RESULTS OF PULSAR TIMING OBSERVATIONS AT 102.5 MHz

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Abstract

A program of pulse arrival time observations made at Pushchino during 1978–1986 is described. The period, period derivative and position derived from the full timing solutions were obtained for 16 pulsars. Comparison of our results with others obtained during 1970–1980 by different groups has shown that the parameters for a number of pulsars have suffered a significant change.

Observations and processing

A pulse timing program for 16 pulsars was carried out with the Pushchino BSA-radiotelescope over the interval from July 1978 to December 1986. Observations were made at a frequency of 102.5 MHz, using a 32-channel radiometer with a 20-kHz passband per channel. The signal was sampled digitally at 2.5-ms intervals in the emission window of the pulsar.

Integrated pulse profiles were obtained through the accumulation of successive pulses (from 100 to 2400 periods for different pulsars), synchronized to the apparent pulsar period. Pulse arrival times were determined by cross-correlating the resulting profiles with a reference profile. These arrival times were then corrected to the solar system barycenter using the JPL DE200/LE200 ephemeris and the known pulsar position (Manchester and Taylor 1981). The pulsar parameters were obtained from a linearized-least-squares solution. In all cases the fit was for period, period derivative and position. The fitting procedure has been described more fully by the author elsewhere (Shabanova 1990).

The time base was provided by a quartz clock, synchronized with the USSR Time and Frequency Standard to within 0.1 μs.

Results and discussion

Parameters derived from pulse timing observations are presented for 16 pulsars in two tables. Table 1 gives the interval fitted, the number of days spanned by the fit, the number of measurements, the typical measurement errors of the daily observations, and the rms arrival time residual. Table 2 gives the fitted parameters right ascension and declination, pulsar period, period derivative, and the epoch of the first observation. Epoch is the Julian day − 2400000.00 to which the period and period derivative are referred. Positions are equinox 1950.0 and do not include the E-terms of annual aberration. The pulsar proper motions were not measured and the epoch of the positions is near the center of the timing data span. Quoted errors are twice the formal standard deviation and refer to the last digit quoted.

Results obtained from the Pushchino pulsar timing measurements are as follows. For eight of the pulsars discussed here new values of the period derivative have been measured. For three of the pulsars, PSR 0320+39, 0809+74 and 1839+56 the period derivative values were significantly improved. For six of the pulsars, PSR 0138+59, 0320+39, 0329+54, 0823+26, 0943+10 and 1839+56, improved positions were obtained.

Period derivative

The pulsars for which new values of the period derivative were measured are given in table 3. The values of these derivatives are outside the error ranges of previously published values. Excluding PSR 2217+47, the derivatives obtained from the present observations are smaller than those quoted by other authors (Manchester and Taylor 1981). Changes in the period derivatives do not account for the secular slowing down of the pulse frequency, because the corresponding braking index n, satisfying the relation $\dot{\nu} = k\nu^n$, does not lie between the theoretically predicted values 1–6 (the last column of table 3). Second derivatives $\ddot{P}$ were computed simply from the change in $\dot{P}$, derived at different epochs; the braking index was then $n = \nu\ddot{\nu}/\dot{\nu}^2$.

Glitches in PSR 0355+54 and 0823+26

Period glitches were investigated for two pulsars PSR 0355+54 and 0823+26. Two jumps in PSR 0355+54 were detected by Lyne (1987). Our data for the first jump on JD 2446077.6 ± 1.0, $\Delta P/P = (5.62 \pm 0.08) \times 10^{-9}$, $\Delta\dot{P}/\dot{P} = 0.0015 \pm 2$, are in good agreement with the previously published values by Lyne. Unfortunately, the timing program was discontinued in 1986 February and the second

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Table 1 Observational parameters

PSR	Interval fitted	Length of data (days)	Number of points	Typical measurement error (μs)	RMS residual (μs)
0138+59	45326–46519	1193	137	760	480
0320+39	44268–46761	2493	65	1800	600
0329+54	44079–46487	2408	86	40	250
0355+54	45086–46474	1388	153	800	—
0809+74	44087–46762	2675	136	240	860
0823+26	45909–46600	691	47	130	240
0834+06	43701–46789	3088	191	70	200
0919+06	45569–46762	1193	109	160	1200
0943+10	45780–46663	883	51	290	1100
1541+09	45088–46759	1671	109	1200	1000
1839+56	45451–46787	1336	118	150	700
1919+21	43715–46821	3106	210	90	420
2016+28	45724–46787	1063	69	240	110
2110+27	45945–46787	842	40	300	240
2217+47	45571–46585	1014	47	50	130
2224+65	45398–46489	1091	70	690	560

