

COMPARISON OF OBSERVED PARAMETERS OF THE SPECTRAL RESONANCE STRUCTURE WITH PREDICTIONS OF THE IONOSPHERIC ALFVEN RESONATOR THEORY

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Abstract

It is believed that resonance structures in spectra of the electromagnetic noise in the range of 0.1-10 Hz are the result of so called ionospheric Alfvén resonator (IAR). The IAR characteristics depend on ionosphere parameters above the observation point. Using the ionosphere model and ionosonde measurements we calculated frequencies of the spectral resonance structure (SRS) and compared them with those observed. In general, the calculations correctly reproduce the observations. This fact confirms the IAR theory.

Introduction

The existence of the ionospheric Alfvén resonator (IAR) was predicted theoretically by *Polyakov* (1976). *Belyaev et al* (1987, 1989a) discovered the resonance structure in the electromagnetic noise spectra in the range 0.1-10 Hz and related it with IAR. The spectral resonance structure (SRS) was first found at mid latitudes, and later in auroral zone (*Belyaev et al*, 1999) and at low latitudes (*Bösinger et al*, 2002). Comprehensive information on the SRS morphology was obtained from observations in the auroral zone (*Yahnin et al.*, 2001, 2002). The study by *Yahnin et al.* (2002), in which the monthly averaged parameters of observed SRS were compared with average ionosphere profiles taken from the ionosphere model, demonstrated that averaged characteristics and long term behaviour of SRS qualitatively agree with the IAR predictions. According to the IAR theory the SRS characteristics (e.g. eigenfrequencies) should depend on ionosphere parameters above the observation point. It is interesting to compare the observed SRS characteristics with the IAR theory for concrete situations. Such comparison has been already done by *Demekhov et al.* (2000) who considered two SRS events and made the calculations on the basis of analytical theory by *Belyaev et al.* (1989b). The result showed rather a good conformity of the observations with the theoretical estimates.

In this report we present the results of similar comparison, but on the basis of the numerical "full wave" algorithm by *Ostapenko and Polyakov* (1990). Using this algorithm one can calculate (for given height profile of the electron and ion densities) the reflection coefficient of the ionosphere. Typically it exhibits the resonance features, and the frequencies of the reflection coefficient maxima should correspond to the SRS eigenfrequencies. As to the ionosphere profiles needed for calculations, the IRI-95 model was used. The model provides users with the ionosphere height profile of the electron and ion density for the given time and place. In addition the model has an option to adapt the profile to some measurable parameters (e.g. maximal electron density in the F region, which can be measured by the ionosonde).

Observations and comparison with calculations

Figure 1 and 2 present spectrograms of geomagnetic fluctuations measured by the search coil magnetometer in Sodankylä Geophysical Observatory (SGO), Finland. The spectrograms of the total power, as well as the left and right polarized signals are shown for January 7-8 and March 7-8 1996. In the bottom of the Figures the frequencies of two first maxima of the reflection coefficient are shown. The thick line presents the frequencies calculated using the ionospheric profiles above Sodankylä obtained from the IRI-95 model. The diurnal behaviour of the frequencies corresponds to the behaviour of the SRS eigenfrequencies, which is well known from earlier studies. The frequencies increase in the night hours and decrease in the daytime. (Note that for SGO MLT=UT+1.5). However at any given time the calculated frequency values may significantly differ from the observed SRS frequencies. For example, at 5 UT of March 7 1996 the two first SRS frequencies are 1 and 2 Hz while the calculated frequencies are 2.5 and >4 Hz. In fact the data correspondence is better if the 4-6 hour time shift is applied to the calculated plot. Thus, in spite of the fact that implication of the IAR theory to the IRI model gives some similarity between the eigenfrequency estimate and real SRS, the significant discrepancies are also present. We suggest that the discrepancies are due to the difference between the real and model ionosphere parameters. In particular, we compared the electron density in the maximum of the F-region obtained from the model and that was revealed from the ionosonde observations in SGO. The solid line in Figure 3(a, b) shows the modelled electron density, and the crosses represent the density obtained from the measurements of the critical frequency f_0F_2 by the ionosonde. (The electron density is proportional to a square root of the critical frequency). The gaps in the observed density are due

