Database of the solar radio observations using RATAN–600 and Large Pulkovo Radio Telescope

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Introduction

We have data of solar radio observations for the last 3 cycles of solar activity. Our archive includes:

- regular solar data obtained with reflector-type radio telescope RATAN–600 (Khaikin et al., 1972) at centimetric and decimetric wavelengths with high spatial one-dimensional resolution ($\Theta_{horisontal}(arcsec) = 0.85\lambda(mm)$, $\Theta_{vertical}(arcmin) = 0.75\lambda(mm)$) since 1975;
- daily solar observations using Large Pulkovo Radio Telescope (Khaikin et al., 1960) with medium spatial resolution ($0'.8 - 0'.9$ at 2.3 cm wavelength) since 1963;

Brief history of solar observations using RATAN–600 and data formats

We observe a passage of Sun through the beam of RATAN–600. The result of one observation is a set of one-dimensional scans on a number of wavelengths for both intensity and circular polarization (Stokes's parameters I and V).

Originally (from 1975 to 1981) the observations of the Sun with RATAN–600 have been executed using the Solar Spectral Polarizational Complex at five wavelengths (2.0, 2.3, 2.7, 3.2 and 4.0 cm). In 1982 a new complex of automatic registration and management of process of observation ICAR–16 (intelligent complex of automatic registration for 16 channels) was made for observations of the Sun (Bogod et al., 1985). The basic concept of ICAR–16 was a real-time processing of source signal and control of receivers. The number of wavelengths increased up to 8 (2.0, 2.3, 2.7, 3.2, 4.0, 12, 20, 30 cm). Afterwards the complex ICAR–16 was essentially modernized twice. The number of wavelengths increased up to 16. ICAR was used for observations till 1991.

The data have been recorded on the magnetic tapes using various formats. To solve the problem of archiving data the concept of two-level archive of observational data was developed in Pulkovo Solar Radio Astronomical Group. The basic idea of this concept is consist of the existence of two archives: primary archive and secondary archive. Primary data of observations stored by the registration program is an archive of a level 1 ("ARCHIVE-1"). The "ARCHIVE–1" format is depended on receiving and registration apparatus. The data in this format contain a plenty of the service and instrumental information. This information is needed for primary processing only, but it is not needed for astrophysical

interpretation of data. The data in "ARCHIVE–1" file may contain soft errors caused by hardware, which may be partially corrected by program methods. The observational data stored in "ARCHIVE–1" format have been exposed to primary processing. The primary processing included sorting for channels, processing of calibration, correction of errors, compression of data. The results of primary processing were being recorded in archive of the second level ("ARCHIVE–2"). "ARCHIVE–2" is a multi-channel hardware independent archive. The "ARCHIVE–2" file is consist of header with common (e.c. date and time of observation, name of source, name of observer), astronomical (declination and right ascention of source and so on) and channels (wavelengths, positions of solar center on scans, steps, etc) information and data sorted by the channels. As a matter of fact, "ARCHIVE–2" (Andrianov et al., 1982) is a fore-runner of binary table extension to FITS (W.D. Cotton et al., 1995).

Since 1991 the observations are carried out using the Panoramic analyzer of spectrum (PAS) (Bogod et al., 1993).

The hard copy of our archive was partially published (Andrianov et al., 1990a; Andrianov et al., 1990b; Bogod et al., 1992).

We have transferred data from magnetic tapes and recorded archive on CD–ROM. The complete set consists of two disks. The first disk contains data from 1979 up to 1988. The second disk contains data from 1989 up to November 1996. The total size of recorded data is about 1.1 Gbyte. The last data may be obtained by Internet (**http://www.sao.ru**) (Bogod et al., 1996).

The summary of data is given in the Table 1.

Archive of solar radio observations using Large Pulkovo Radio Telescope

Regular solar observations using Large Pulkovo Radio Telescope began in 1963. Large Pulkovo Radio Telescope was made as a model of larger telescope (RATAN–600). And the results of observations using Large Pulkovo Radio Telescope are analogous of the results of observations on RATAN–600. It is a set of one-dimensional scans. The spatial resolution of Large Pulkovo Radio Telescope lower than the resolution of RATAN–600 (on the wavelength 2.3 cm it changes from $0'.8$ (when the height of the sun is about $50°$) to $0'.9$ (when the height of the sun is about $10°$). Number of wavelengths changes from 3 to 7 in different periods of observations. Two polarizational parameters (intensity I and circular polarization V) are recorded. Observational data was recorded on paper only till 1998. Now we have created the data acquisition system based on computer AT 386 and we scan old paper archive. We hope that anyone will get access to this data by Internet this year. Now the page is under construction (**http://www.gao.spb.ru**).

The main advantage of Large Pulkovo Radio Telescope is longer series of observations (about 3 cycles of solar activity). And it is really daily observations! The summary of the archive, accumulated using Large Pulkovo Radio Telescope, is given in Table 2. In Table columns "1" contain number of days of observations, columns "2" contain proportion from calendar number of days (%), columns "3" contain number of one-dimensional scans.

Table 1 Summary of RATAN–600 data

Period	1979–1981	1982 – 1991	1992–1996	1996–1999
Number of wavelengths	5 (I, V)	up to 16 (I, V)	up to 40 (I, V)	up to 40 (I, V)
Wavelengths/ frequencies	2.0, 2.3, 2.7, 3.2, 4.0 cm	0.8, 1.7, 2.0, 2.3, 2.7, 3.2, 4.0, 6.0, 8.0, 12, 20, 30 cm	12–18 GHz 8–12 GHz 5.5–8 GHz 3.5–5.5 GHz 2.5–3.5 GHz 1.5–2.5 GHz	12–18 GHz 8–12 GHz 5.5–8 GHz 3.5–5.5 GHz 2.5–3.5 GHz 1.5–2.5 GHz 0.95–1.05 GHz
Primary data medium	Magnetic tapes and paper	Magnetic tapes	ZIP-disks	ZIP-disks
Finally data medium	CD–ROMs	CD–ROMs	CD–ROMs	CD–ROMs Internet
Software for primary treatment	ARCHIVE2O	ARCHIVE2N FORMAT6 FORMAT7	SORTDOS	WORKSCAN
Access to software by Internet	www.gao.spb.ru under construction	www.gao.spb.ru under construction		www.sao.ru
Author of software	Abramov–Maksimov V.E.	Abramov–Maksimov V.E.	Shatilov V.A.	Garaimov V.I.
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Table 2 Summary of Large Pulkovo Radio Telescope data

Year	1	2	3	Year	1	2	3	Year	1	2	3
1966*	114	41	450	1978	359	98	1606	1990	354	97	3402
1967	163	45	677	1979	364	99	1278	1991	365	100	2850
1968	216	59	1014	1980	362	99	1301	1992	362	99	2961
1969	202	55	1189	1981	348	95	896	1993	341	93	2620
1970	271	74	1719	1982	332	91	1778	1994	326	89	2170
1971	269	74	1880	1983	344	94	1897	1995	354	97	2380
1972	240	66	1434	1984	355	97	1953	1996	340	93	2808
1973	252	69	1637	1985	360	99	2219	1997	321	88	2373
1974	221	61	956	1986	363	99	1778	1998	361	99	2753
1975	314	86	1407	1987	360	99	2540	1999**	118	98	927
1976	338	93	1684	1988	365	99	3162				
1977	364	99	2168	1989	360	99	3244	Total	9938	86	60964

* - since April, ** - till April

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