TEMPORAL VARIATIONS OF IONOSPHERIC SCINTILLATION INDEX ON COSMIC RADIOSOURCES OBSERVATIONS AT DECAMETRIC WAVE RANGE

R.O. Kravetz, O.A. Litvinenko, S.K. Panishko

Observatory URAN-4, Kharkov Radioastronomical Institute of National Academy of Sciences
Pushkinskaya str. 37 Odessa 270011 Ukraine
uran@paco.net

ABSTRACT. The measurements of cosmic radiosources have scintillations on ionospheric irregularities at decametric waves. The analysis of temporal variations of the scintillation indexes was carried out on the base of observation data obtained on RT URAN-4 during 1998-2001. Daily-seasonal dependence of these indexes was investigated. The values of scintillation indexes varied within intervals from several minutes to several years, the amplitudes of such variations can reach 70 per cent from mean value.

Key words: Radiosources: scintillations; ionosphere: irregularities: electron density.

1. Introduction

At realization of radioastronomical observations in decametric wave range the essential effect appears the scintillations of compact cosmic source signals on ionospheric plasma irregularities. Basic measuring parameter reflecting the depth of scintillations is the index m determined on the formula:

$$m = \sqrt{< (I - < I >)^2 >} / < I > \qquad (1)$$

where I – intensity, measuring on the receiver's output of the radiotelescope (RT). At the certain values of the scintillation index the conditions of realization decametric radioastronomical observations can be worsened, that has an effect for results of measurements. Therefore, at realization of such observations it is important to take into account a level of ionospheric scintillation activity, which can varies with time. Ionospheric scintillations were studied in numerous investigations (for example, Crane, 1977; Aarons, 1982), but as on a state of the ionosphere renders influence set of the factors to reveal the exact formation mechanism of irregularities, resulting to scintillations, yet it is not possible, and, hence, to determine a level of scintillation activity in the given place and in the given time the further researches are required. The purpose of work is the study of temporal variations of ionospheric scintillation index, received on cosmic radiosources observations at decametric wave range.

2. Observations and technique of processing

To get the estimations of ionospheric scintillation index the observation data of powerful cosmic radiosources were used. These observations were obtained on RT URAN-4 (Galanin et al., 1989) in 1998-2002 at frequencies 20 and 25 MHz. The observations consist that for one day some passages of each source through the direction pattern of RT were recorded. Through automatic system of registration the readout from RT receivers were entered into memory of the computer with an interval of 1 second. Then the data processing was spent which consist in the following. Each recording was checked visually on presence of interferences and the strongly deformed records were rejected. The theoretical direction pattern function was fitting into the record received from observations on it the amplitude of record was determined. To reduce influence of the direction pattern on the fluctuation readout level on an observable curve the segment of length 15 minutes symmetrically from the maximal value of the fitted curve got out. On this segment from an observable curve the fitted curve was subtracted. For the received sample the scintillation index from the formula (1) was calculated.

3. Results and their discussion

In the table 1 the names of observable sources, their identification and coordinates, and also average values of scintillation indexes for all considered period on two frequencies are given. All sources show the scintillations on ionospheric irregularities. The different values of scintillation indexes for different sources are caused

Table 1:

Source	α	δ	$m20$(MHz)	M(25MHz)
3C144 Taurus A (RSN)	$05^h31^m30^s$	21°58.4′	0.40 ± 0.20	0.36 ± 0.20
3C274 Virgo A (radiogalaxy)	$12^h28^m18^s$	12°40.1′	0.36 ± 0.22	0.30 ± 0.22
3C405 Cygnus A (radiogalaxy)	$19^h57^m45^s$	40°36.0′	0.29 ± 0.19	0.30 ± 0.18
3C461 Cassiopeia A (RSN)	$23^h21^m11^s$	58°33.1′	0.24 ± 0.17	0.22 ± 0.19

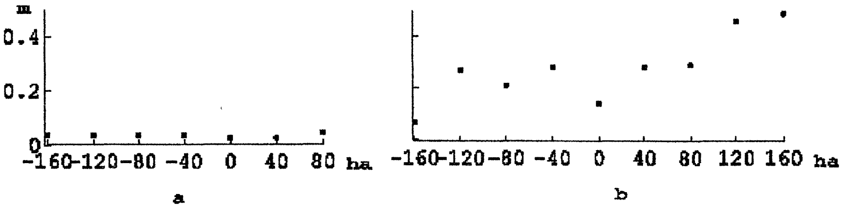

Figure 1: Variations of scintillation index on the dependence of hour angle obtained from 15-minute samples for source $3C405$ in 2001 at frequency 25 MHz: a – "quiet" period, April, 4; b – "active" period, June, 4.

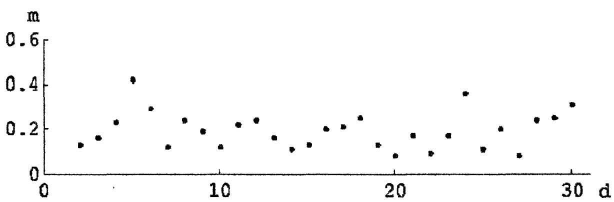

Figure 2: Daily mean scintillation index values obtained for source $3C405$ in June 2001 at frequency 25 MHz.