to the lack of observations of the critical frequency. From Figure 3 one can see that the maxima of calculated density are indeed shifted relatively to the observed maxima in the observed daily variations. In addition, the maximum values differ. For example, at 15 UT of January 7, 1996 the calculated density maximal value is $3.5 \cdot 10^5 \text{ cm}^{-3}$. The observed maximal density is $7.5 \cdot 10^5 \text{ cm}^{-3}$. For March 7-8, 1996 the tendency is opposite - the calculated density is greater.

The ionosonde data were used to correct the ionosphere model. The procedure of the reflection coefficient calculations was applied to the adapted model, and the result is shown in the bottom of Figures 1 and 2 by crosses. The crosses exhibit a clear shift relative to the solid line, so the corrected data fit the observed SRS frequencies much better.

Conclusions

On the basis of the IAR theory and using the ionosphere model IRI-95 we calculated the IAR eigenfrequencies for several days of 1996 and compared those with the observed SRS frequencies.

We showed that the use of the model adapted to the really observed ionosphere parameter (the electron density in the maximum of the F region) allows one to correctly reproduce the observations.

This result confirms the suggestion that SRS is the consequence of the IAR existence in the ionosphere

Acknowledgements. We are grateful to the SGO staff for providing us with the good quality data of the search coil magnetometer and ionosonde. The work was supported by RFBR grant 01-05-64437 and INTAS 99-0335. N.V.Semenova also appreciates the RFBR grant 02-05-06228 for young scientists.

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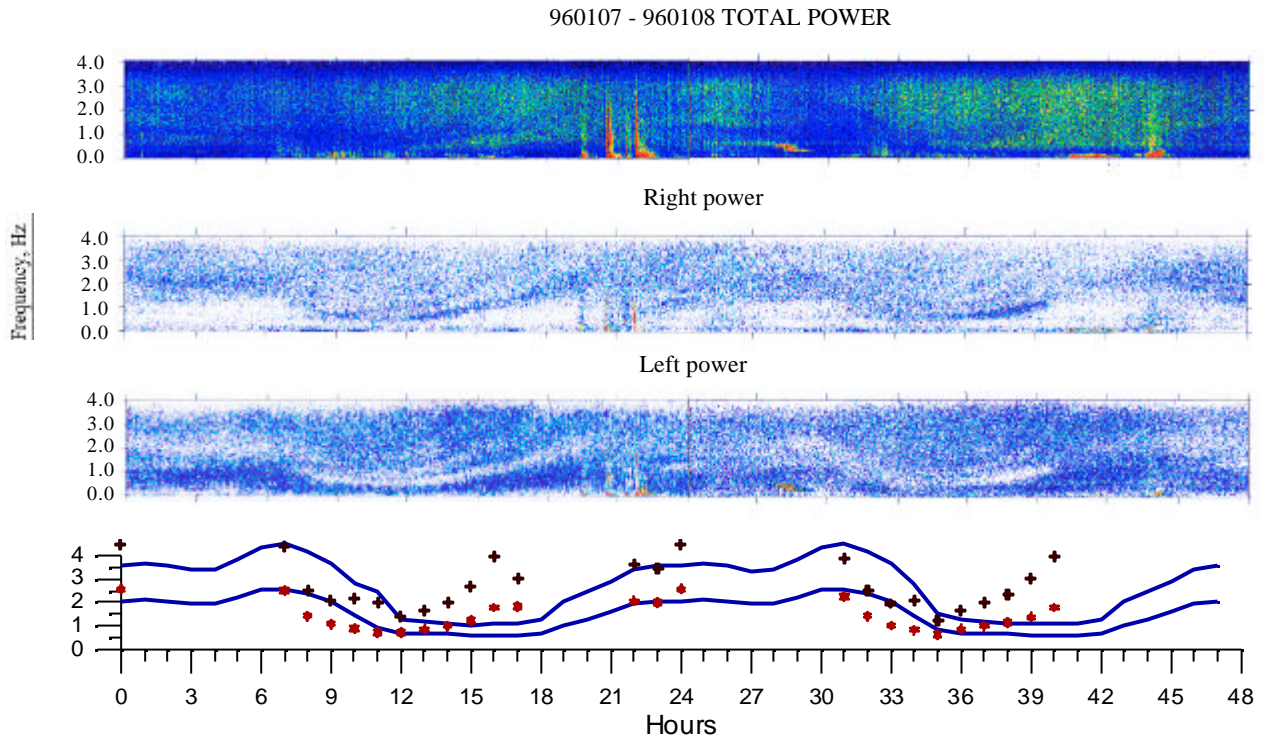


