Pulsar

Glitches Detected in Southern Radio Pulsars

Meng Yu 于萌[1,2,3], R. N. Manchester[3], G. Hobbs[3], S. Johnston[3], V. M. Kaspi[4], M. Keith[3], A. G. Lyne[5], G. J. Qiao[1], V. Ravi[6,3], J. M. Sarkissian[3], R. Shannon[3], R. X. Xu[1]

1 Department of Astronomy, School of Physics, Peking University

2 National Astronomical Observatories of China

3 CSIRO Astronomy & Space Science

4 Department of Physics, McGill University

5 Jodrell Bank Centre for Astrophysics, The Unversity of Manchester

6 School of Physics, Unversity of Melbourne

Contact:
vela.yumeng@gmail.com

What is a Glitch?

Glitches are unexpected jumps of the spin rates of rotating neutron stars. One of the glitches occurred in the famous Vela pulsar B0833-45 was captured in February 1969 as the first discovery for such events. Pulsar spin can jump! Mmmm... Does this mean anything to neutron stars?

Timing Routine

Pulse times-of-arrival measured at the solar system barycentre are further transferred to form pulse emission times when excess propagation delays due to passage through the interstellar medium and a possible binary system are corrected.

Time-correction signals broadcasted by GPS satellites are used to correct the hydrogen-maser clock at the observatory, which are then used to determine the pulse arrival-times at the site.

GPS satellite

The earth

To measure the pulse arrival-times in an ideal inertial reference frame, pulse topocentric times-of-arrival are corrected to the times at the Solar System Barycentre: with using the planetary ephemeris provided by JPL, propagation delays brought by the motion of the earth (Roemer delay) and the warps of time (Einstein delay) and space (Shapiro delay) etc. are removed.

The sun

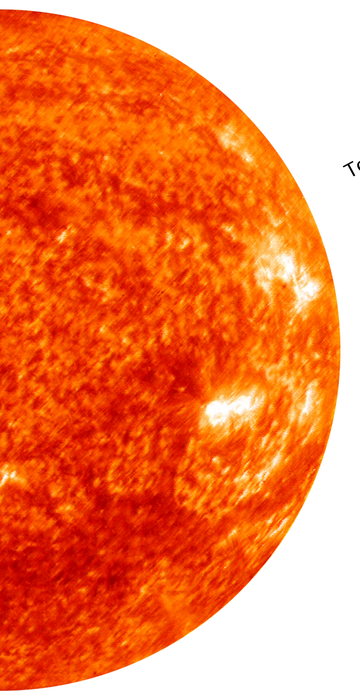


Fig. 1 CSIRO Parkes 64-m radio telescope. The greatest achievement of this antenna is that it transmitted the television signal of Apollo 11 to all over the world, rather than pulsars!(photo: David McClenaghan, CSIRO)

The Observations

The dish (Fig. 1) —— CSIRO 64-m radio telescope located at Parkes, west NSW, Australia —— has been, from 1990 to 2011, working for a series of programmes carried out for monitoring the timing attributes for approximately 170 young pulsars. Data were collected in the 20-cm band, having a central frequency around 1400 MHz. During the 20 years, efforts have been made to upgrade the dish. Several front-ends and back-ends have been used in the observations. Table 1 tells you more... Fig. 2 is the period-period-derivative diagram showing 165 pulsars that are in our sample.

Table 1. Observing log.

Range	Receiver	Back-end	BW (MHz)	Pol.	Cadence (week)	Integration/TOA (min)
1990 - 1994	H-OH	analogue filterbank	64 x 5	2	2 - 4	1 - 10
1994 - 1997	H-OH	FPTM	256	2	2 - 4	1 - 10
1997 - 2001	multi-beam	FPTM/ analogue filterbank	256 96 x 3	2 2	2 - 4 2 - 4	1 - 10 1 - 10
2001 - 2007	multi-beam	analogue filterbank	96 x 3	2	2 - 4	1 - 10
2007 - 2011	multi-beam	PDFB	256	2	4	2 - 20

