The timing behavior of PSR B0540-69 with X-ray observations of RXTE

Mingyu Ge, Fangjun Lu, Shijie Zheng et al.

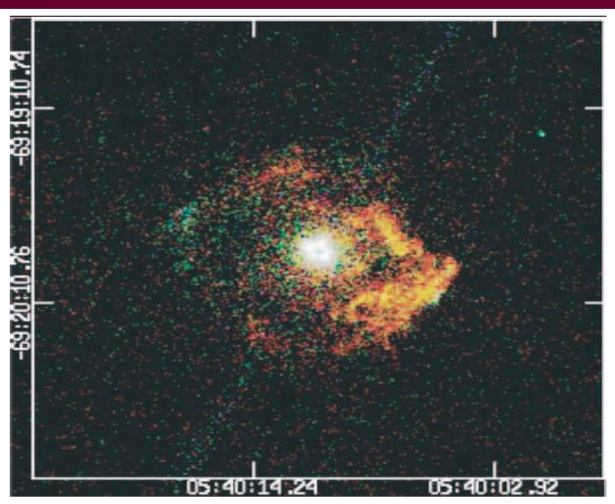
Particle Astrophysics Division, IHEP, CAS

gemy@ihep.ac.cn

Abstract

We present a new phase-coherent timing result for the young, energetic pulsar PSR B0540-69 using about 15 yr data from the Rossi X-Ray Timing Explorer. Three new glitch events were discovered with $f_g/f \leq 10^{-9}$ and $f_{1g}/f_1 \leq 1.5\times10^{-4}$. The mean time between two glitches is 1809 days and glitch activity parameter $A_g \simeq 3.9\times 10^{-10}yr^{-1}$ which is remarkably less than Crab pulsar. The braking index is 2.1502(2) and varies in different time interval with amplitude 0.035.

Basic information of PSR B0540-69



PSR B0540-69 is a young and bright pulsar. The parameters are listed in the following table.

	PSR B0540-69
Remnant	SNR in LMC
P(ms)	50.3
P-dot(10^{-15}ss^{-1})	479
Age(yr)	1670
Detections	R,O,X,G
Brake Index	2.04(0.02)
Dist(kpc)	55
B(10^{12}G)	1.6
E_{rot}(10^{38}ergs^{-1})	1.5

Methods

The time of arrivals were produced observation by observation and were merged together according to their respective phase bin for the final timing analyses. Two methods were used to calculate the glitch parameters, similar to Livingstone et al.(2005).

(1) Partially phase-coherent timing process is described as follows: First, fitting 2N TOAs with second frequency derivative. Second, moving N TOAs and fitting the next time interval, which also including 2N TOAs. After these steps, ν, ν_1 and ν_2 series were measured.

(2) Full coherent timing method: (1) TOAs were fitted at test glitch epoch and the χ^2 was calculated. Second, change test glitch epoch and repeated the first step. At last, the χ^2 is the function of test glitch epoch. The epoch of the glitch is obtained where the minimum χ^2 reached.

Results

The pulse profile and timing results

Four glitches have been observed from the RXTE observations. One of the glitches has been reported by Livingstone et al.(2005). The glitch epochs are 51345, 52945, 54434 and 55660 as shown in tables below. The ν_1 also displays interesting behaviors as shown in Fig. 4.

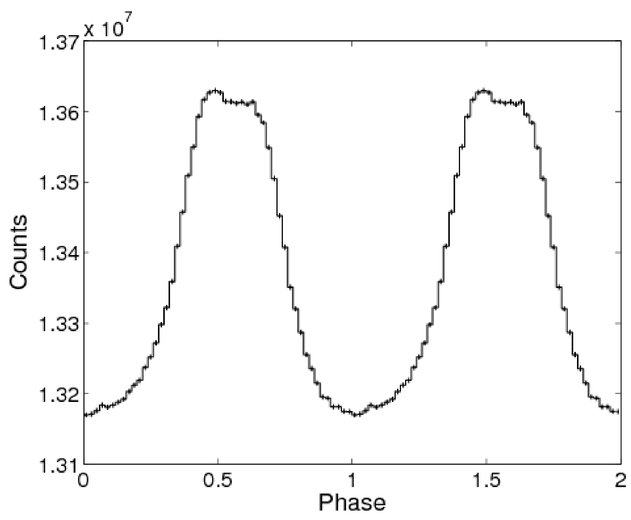


Fig.1 The pulse profile of PSR B0540-69. The profile is a typical broad profile.

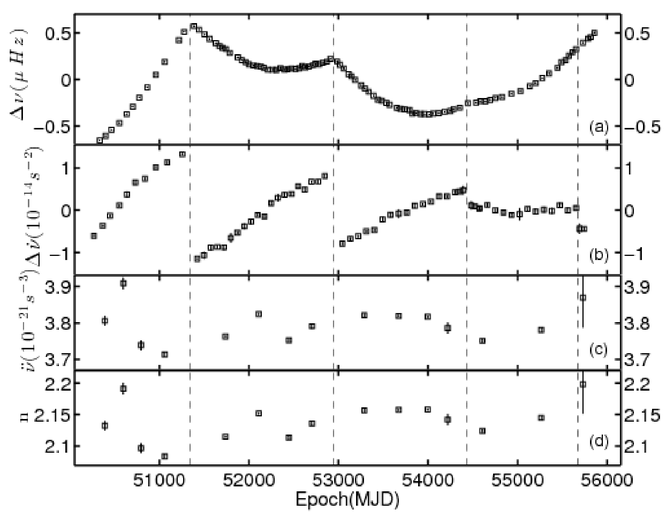


Fig.2 The spin parameters of PSR B0540-69. The vertical dashed lines represent the position of four glitches. (a): the residuals with two frequency derivatives fitting. (b): the residuals with two frequency derivatives fitting. (c): as function of time. (d): braking indices n as function of time.