Figure 1. Spectrograms of the observed ULF magnetic noise variations in the range of 0 - 4 Hz in Sodankylä during two days (7-8 January 1996) as well as variations of the 1st and 2nd SRS harmonics calculated using the IRI-95 model on the basis of theory of ionospheric Alfvén resonator.

From top to bottom: total power, right and left polarized emissions, frequencies of 1st and 2nd harmonics (thick line) calculated on the basis the IRI model only, and frequencies of 1st and 2nd harmonics calculated using the ionosonde observations (stars and crosses).

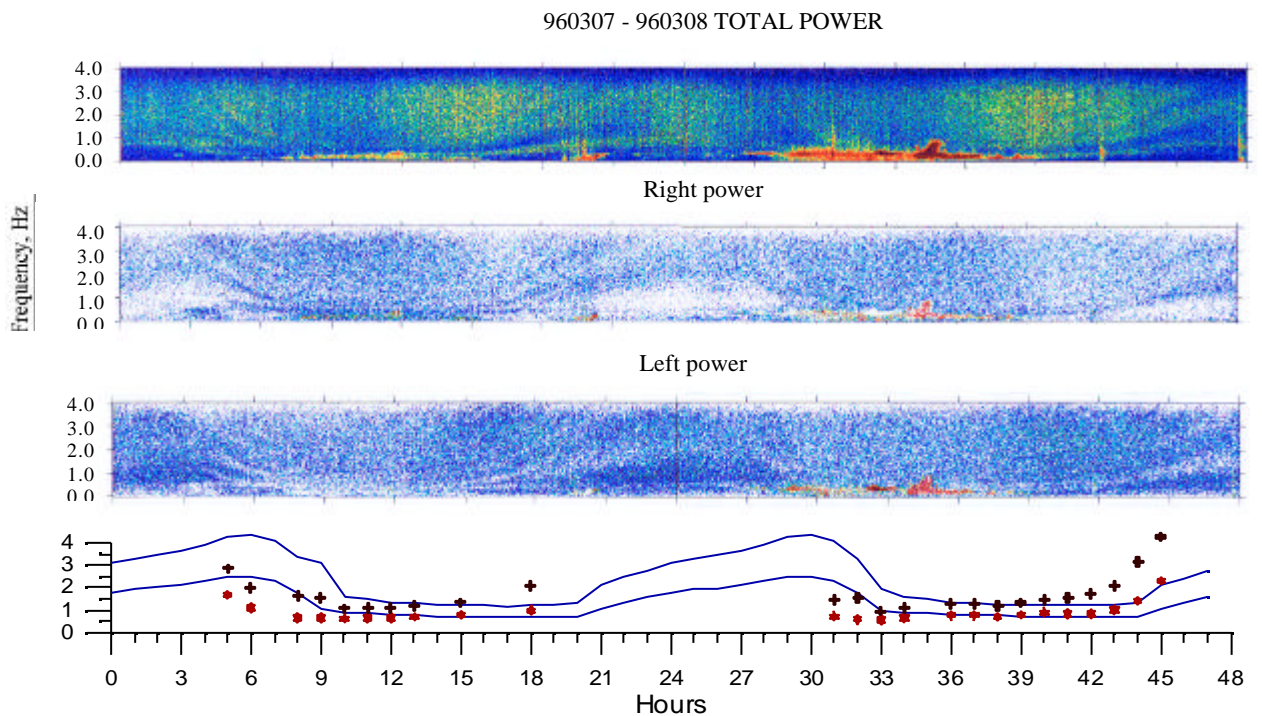


Figure 2. The same as Figure 1, but for 7-8 March 1996

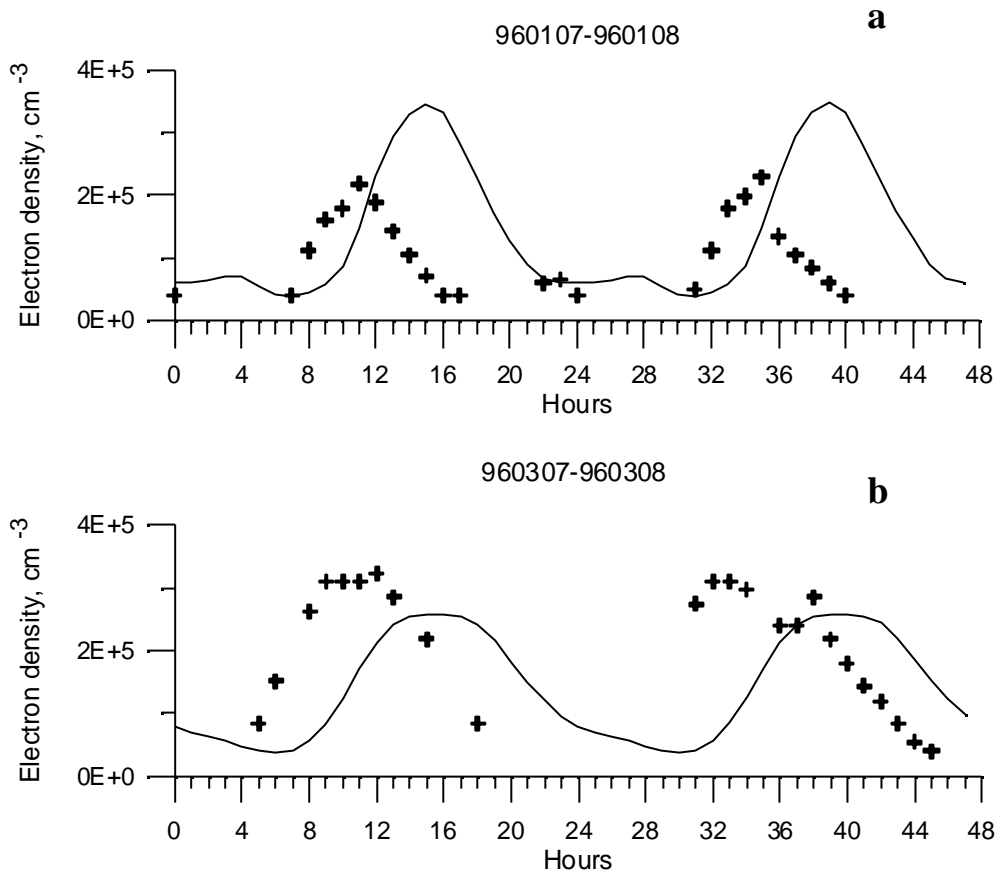


Figure 3. Comparison of the observed electron density in the maximum of the F-region in Sodankylä (crosses) and calculated electron density (solid line) for 7-8 January 1996 (a) and 7-8 March 1996 (b).