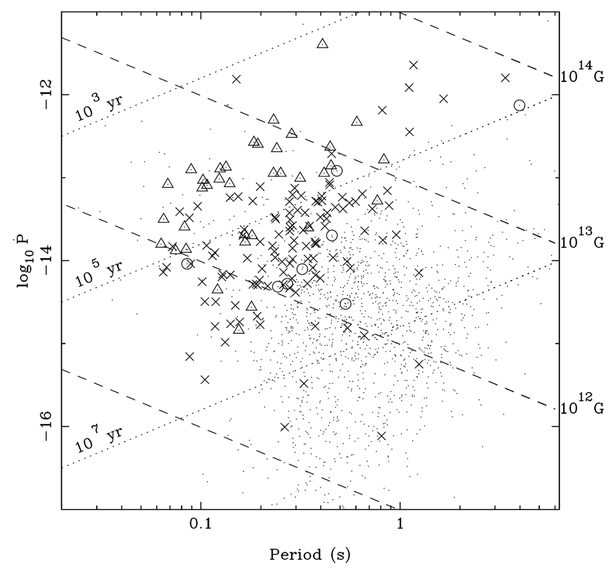


Fig. 2 P-$\dot{P}$ diagram showing the 165 pulsars in the sample. For those where no glitch has been detected, a glitch was detected in this work and a glitch was detected prior to our data are indicated by crosses, triangles and circles, respectively.

How to identify a glitch?

A glitch means a sudden jump in the pulse frequency, what do you expect to see in timing residuals? Yes!-The sudden earlier arrival of pulses! Glitches that increase the pulse frequency by one part in a million are actually very large. The frequency is changed so much that you lose your counts for pulses soon after the glitch. Small glitches are not that strong such that you can clearly see the advanced-arrival of subsequent pulses (Fig. 3 shows the examples).

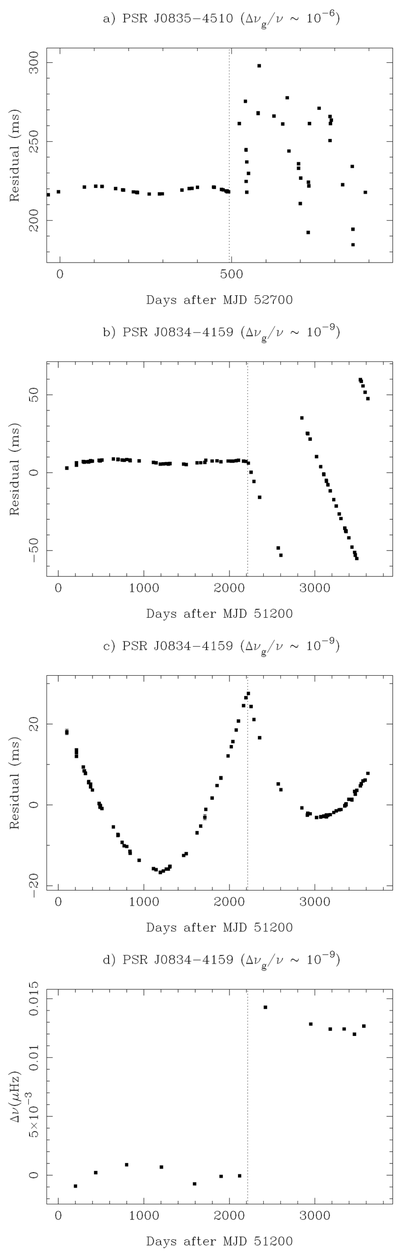


Fig. 3 Impact on timing residuals brought by glitches. Plot a) shows the MJD ~ 53193.09 large glitch suffered by the Vela pulsar; timing residuals relative to the pre-glitch solution become messy after the event. Plots b), c) and d) are for the MJD ~ 53415 small glitch in PSR J0834-4159. Timing residuals referring to the pre-glitch model are shown in b). Plot c) further shows the residuals after fitting for the entire data span but without modelling the glitch. Seen a cusp? Plot d) shows you the measured evolution of the pulse frequency: YES! The frequency jumped!

Data Reduction

The flow chart (Fig. 4) shows the procedures of data reduction.

