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Single Dish Radiometric Observations of Geodetic Sources on Radio Telescopes of the QUASAR Network

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Abstract. The radio telescopes of the Quasar Network are equipped with control system integrated with Mark IV Field System (FS) software that is used for radio interferometric observations. A complex of software was developed at IAA RAS in order to perform single dish radiometric observations. This complex consists of FS extensions, scheduling, and data processing software packages. Different methods of antenna beam scanning required for single dish observations are implemented in the control system. A complete set of software support for radiometric registration devices used in IAA was developed. It provides device control, graphical visualization, and data recording in special compressed file format. All these capabilities are controlled by the commands added to the FS SNAP language. Two special software packages SchedMaker and Class Visual were developed for observation scheduling and radiometric data processing respectively. The scheduling uses SNAP language with additional non-standard commands. These observation facilities are used for regular monitoring of the flux density of the sources from the four lists, which are used in the following IVS programs: 1) Intensives INT1 and INT2, 2) CRF, 3) ICRF and 4) Geodesy (R1, R4, T2). The complete list of sources consists of 128 sources. The observations are carried out every month on X-band. Each time from 30 up to 50 sources are being observed. The program of monitoring was started in July 2005. There are 1782 single source sets observed during the period up to May 2007.

1. Introduction

The IVS carries out regular observations of radio sources in geodesy and astrometry programs: 1) Intensive (IVS-INT1, IVS-INT2); 2) CRF; 3) ICRF; 4) Geodesy programs (R1, R4, T2). The ICRF sources showing an appreciable increase of the flux density are to be included certainly into the VLBI observations. It is important to forecast the flux density changes of the radio sources at scheduling other IVS sessions as well. The validity of the forecast strongly depends on the quantity of information about the history of radio sources behavior.

Single dish radiometric monitoring of the required sources is able to pro-

vide additional data for a reasonable selection of sources when scheduling IVS sessions. The project of monitoring the flux density histories (FDH) based on single dish observations was begun on the QUASAR network radio telescopes of the IAA RAS. The measurements were made monthly between July 2005 and May 2007 on X-band. There are 1782 single source sets observed.

2. Observing Methods and Software

The radio telescopes of the Russian VLBI QUASAR network participate since 2003 in the regular international VLBI observations within IVS programs. These radio telescopes are equipped with a control system integrated with the Mark IV Field System (FS) software that is used for radio interferometric observations. A set of radiometric registration devices and software packages was developed at IAA RAS in order to perform single dish radiometric observations. The software consists of FS extensions, scheduling, and data processing software components.

The technique of single dish observations is essentially different from the one used for VLBI. In particular, there are various methods of antenna beam scanning required for single dish observations. Such methods are implemented in the antenna control program on the central computer.

The radiometric registration devices used in single dish observations are connected directly to the central control computer of the radio telescope. The control software supports several generations of such devices developed at IAA RAS. There are also the software units for real time graphical data visualization and for writing data into the files for the forthcoming processing. Data are saved into the files in a specially developed compressed format.

The QUASAR network is dedicated to VLBI and therefore FS is the key part of the radio telescope central control computer software. All extra single dish observation capabilities are controlled by the non-standard commands added to the FS SNAP language. There are two noticeable improvements in the FS architecture implemented for the QUASAR radio telescopes: 1) integration of "asynchronous" programs into FS structure, and 2) using more reliable method for interprocess communications.

Two special software packages, SchedMaker (SM) and Class Visual (CV), were developed for observation scheduling and radiometric data processing respectively. The scheduling uses the SNAP language with additional non-standard commands. Both packages support various methods of single dish observations used on the QUASAR network radio telescopes (on/off, linear and raster beam scanning).

The X-band RCP was chosen for single dish observations according to frequency band used for corresponding VLBI sessions. The full list of sources consists of 110 objects used in geodesy and astrometry sessions (Tabl. 1). The list was built in coordination with NVI, Inc./NASA Goddard Space Flight Center. The flux density values of these sources are in the range from several units up to tens of Jansky. Therefore they are strong enough to be registered with

the QUASAR network radio telescopes.

Table 1. Source list (only source names)

Stable or slightly variable					
0014+813	0106+013	0119+115	0201+113	0202+149	0229+131
0454+844	0458-020	0552+398	0556+238	0602+673	0642+449
0718+793	0743+259	0805+410	1004+141	1038+52A	1101+384
1117+146	1128+385	1150+812	1252+119	1345+125	1611+343
1741-038	1745+624	1803+784	1823+568	1923+210	2029+121
2113+293	2128-123	2134+00	2255-282	3C274	3C371
3C418	3C446	CTA26			
Variable					
0059+581	0133+476	0234+285	0235+164	0528+134	0536+145
0657+172	0722+145	0727-115	0748+126	0749+540	0804+499
0808+019	0823+033	0827+243	0917+449	0955+476	1044+719
1053+815	1300+580	1308+326	1334-127	1354+195	1357+769
1417+385	1726+455	1749+096	1849+670	2121+053	2318+049
OJ287	NRAO512				
Need more data					
0003-066	0048-097	0104-408	0111+021	0119+041	0434-188
0454-234	0607-157	0749+540	1034-293	1116+128	1124-186
1156+295	1219+044	1307+121	1351-018	1418+546	1538+149
1606+106	1622-253	1739+522	1908-201	1921-293	1954-388
1958-179	2126-158	2136+141	2145+067	2149+056	2201+315
2209+236	2234+282	2243-123	2356+385	4C39.25	DA426
OQ208	NGC6251	VR422201			

About 30–50 sources were observed during each session. To measure the flux density of VLBI sources a multiple elevation beam scan was used during 40 minutes for each source. Additionally, 15 minutes beam scanning of calibrators was carried out periodically. A telescope gain curve (including atmosphere attenuation) was determined for each session from measurement of calibrators in elevation range from 15 up to 75 degrees.

