Glitches in the Vela Pulsar

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HartRAO

The Vela pulsar (J0835-4510) has been observed almost daily from HartRAO since 1984.

Observations include eight of the fourteen large glitches in rotation frequency seen in this pulsar, and two smaller spin-ups clearly distinct from timing noise.

Middleditch et al (2006) reported on 21 "glitches" in the spin-rate of the 16 ms X-ray pulsar J0537-6910. They showed that the time interval from one glitch to the next depends on the amplitude of the first glitch. This correlation allows the prediction of glitches to within a few days.

In contrast, Wong et al (2001) concluded that glitches in the Crab pulsar are randomly distributed in time, consistent with a Poisson distribution.

We compare glitch data from four "glitching" pulsars covering a range of ages.

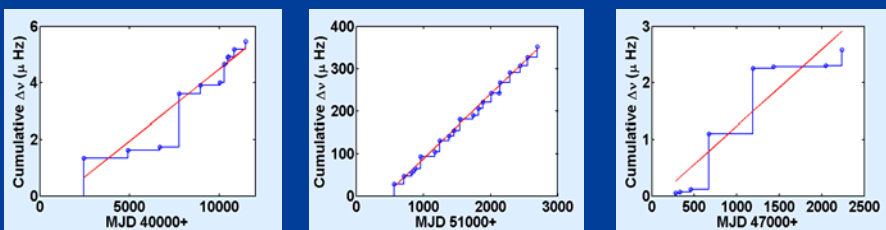
PSR J0534+22
Crab
ν = 30 Hz
$\dot{\nu}$ = -3.9 $\times 10^{-12}$ Hz/s
Age: 1 000 yr
12 glitches $\Delta\nu/\nu \sim 10^{-9}$

PSR J0537-6910
ν = 62 Hz
$\dot{\nu}$ = -2 $\times 10^{-10}$ Hz/s
Age: 5000 yr
21 glitches $\Delta\nu/\nu \sim 10^{-7}$

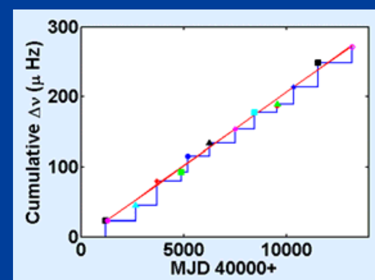
PSR J1740-3015
ν = 1.6 Hz
$\dot{\nu}$ = -1.3 $\times 10^{-12}$ Hz/s
Age: 20 000 yr
9 glitches $\Delta\nu/\nu \sim 10^{-9}$ - 10^{-8}

PSR 0835-4510
Vela
ν = 11 Hz
$\dot{\nu}$ = -1.6 $\times 10^{-11}$ Hz/s
Age: 11 000 yr
12 glitches $\Delta\nu/\nu \sim 10^{-6}$

1



(1) Sum of glitch magnitudes vs time – the slope gives A_g- the glitch activity index. For Vela A_g ~ 8 μHz / yr.



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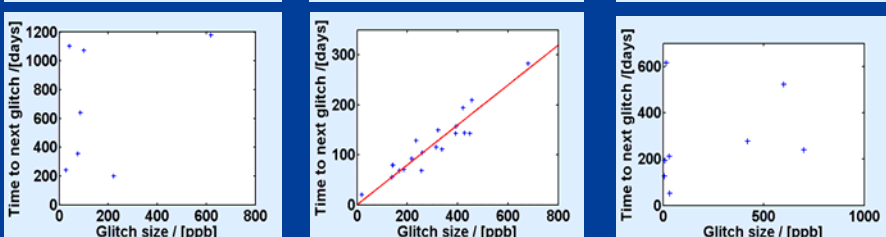
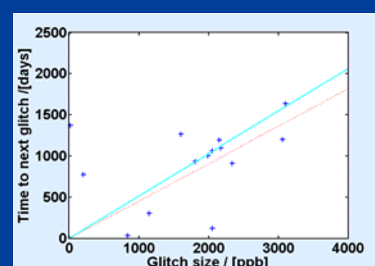


(2) The dotted red line is a linear fit (passing through the origin) to all the data. The cyan line is fitted only to the large glitches.



