Interplanetary scintillations of an ensemble of radio sources during the solar activity minimum of cycles 23/24

Chashei I[1]., **Glyantsev[1,2] A**., Tyul'bashev[1], S., Shishov[1], V., Subaev, I.

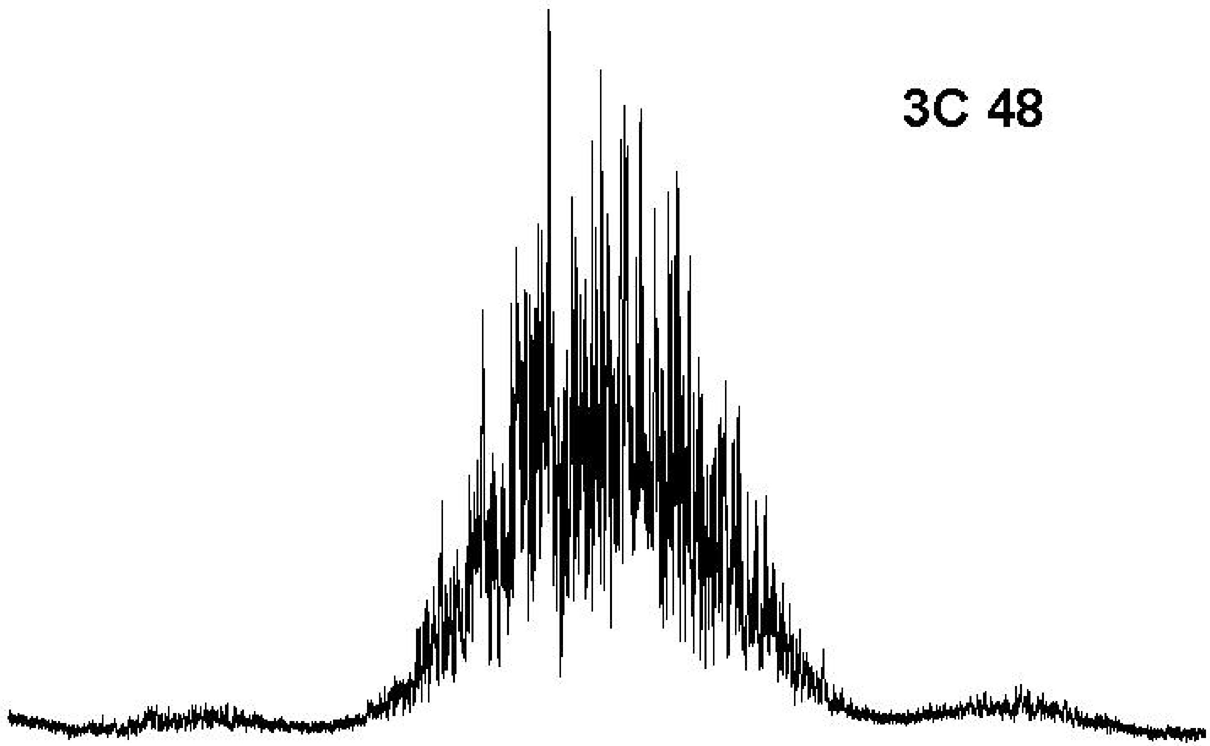
1. Pushchino Radio Astronomy Observatory
2. Pushchino State Natural-Scientific Institute.

What is scintillation?

Radio waves from space radio sources propagate through interplanetary plasma.

Fluctuations of interplanetary plasma density create diffractive pattern. The diffractive pattern moves relate to Earth with solar wind. So a radio telescope locates in maximum, minimum and maximum again by turn. It is observed as flux density fluctuations. The typical period is about 0.1 s.

The example of scintillation record for the source 3C48



What for?

- 1. We can estimate solar wind velocity from typical frequency of scintillation power spectrum. Scintillations are caused by the diffractive pattern moving. So typical frequency of interchange of minimums and maximums is determined by solar wind velocity.

What for?

- 2. Scintillations allow to trace coronal mass ejections (CME). CME moving causes a rough surge of turbulence level. So a rough surge of scintillations is observed. If we have a dense net of scintillating sources in the sky sphere, we can trace a CME.

What for?

- 3. We can estimate an angle size of a source. There are a few methods for angle size estimating from scintillation observations. In any case, radio source shows significant scintillations if its angular size ~ 0.1’’. Without scintillations observations such resolution may be gotten only from VLBI observation. But nobody have VLBI on low frequencies (~ 100 MHz).

What for?

- 4. Scintillations give information about the solar wind large scale structure. The intensity of scintillations depends on plasma density and turbulence level. If we know density distribution, we can derive data about turbulence distribution, and vice versa.

This work

- In this work we present the results of observation of a few hundred scintillating sourced from 2007 to 2011.