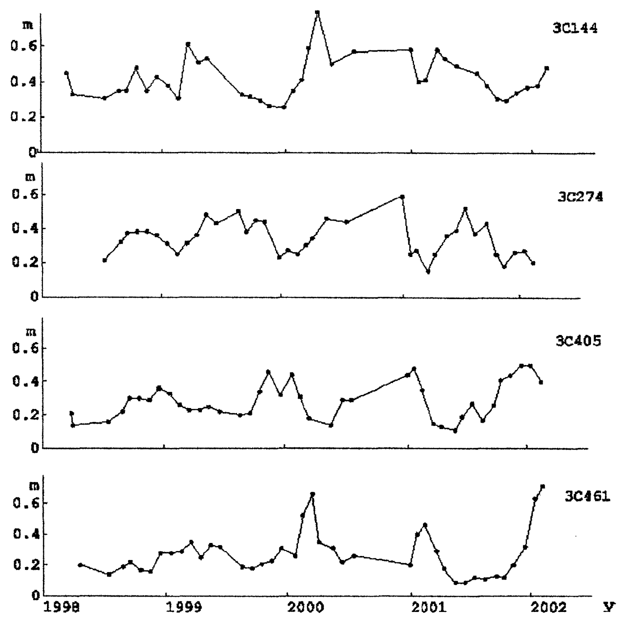

Figure 3: Monthly mean scintillation indexes obtained for four radiosources in 1998-2002 at frequency 25 MHz.

by features of the source structures and range of angular heights on which they are observed. It is necessary to note, that the behavior of scintillation indexes at two frequencies is like, with that difference, that on lower frequency the level of their activity is higher, but also the level of interferences too is higher, therefore further the results of measurements on frequency 25 MHz are demonstrated, as here there are more records not deformed by interferences. As was already spoken, the state of ionosphere is influenced by set of the factors, therefore ionosphere is very changeable medium and that is reflected in behavior of a scintillation index.

Temporal scales of observed variations lay in an interval from parts of hour to several years. For the most of temporal scales of the variation values can reach 70-90 per cent of mean. The examples of scintillation index variations on time intervals day, month, 4 years are below given. In a figure 1a the plot of scintillation indexes, received on 15-minute samples within day is given which it is possible to consider "quiet". In a figure 1b the same plot, but for one of "active" days.

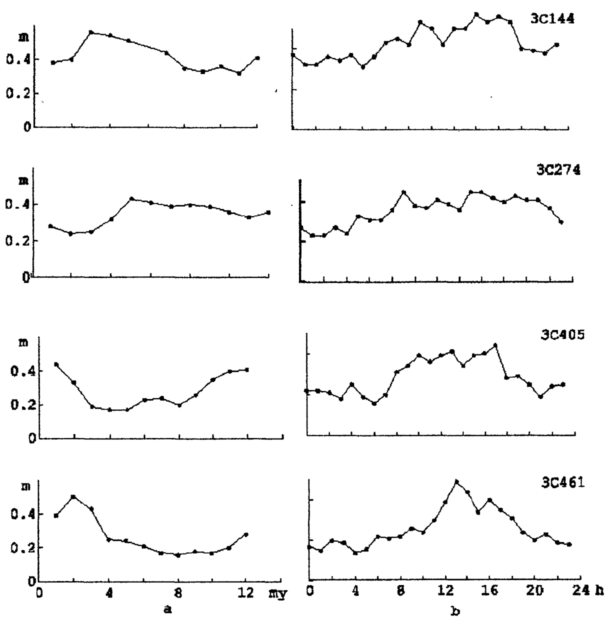

Figure 4: Mean values of scintillation indexes obtained for four radio sources on whole observation period at frequency 25 MHz: a – monthly mean, b – hour dependence.

In a figure 2 the plot of daily average values of an index m for one month for a source 3C405 is showed. Carried out before research of compact radiosources scintillations on observation data in 1987-1990 (Litvinenko & Panishko, 2000) have shown weak dependence of an scintillation index from parameters of solar and geomagnetic activity. It allows at research of various dependences in common to use the data concerning various states of ionosphere. The complexity of division of seasonal and daily dependence of a scintillation index is, that, using observation of one source, it is possible to receive the data for a time interval approximately at 5 hours, which is slowly displaced inside day, making a complete cycle for one year. That is one source gives the mixed seasonal-daily dependence. Regular character of the data, which were used in the present research, and also their performance in a digital kind, due to what exacter estimates of a scintillation index are received, allow closer to approach to the decision of this task.

In a figure 3 the plots of monthly average values of scintillation index for observed sources for all considered period are represented. The year cycle for all sources is rather well looked through, the value of variations reaches (45-70) per cent from average value. The nature of a year cycle can be determined both seasonal, and daily effect. In a figure 4a the dependences of a scintillation index from month of year is showed. Each point is the result of averaging of monthly average values for four years. The year cycle is well seen, and its phase varies from a source to a source. It testifies to a dominant role of daily dependence in the level of scintillation activity. In figure 4b the dependences of scintillation index from time of day are given, from which the increase of an index in day time and minimum at the night is visible.

4. Conclusions

If to exclude effects of solar and geomagnetic activity that is reached by averaging of a plenty of the data this research possible to established that the daily dependence is determining in seasonal-daily behavior of scintillation index. The variations of an index within one year make (45-75) per cent from average value. The minimum of scintillation activity is observed in the nighttime. These data can be considered at planning radioastronomical observations when it is necessary to take into account the influence of the ionospheric scintilations. Systematic and long-time observations of scintillation indexes allow to monitor the state of ionosphere at decametric radiowaves.

References

Crane R. K.: 1977, *Proc. IEEE,* **65**, 180.
Aarons J.: 1982, *Proc. IEEE,* **70**, 324.
Galanin V. V., Inyutin G. A., Kvasha I. M. et al.: 1989, *Kinematica i fizika nebesnykh tel,* **5**, 87.
Litvinenko O. A., Panishko S. K.: 2000, *Geomagnetizm i aeronomiya,* **40**, 116.