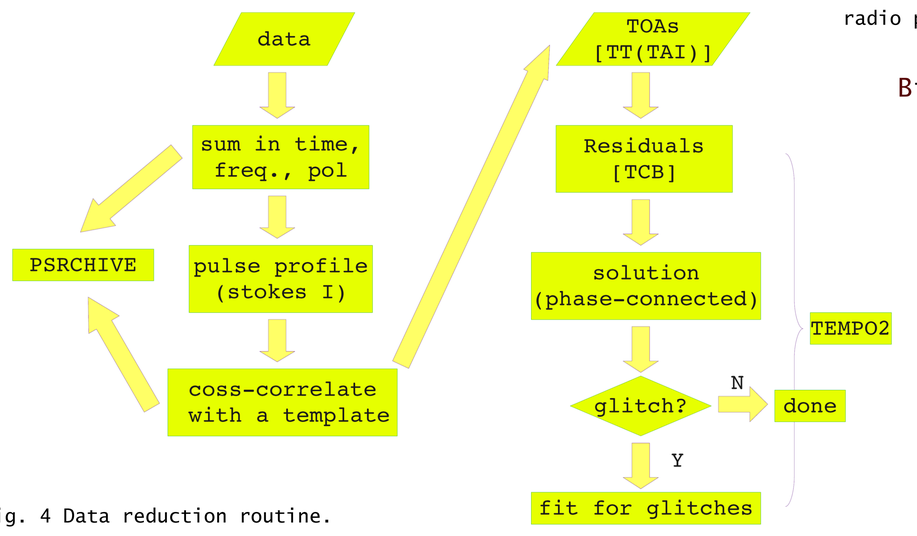
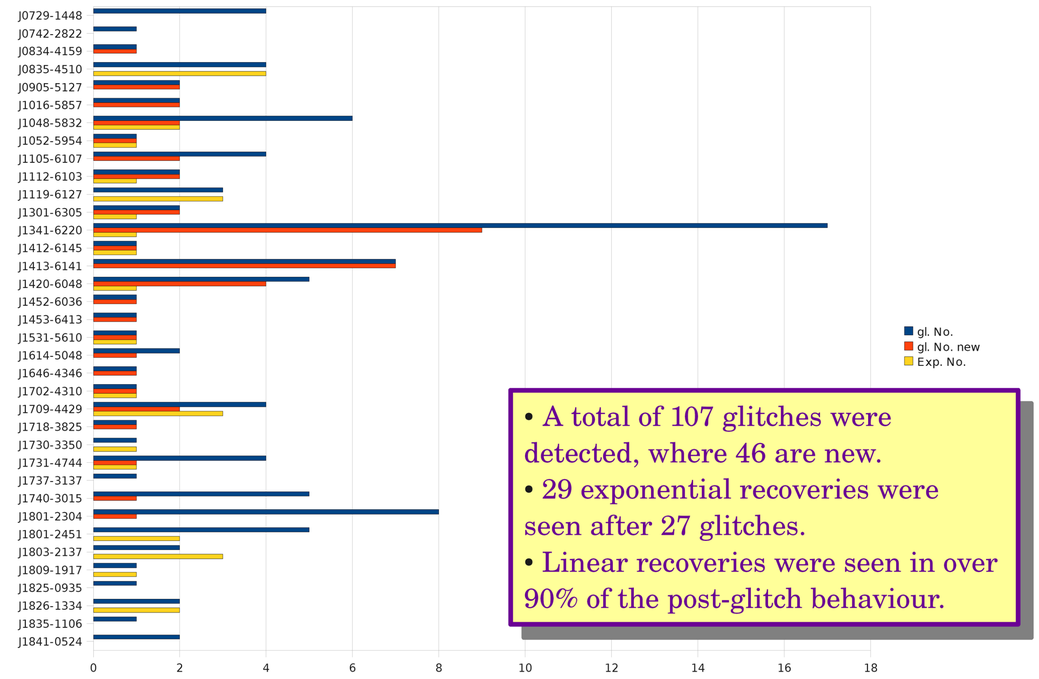


Fig. 4 Data reduction routine.

Results

The bar chart below shows what we have found after processing our data.



- A total of 107 glitches were detected, where 46 are new.
- 29 exponential recoveries were seen after 27 glitches.
- Linear recoveries were seen in over 90% of the post-glitch behaviour.

Fig. 5 Numbers of glitches and exponential recoveries for 36 southern radio pulsars observed at Parkes.

Bimodal distribution

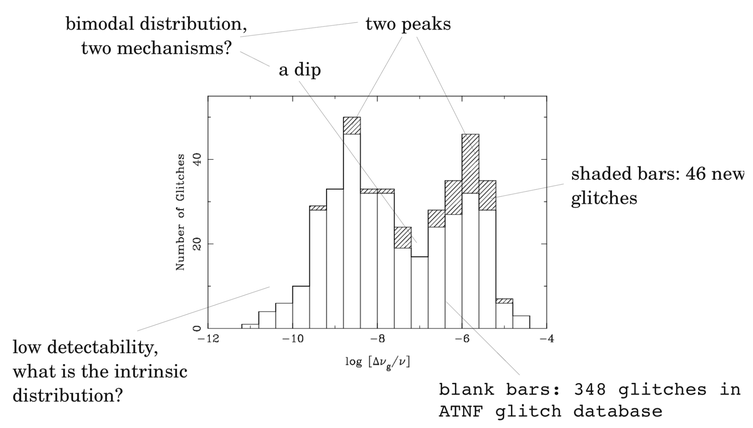


Fig. 6 Histogram for glitch fractional sizes.