The observations parameters

- Central frequency: 111 MHz
- Wave bandwidth: 600 kHz
- The effective area of the array in the zenith direction:

  20 000 – 25 000 square meters.
- The array beams system includes 16 beams, covering the sky strip with width about 8 degrees in declination during 24 hours in right ascension.
- Observed sourced had scintillating flux greater than 0.2 Jy.

The observed field

- Our radio telescope observation field has fixed declination. Right ascension depends on time of day. In each moment the size of observation field is about 8 * 8 degrees.

Scintillation index

- A general scintillation parameter is the scintillation index. It is the r.m.s. source intensity variance normalized to average intensity.
- Here *I* is intensitv. *t* is time. *m* is scintillation

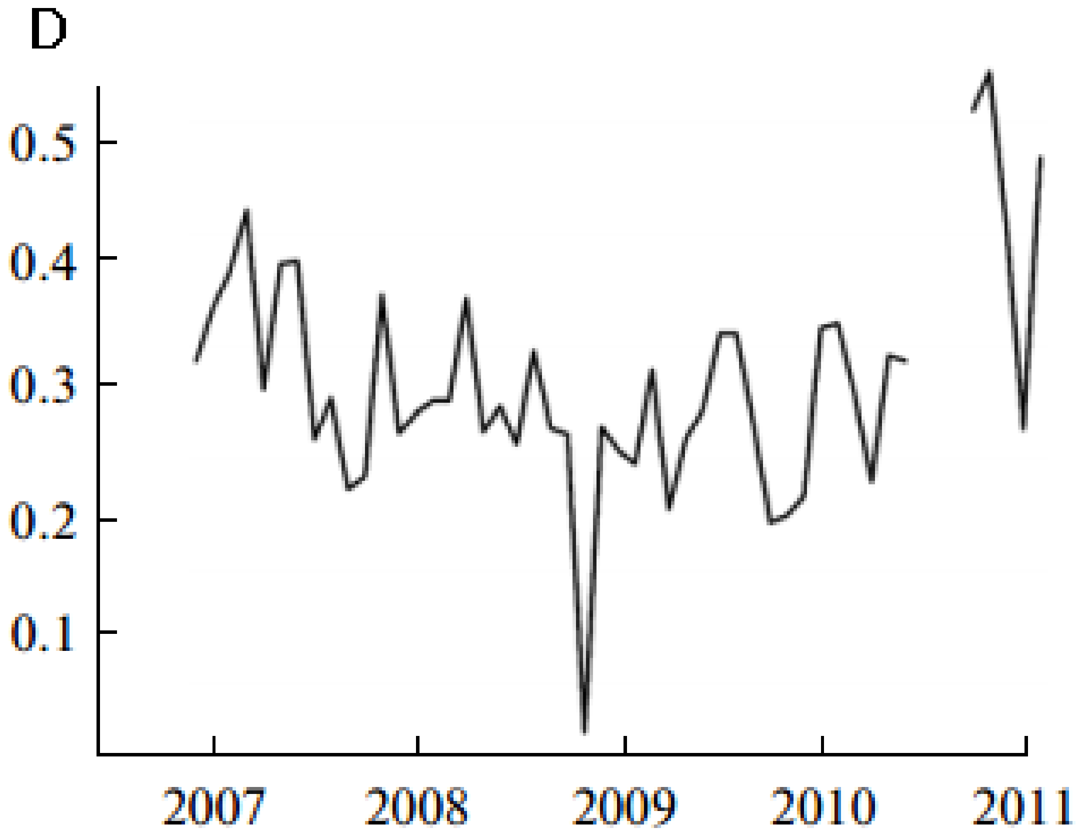
$$\delta I\,(t) = I\,(t) - \langle I\,(t)\rangle$$

$$m^2 = \langle\, \delta I^2\,(t)\rangle \,/\, \langle I\,(t)\rangle^2$$

The statistical ensemble

The majority of observed sources are weak. So "signal/noise" ratios are small and the scintillation index estimating is hard. In this work we don't investigate separate sources. We analyse the statistical ensemble of observed radio sources in total. The mean for full ensemble variance of a scintillating flux is estimated. It is proportional to the squared scintillation index.