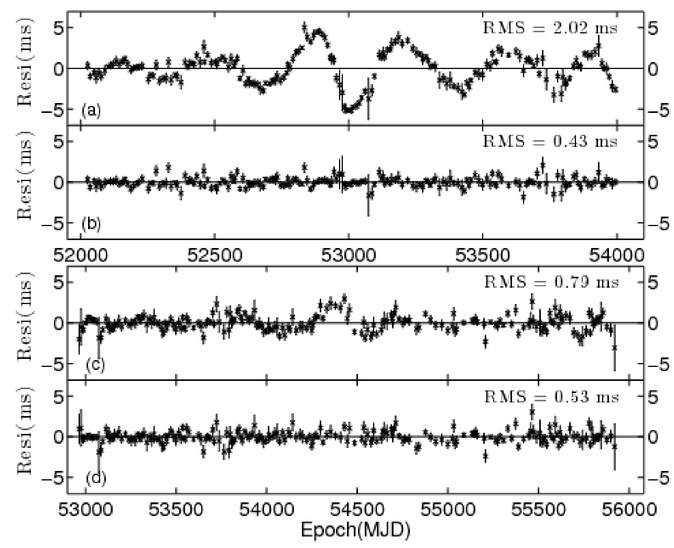


Fig.3 PSR B0540-69 timing residuals. (a): Timing residuals without parameters of G2 for MJD 52000-54000. (b): Timing residuals with parameters of G2 for MJD 52000-54000. (c): Timing residuals without parameters of G3 and G4 for MJD 52984-55920. (d): Timing residuals with parameters of G3 and G4 for MJD 52984-55920 .

Results

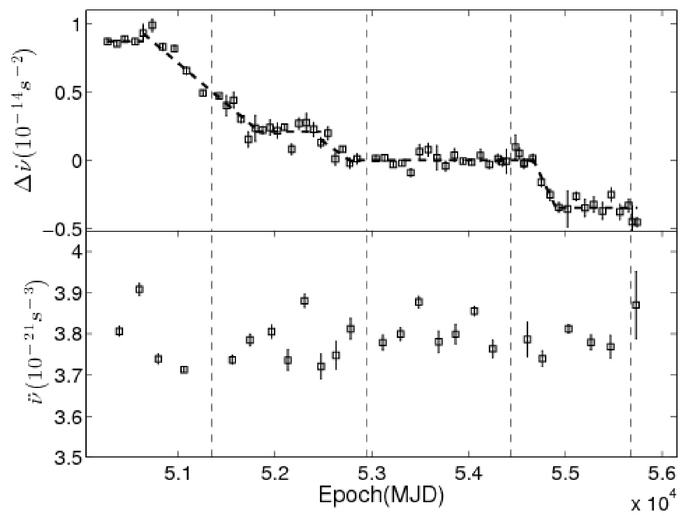


Fig.4 ν_1 varies continue and descend slowly if the ν_g was added to ν_1 and subtracted the trend between G2 and G3 plateaus and descend slowly from one plateau to another.

No	Glitch Epoch MJD	$\dot{\nu}_g$ ($10^{-15}s^{-2}$)	$\dot{\nu}_g/\dot{\nu}$ (10^{-5})
1	51363 ± 25	-28.1 ± 1.8	15.0 ± 1.0
2	52955 ± 17	-18.7 ± 1.4	10.0 ± 0.7
3	54454 ± 45	-5.2 ± 1.6	2.8 ± 0.8
4	55671 ± 34	-3.7 ± 3.2	2.0 ± 1.7

No	Timing range MJD	Glitch Epoch MJD	ν_g ($10^{-9}s^{-1}$)	$\dot{\nu}_g$ ($10^{-15}s^{-2}$)	ν_g/ν (10^{-10})	$\dot{\nu}_g/\dot{\nu}$ (10^{-5})
1	50185-52944	51345 ± 11	3.0 ± 2.5	-27.54 ± 0.27	1.5 ± 1.4	14.7 ± 0.1
2	52004-54042	52945 ± 12	0.6 ± 3.9	-19.08 ± 0.62	0.3 ± 2.0	10.2 ± 0.3
3	52991-55857	54434 ± 41	8.2 ± 5.8	-3.09 ± 0.46	4.1 ± 3.0	1.7 ± 0.3
4	55200-55920	55660 ± 40	17.1 ± 3.0	-3.47 ± 0.29	8.7 ± 1.5	1.9 ± 0.2

Epoch MJD	Time range MJD	ν (Hz)	$\dot{\nu}$ (10^{-10} s^{-2})	$\ddot{\nu}$ ($10^{-21}s^{-3}$)	n
50735	50150 - 51345	19.8099433121(8)	-1.8795208(3)	3.788(3)	2.124(2)
52151	51345 - 52945	19.7869749611(3)	-1.87519515(7)	3.7999(6)	2.1382(4)
53734.5	52945 - 54434	19.7613538578(2)	-1.87017787(6)	3.8209(5)	2.1588(3)
55000	54434 - 55660	19.7409279892(4)	-1.866083(5)	3.784(1)	2.1451(7)
55799.5	55660 - 55920	19.728046690(1)	-1.863499(3)	3.88(9)	2.20(5)

Conclusion

(1) Another three glitches of PSR B0540-69 have been observed with RXTE data.

(2) The mean braking index of PSR B0540-69 is 2.1502.

Acknowledgements

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