Table 2 Pulsar parameters from timing observations

PSR	Right Ascension (1950.0)	Declination (1950.0)	Epoch (JD−2400000)	Period (s)	$\dot{P}$ (10^{-15} s s^{-1})
0138+59	01 38 17.248 ± 0.014	59 54 24.07 ± 0.12	45327.208	1.222948386520 ± 30	0.3910 ± 5
0320+39	03 20 10.154 ± 0.008	39 34 14.63 ± 0.30	44269.176	3.032071680806 ± 70	0.6339 ± 7
0329+54	03 29 11.036 ± 0.010	54 24 37.36 ± 0.15	44079.696	0.714519276109 ± 4	2.04746 ± 4
0809+74	08 09 02.826 ± 0.026	74 38 12.06 ± 0.26	44087.863	1.292241373159 ± 18	0.16803 ± 15
0823+26	08 23 50.543 ± 0.026	26 47 17.8 ± 0.7	45909.888	0.530660431603 ± 15	1.7109 ± 5
0834+06	08 34 26.179 ± 0.002	6 20 43.75 ± 0.12	43701.941	1.273765342824 ± 4	6.79924 ± 3
0919+06	—	—	45569.858	0.430616302210 ± 30	13.7222 ± 5
0943+10	09 43 27.56 ± 0.100	10 05 59.0 ± 4	45781.306	1.097704890211 ± 92	3.4884 ± 23
1541+09	15 41 14.40 ± 0.050	09 38 42.6 ± 0.6	45088.452	0.748448281305 ± 24	0.4289 ± 3
1839+56	18 39 50.860 ± 0.006	56 38 0.48 ± 0.05	45451.573	1.652861431105 ± 50	1.4955 ± 9
1919+21	19 19 36.179 ± 0.004	21 47 16.21 ± 0.08	43716.359	1.337301544781 ± 9	1.34813 ± 6
2016+28	20 16 00.164 ± 0.008	28 30 30.13 ± 0.14	45724.891	0.557953471951 ± 3	0.14863 ± 8
2110+27	21 10 54.227 ± 0.006	27 41 37.61 ± 0.13	45946.331	1.202851120630 ± 40	2.6225 ± 10
2217+47	22 17 45.859 ± 0.008	47 39 47.80 ± 0.13	45571.401	0.538468576220 ± 6	2.76626 ± 13
2224+65	22 24 17.314 ± 0.052	65 20 15.31 ± 0.46	45398.871	0.682534968791 ± 38	9.6634 ± 8

large jump in this pulsar in 1986 March was not observed. Figure 1a shows time residuals from a fit of P, $\dot{P}, \ddot{P}$ (Lyne 1987) and position (Helfand *et al.* 1980)

The period jump in PSR 0823+26 was detected in our observations in 1983 June (JD 2445500 ± 5). This jump had a small amplitude, $\Delta P/P = -(0.40 \pm 0.05) \times 10^{-9}$, $\Delta\dot{P} = 0$, and presented a simple abrupt change of period. A detailed description of the frequency behavior is given in figure 1c and 1d.

Time residuals for PSR 0919+06 and 0943+10

Figure 2 shows the fit residuals from PSR 0919+06 arrival-time data. Sudden changes in the slope of the residuals are observed, which appear to be discontinuities in ΔP and $\Delta\dot{P}$ with the small estimated amplitudes of $\Delta P/P = 3 \times 10^{-10}$ and $\Delta\dot{P}/\dot{P} = 4 \times 10^{-4}$. Time residuals for the mode-changing pulsar PSR 0943+10 are shown in figure 3. The rms arrival-time residuals for each mode are about 1 ms. Apparently, the mode-changing phenomenon does not significantly influence the pulse time stability.

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Table 3 Computed braking index n

PSR	$\dot P_{obs}$ (10^{-15})	$\dot P_{table}$ (10^{-15})	$\Delta\dot P$ (10^{-15})	ΔT (days)	$\ddot P$ (s^{-1})	n
0329+54	2.04746 ± 4	2.04959 ± 8	-0.00213	3458	-7.12×10^{-27}	1200
0823+26	1.7109 ± 5	1.7236 ± 4	-0.0127	3193	-4.60×10^{-26}	8200
0919+06	13.7222 ± 5	13.7248 ± 5	-0.0026	1679	-1.79×10^{-26}	41
0943+10	3.4884 ± 23	3.5291 ± 22	-0.0407	4116	-1.14×10^{-25}	10100
1541+09	0.4289 ± 3	0.43030 ± 12	-0.0014	2784	-5.81×10^{-27}	23500
2016+28	0.14863 ± 8	0.14936 ± 2	-0.00073	5036	-1.67×10^{-27}	42000
2217+47	2.76626 ± 13	2.76421 ± 3	$+0.00205$	4947	$+4.79\times10^{-27}$	-340
2224+65	9.6634 ± 8	9.671 ± 2	-0.0076	1510	-5.82×10^{-26}	420