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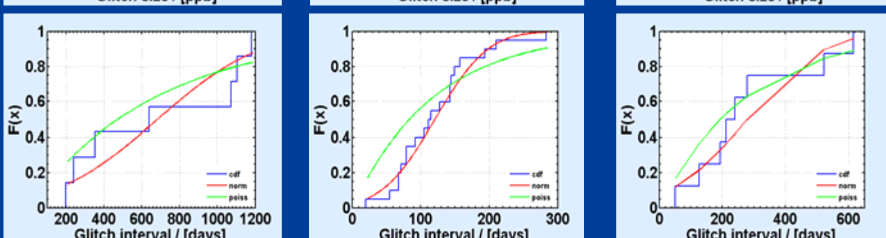
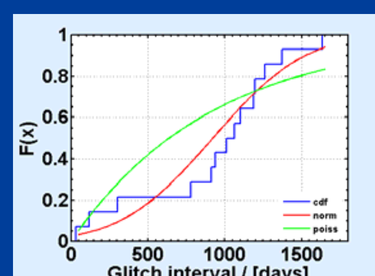


(3) A cumulative distribution function is plotted for inter-glitch intervals. Theoretical Poisson and normal distribution functions are shown. A Kolmogorov-Smirnov test rules out a Poisson distribution, suggesting the glitches are not randomly distributed in time.



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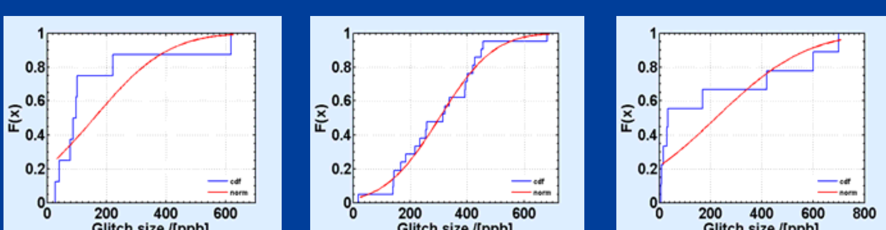
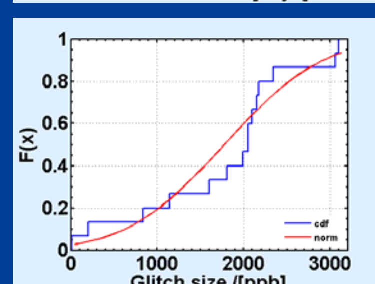


(4) A cumulative distribution function is plotted for the glitch sizes and compared to a theoretical normal distribution functions.



(1) Sum of glitch magnitudes vs time – the slope gives A_g- the glitch activity index.

(2) The glitch interval plotted against the size of the first glitch. Following Middleditch et al (2006) we fit a straight line (passing through the origin) to the J0537-6910 data. The slope of this line is 399 days ppm^{-1} or 6.4 days μHz^{-1}.

(3) A cumulative distribution function is plotted for inter-glitch intervals. Theoretical Poisson and normal distribution functions are shown. A Kolmogorov-Smirnov test rejects a Poisson distribution for pulsar J0537-6910.

(4) A cumulative distribution function is plotted for glitch sizes and compared to a theoretical normal distribution functions.

Questions

- Are the small glitches "aftershocks"?
- Is there a correlation between the size of a glitch and the time until the next glitch?
- Are there two types of glitches?
- Is there an evolution of glitch behaviour with pulsar age?

Acknowledgments

The ATNF Pulsar Catalogue has been used: http://www.atnf.csiro.au/research/pulsar/psrcat/, (Manchester, R. N., Hobbs, G. B., Teoh, A. & Hobbs, M., 2005, AJ, 129, 1993).

References

Middleditch, J.; Marshall, F.E et al, (astro-ph/0605007)

Wong T, Backer D.C. & Lyne A.G., 2001, ApJ, 548, 447