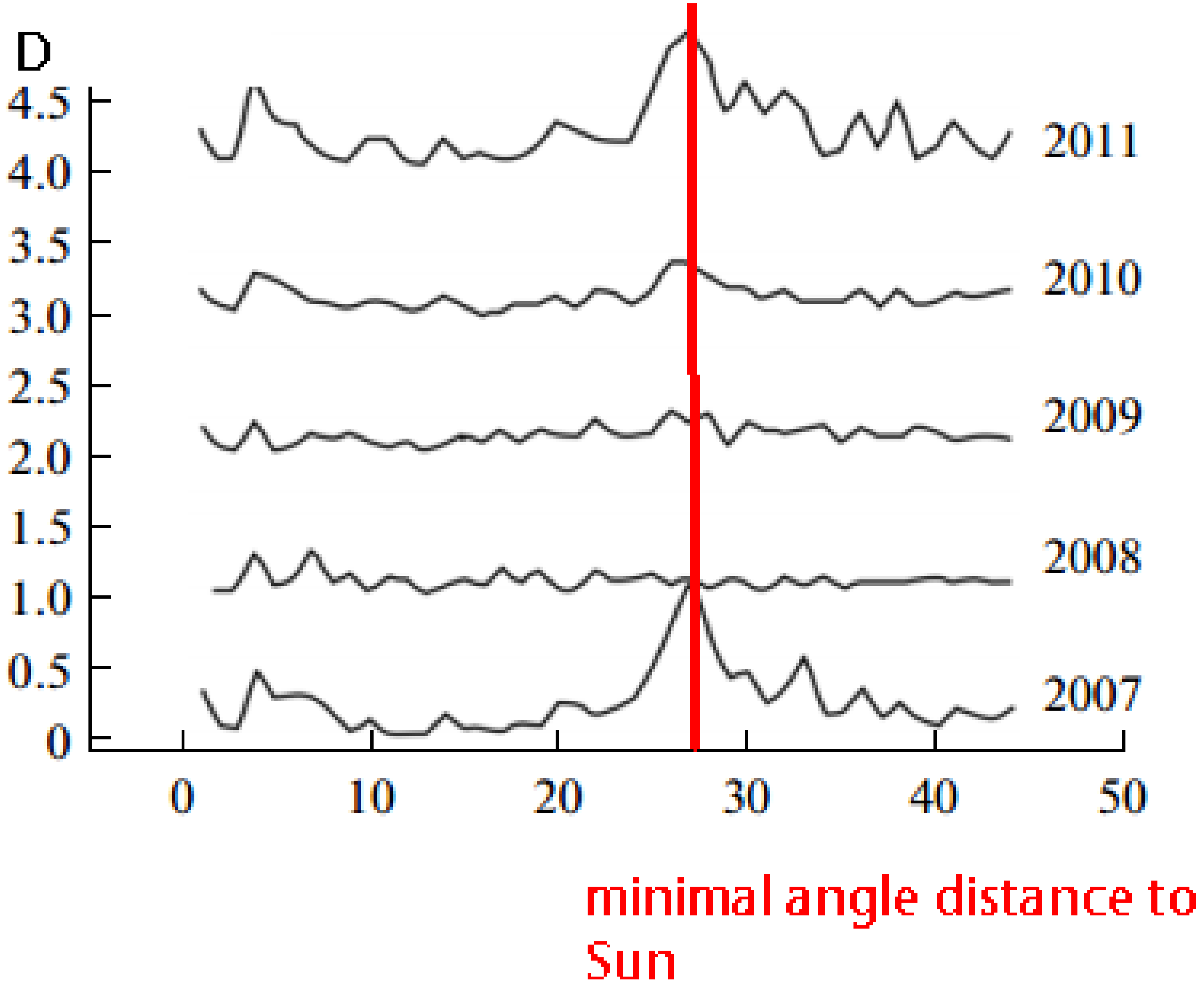
The scintillation flux mean variance D, averaged for a month, was synchronous with the solar activity level in general



The dependence scintillation level from angle distance from a source to the Sun

The spacecraft measures shows that the plasma density increase with distance to Sun as 1/ R^2. So, must be observed the strong dependence of scintillation level on angle distance from a source to the Sun (elongation). For minimal elongation a sight beam to a source crosses nearest to Sun plasma fields, and scintillations must be most power.

The dependence of the scintillation flux mean variance D, averaged for February, on time of day. 1 point = 32 minutes



The interpretation

The spherically symmetric model of the solar wind states that the general contribution to scintillations is made by nearest to Sun plasma fields. However data for a deep solar activity minimum 2008-2009 are not correspond to this model. We suppose that the general contribution to scintillations is made by the heliospheric current sheet. It have the higher turbulence level in comparison with other solar wind fields. A sight beam to a sources crosses the heliospheric current sheet independently on an elongation. So data for 2008-2009 don’t contain this dependance.

Conclusions

- Scintillations is fluctuations of observed flux density, caused by moving of solar wind plasma density fluctuations.
- Scintillation observation allows to obtain various information about solar wind and radio sources.
- In this work results of observation of a few hundred scintillating sources during 2007-2011 have presented.

Conclusions

- The scintillation flux mean variance was synchronous with the solar activity level in general.
- During the period deep solar activity minimum 2008-2009 the dependence of the scintillation level on a source elongation was not detected. We suppose that the general contribution in scintillation was made by the heliospheric current sheet during this period. It explain this fact, so a sight beam to a sources crosses the heliospheric current sheet independently on an elongation.

- **Thahk you!**
- **Danke schön!**
- **Спасибо!**