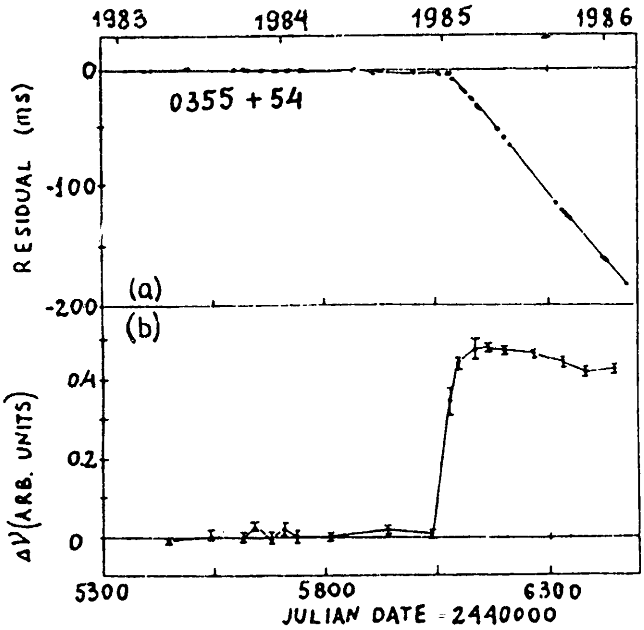

Figure 1a, b The period glitch in PSR 0355+54. (*a*) Time residuals from fitting the pre-jump timing parameters to the data. (*b*) Frequency behavior, obtained by differencing successive time residuals.

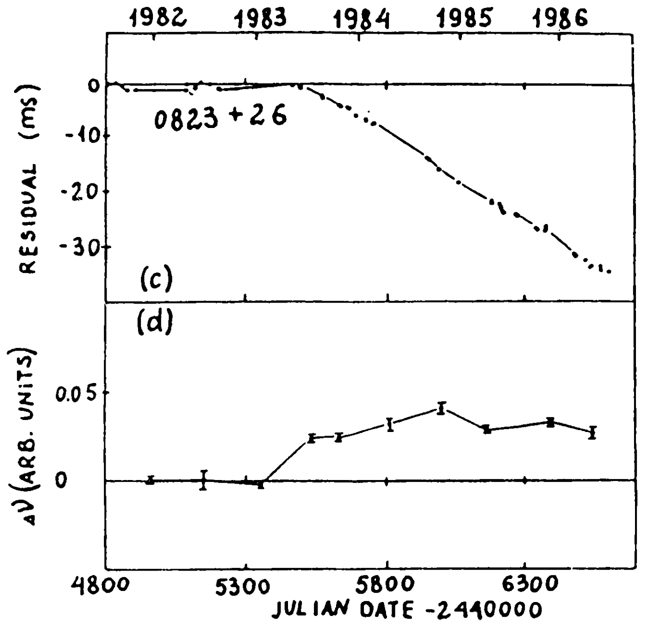

Figure 1c, d The period glitch in PSR 0823+26. (*c*) Time residuals from fitting the pre-jump timing parameters to the data. (*d*) Frequency behavior, obtained by differencing successive time residuals.

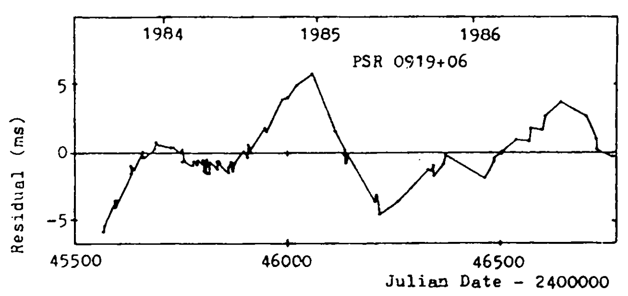

Figure 2 Time residuals for PSR 0919+06 after fitting arrival times for the parameters in table 2.

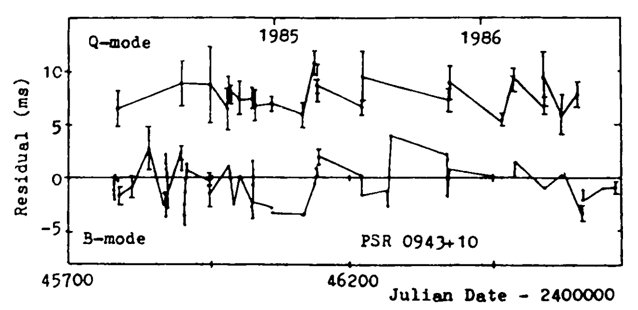

Figure 3 Time residuals for the mode-changing pulsar PSR 0943+10. Successive points of B and Q modes are joined by straight lines. Error bars are shown when they exceed 500 μs.

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