Solar radio bursts study with high spatial and temporal resolution

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Theoretical and experimental researches of the energy release fragmentation in solar flares need observations with high spatial (0.01 – 1 arcsec) and temporal ($\sim$ 1 ms) resolution. An important role for these studies as well as for the theory of short lived radio bursts can play VLBI observations. They could allow: a) to study the spatial and temporal development of the flare fragmentation; b) to determine the size and the brightness temperature of the 'elementary' burst sources; c) to learn how different micro fragments of a flare relate each other in space and in time; are there any deterministic connections exist between them or not.

From 1994 we carry out interferometric observations of spatially fragmented energy release processes on the Sun including the study of spike-like radio bursts. During this time the receivers and other equipment for VLBI observations at the frequencies 327, 610 and 1665 MHz have been developed and constructed in NIRFI. Several VLBI stations all over the Russia were supplied by this set of equipment. The equipment for the new two-element radio interferometer with the intermediate baseline length of 70 km at 327 MHz has been installed at RAS NIRFI "Zimenki" and "Staraya Pustyn". In 1998 this interferometer operated as a part of the Russian and international radio interferometry networks. The similar equipment for the frequency of 610 MHz is under development now.

To study solar flares and coronal plasmas with different baseline orientations and lengths (from hundreds to several thousands kilometers) at frequencies 327 and 1665 MHz a number of VLBI experiments have been carried out during 1994-1998 (see Table 1).

Until now the preliminary processing of magnetic tapes with data in the MARK-2 format is done with the correlator Block 2 JPL/Caltech, Pasadena, USA. The final data processing is carried out by NIRFI group. However, in near future our own correlator will be brought into operation. This correlator is now under tests, and it will allow us to process data on magnetic tapes with the millisecond time resolution.

The following main observational results have been obtained:

a) High precision of relative position measurements with millisecond time resolution (via measuring phase variations of the interferometric signal) is realized in interferometric observations of solar radio bursts in October-November 1994 at RAS NIRFI "Staraya Pustyn". For most intense bursts the precision of position measurements in these experiments was 1-2 arc seconds. It is shown for the first time that the positions of sources of neighboring peaks in the course of the multi component bursts are sometimes remarkably different from each other and this difference can reach 15 arc sec for the peaks separated only by 100-500 milliseconds. This fact puts new limitations on the theory of flare fragmentation.

b) The analysis of data obtained in the VLBI experiment of February 28, 1995 (VA01, 18 cm wavelength, Medvezhie Ozera - Puschino baseline) has been done. Two solar spike-like events with duration less than 2 s showed well pronounced interferometric responses (with the excess over noise of 3-5 times). It is shown that the apparent angular sizes of the relevant solar radio sources are less than 5 arc sec.

c) To study of inhomogeneities in the solar corona and to research its effect on size of spike sources the data analysis of the VLBI observations were carried out in 1994-1997. The influence of coronal inhomogeneities on the interferometric spectrum of signals from far space radio source at 18 and 92 cm wavelengths for wide region of elongation angles (3-150 degrees) was studied. New data on the structure of small scale and large scale inhomogeneities have been derived. It was found that inhomogeneity sizes are more than 200000 km along solar wind and $\sim 1500 - 2000$ km across it.

Hence, the radio interferometric equipment performed by our group and radio interferometric observations carried out autonomously and in the frame of VLBI networks allow us to found out some new spatial and temporal characteristics of sources of solar spike-like radio bursts. Proposed method of investigation of solar system allowed us to get new data on the structure of solar coronal plasma.

Table 1

Date	Interval of observation (UT)	Stations	Frequency (MHz)	Results
27.10.94 28.10.94	06:24-07:30 05:42-07:00	Ussuriysk, Puschino	327	no interferometric response
28.02.95	05:20-08:20	Puschino, Medvezhie Ozera	1665	spike-like events are found
24.10.95 25.10.95 27.10.95	05:30-07:30 05:30-07:30 05:30-07:30	Puschino, Medvezhie Ozera	327	no interferometric response
30.11.97 01.12.97 02.12.97 03.12.97 04.12.97	07:30-08:23 07:27-08:23 07:32-08:25 08:50-09:26 06:57-10:44 06:57-10:42	Puschino, Staraya Pustyn, Ooty, GMRT, Noto	327	data is in process
04.04.98	06:00-08:40	Puschino, Medvezhie Ozera, Noto, Urumchi	1665	data is in process
03.08.98	02:30-04:20 05:40-07:40	Zimenki, Staraya Pustyn	327	data is in process
21.08.98	08:10-11:45	Medvezhie Ozera, Puschino, Urumchi, Medichina, Hart RAO	1666	data is in process
31.10.98	06:25-08:25	Puschino, Evpatoria, Staraya Pustyn, Urumchi, Ooty	327	data is in process