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Power spectra of ionospheric scintillations obtained from observations of Cygnus A on the radio telescope URAN-4

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There are many records of Cygnus A passages through the direction pattern obtained on the radio telescope URAN-4 during 1998–2004. Most of these show fluctuations in the flux density caused by ionospheric scintillations. The power spectrum is an important characteristic of the stochastic process and such processes are the main reason for the nature of scintillations. In this paper, estimations of the power spectra of ionospheric scintillations are made from the observations of Cyg A on the radio telescope URAN-4. Examples of the spectra are presented for observations under different circumstances and for several scintillation activity levels.

Keywords: Radio sources; Ionosphere; Scintillations; Power spectra

1. Introduction

To study the variability of cosmic radio sources, observations of four power radio sources were carried out during 1998–2004 on the radio telescope URAN-4 at two frequencies 20 and 25 MHz. The effects of ionospheric scintillations are very strong at these frequencies and it is necessary to take them into account during radio astronomy measurements. The radio source Cygnus A (or 3C405) is one of the strongest power sources at decametric waves. Like most extragalactic radio sources, 3C405 has a discrete component with angle size less then $1'$ and therefore it scintillates with the irregularities of the ionospheric plasma. The large amount of scintillation activity is the reason for using the records on 3C405 to study ionospheric scintillations. Considering scintillations as a stochastic process, we can estimate the power spectra as their very important characteristic, which allows us to investigate the dynamics of their behaviour.

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2. Observations and processing technique

To obtain the power spectra of ionospheric scintillations we used the records of source passages through the radio telescope URAN-4 direction pattern. The data were entered into the computer memory with an automatic system of recording; then they were processed and the results were saved in text files. The part that was associated with scintillations was distinguished by fitting to the theoretical direction pattern function in the observation record. The index S_4 of ionospheric scintillations was calculated from this number sequence. This procedure has been described in more detail in [1]. To find the power spectra, the fast Fourier transform was determined for the obtained scintillations [2].

3. Results

Figure 1 shows two examples of the records for radio source 3C405 obtained on the radio telescope URAN-4 for different values of the scintillations index. Such records are typical of this source in the absence of radio interferences. Graphs of the scintillations and their spectra on a logarithmic scale are plotted in figure 1. We can distinguish three parts of the spectrum in these cases: the low-frequency part caused by the Fresnel filter, the roll-off part associated with scintillations, and the high-frequency part corresponding to noise which is contained in the record. The change in the spectrum slope in the roll-off part indicates the change in the structure of ionospheric irregularities. Figure 2 shows the behaviour of the year-averaged scintillation index and spectrum slope calculated for 3C405 during 1998–2004 at a frequency of 25 MHz. The values of the scintillations index and spectrum slope change in the ranges 0.22 ± 0.12

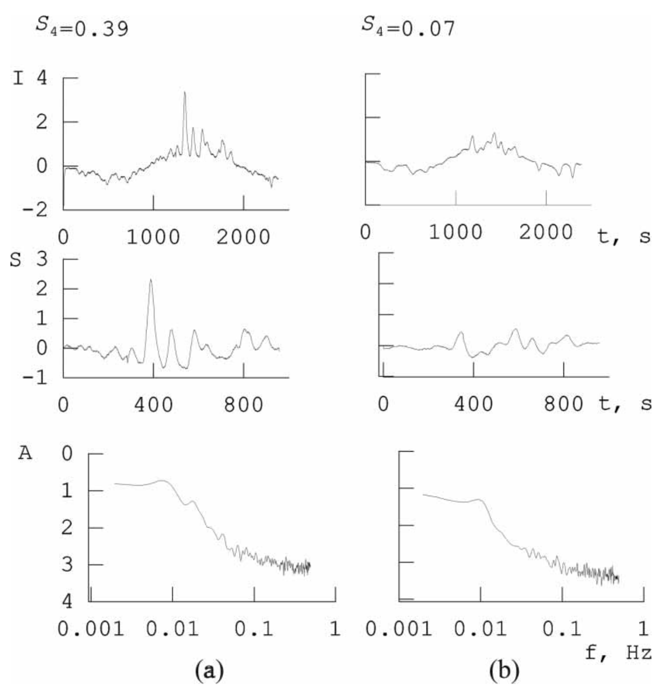

Figure 1. Two examples of the observation records I, scintillations S and their power spectra A for the radio source 3C405 at a frequency of 25 MHz for different values of the scintillations index: (a) 24 May 1999; (b) 28 My 2001. The values of the scintillations index S_4 for these dates are given at the top of the figure.

Figure 2. Year-averaged values of the scintillation index S_4 and spectrum slope p for the radio source 3C405 during 1998–2004 at a frequency of 25 MHz.

and 3.4 ± 1.8 respectively, which coincide with the values obtained in [3]. It should be noted that the graph of the spectrum slope follows the graph of the scintillations index. Both values reach their maxima in years of high solar activity, which may be the reason for the behaviour of ionospheric scintillations.

4. Conclusions

Examples of the scintillations spectra of the extragalactic radio source Cyg A which scintillates owing to the ionospheric irregularities are considered. The behaviour of the year-averaged values of the scintillations index and scintillations spectrum slope indicate a relation with solar activity. The available observation data on this and other power radio sources allow us to carry out further investigations in this direction.

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