direction, $\vec{z}$ in the meridian plane pointed toward the local magnetic pole, and $\vec{y} = \vec{z} \times \vec{x}$. The tangent plane latitude is the angle between the spacecraft vector and the tangent (xy) plane, while the longitude is the angle between the spacecraft vector projected onto the tangent plane and $\vec{x}$.* Such system is working well for AKR beams tangent to the auroral oval (or strictly speaking to the line of constant magnetic latitude), but is not so well suited for identification of oblique or transversal AKR beams produced in cavities not aligned with lines of constant magnetic latitude. That such beams exist can be seen in paper by Menietti et al. [1]. Authors successfully modeled AKR dynamic spectra for sources confined to auroral arcs deflected from constant magnetic latitude circles.

New coordinates

In this note a spherical coordinate system with symmetry axis aligned with local magnetic field line direction at the AKR source is presented. Corresponding angular coordinates are: emission angle measured with respect to the direction of the local magnetic field (upwards) and azimuth measured with respect to the direction tangent to a circle of constant magnetic latitude.

What does it look like...

For a given spacecraft position measured in the centered dipole magnetic coordinates and for a given AKR emission frequency, analytical formulas for corresponding angles in both coordinate systems have been derived. Angles corresponding to direction to the spacecraft have been calculated for alleged AKR sources located on a bunch of magnetic field lines covering invariant latitudes from $50°$ to $90°$ and full MLT range. Lines of constant angular coordinates have been projected on Invariant Latitude - MLT coordinate system.

Due to geometrical restrictions for AKR beams (as shown by Mutel et al. [2]) only some AKR sources located on the active parts of the auroral oval can be seen from a given spacecraft location. Figures 1 and 2 show generic visibility maps calculated for spacecraft position defined by radius vector equal to 22 364 km, magnetic latitude $51.7°$ and MLT 21.6 h. AKR sources are radiating at 325 kHz. For every position of the AKR source established in the Invariant Latitude - MLT coordinate system one can directly determine direction to the observer in both coordinate systems. Yellow areas on the maps correspond to AKR beams restricted in TP latitude or azimuth ($\pm 20°$ for both coordinate systems). For real AKR sources further restriction in TP longitude or emission angle can be expected due to strong refraction of the AKR ray paths at the source [2].

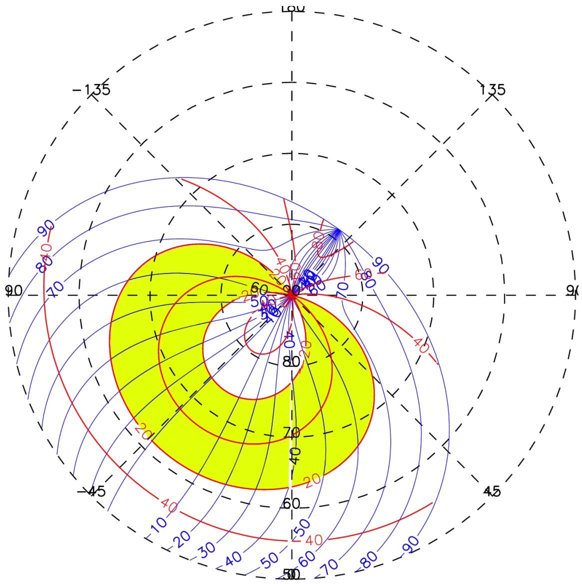

Figure 1: Example of generic AKR visibility map for TP coordinates. Blue lines - TP longitude [°], red lines - TP latitude [°], black lines - InvLat-MLT [°]. Yellow region corresponds to ±20° TP latitude range.

Acknowledgements

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References

[1] Menietti, J. D., R. L. Mutel, I. W. Christopher, K. A. Hutchinson, and J. B. Sigwarth (2011), Simultaneous radio and optical observations of auroral structures: Implications for AKR beaming, *J. Geophys. Res., 116*, A12219, doi:10.1029/2011JA017168.

[2] Mutel, R. L., I. W. Christopher, and J. S. Pickett (2008), Cluster multispacecraft determination of AKR angular beaming, *Geophys. Res. Lett., 35*, L07104, doi:10.1029/2008GL033377.

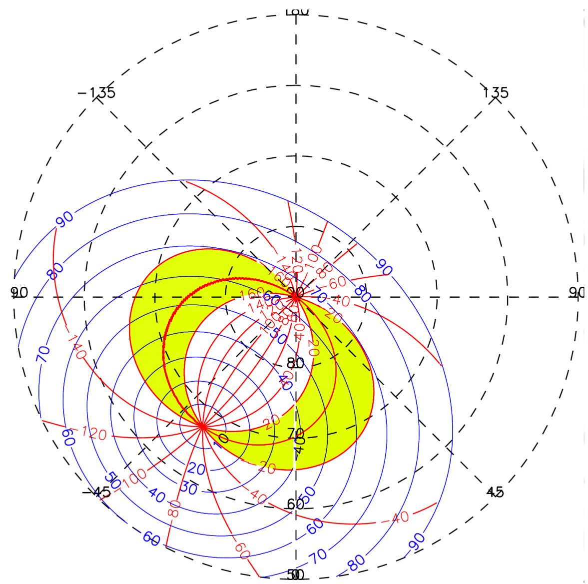

Figure 2: Example of generic AKR visibility map for spherical coordinate system. Blue lines - emission angle [°], red lines - azimuth angle [°], black lines - InvLat-MLT [°]. Yellow region corresponds to ±20° azimuth range.