The data processing performed with CV package consists of the following steps: 1) Each scan was corrected for sky emission and different instrumental errors. 2) Multiple beam scans were averaged. 3) A Gaussian was fitted to average scan and the peak value of the Gaussian fit was taken as final result.

The flux densities of calibrators were taken from [1].

3. The Flux Density Histories (FDH) for IVS Sources

Single dish observations were carried out and processed at IAA RAS. Final results were sent to NVI, Inc./NASA Goddard Space Flight Center. Besides, at IAA RAS a database of FDH based on the results of single dish observations

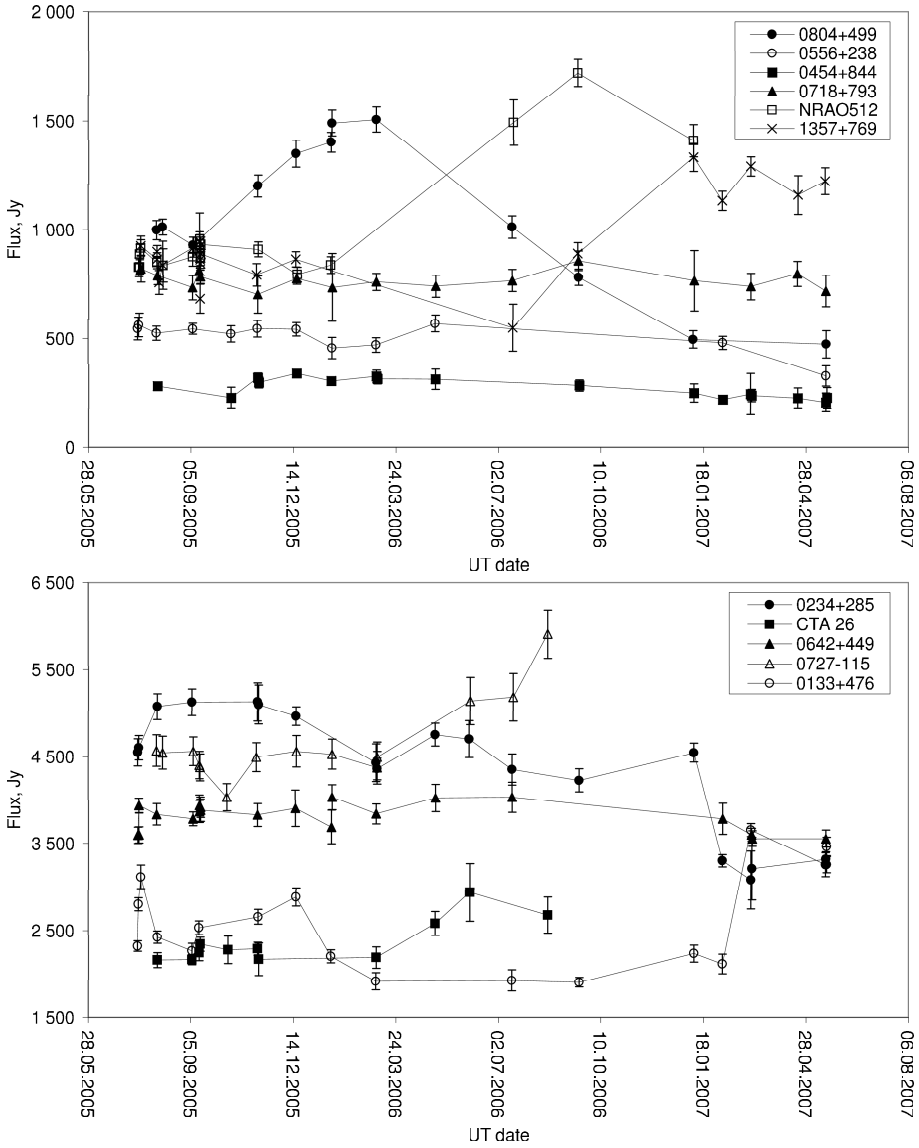

Figure 1. Flux density of the IVS sources 0133+476, 0234+285, 0454+844, 0556+238, 0642+449, 0718+793, 0727-115, 0804+499, 1357+769, CTA 26, and NRAO512

of IVS sources was created. All sources have different kinds of radiation variability: stable enough, with slow monotonous changes, and with fast bursts. As a result of database analysis, the general source list was divided into three parts (Tabl. 1):

"Stable or slight variable" — sources with stable enough flux density or with small variability;

"Variable" — sources with significant changes of flux density;

"Need more data" — for these sources more observations are needed to determine their behavior.

Several typical curves of brightness for sources from the first and second groups are presented in Fig. 1. As shown the sources 0454+844, 0556+238, 0642+499, 0718+793, and CTA26 belong to the first group. The sources 0234+285, 0727-115, 0133+476, 0804+499, and NRAO512 tend to have significant changes of their flux density and these sources at the moments of decline could be unwanted for VLBI sessions.

4. Summary

The complex methodology for automatic radiometric single dish observations was formed based on developed software for scheduling, carrying out and processing single dish observations. Operability of this methodology and of the software complex was tested and then used for observations of a list of geodetic and astrometric sources. A preliminary data base of the IVS sources flux density history (FDH) was formed as a result of the observations. The data base allows to evaluate the stability of the sources flux density and probability of their declines or bursts.

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References

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