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Twelve years of Glitches in the Vela Pulsar

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1. Introduction

The Vela pulsar (PSR B0833–45) has been observed from Hartebeesthoek RAO since 1984, as part of an ongoing monitoring project. During this time, the pulsar has undergone five sudden and relatively large spin-ups ("glitches"). Good observational coverage was obtained for the four most recent of these events.

2. Post-glitch Timing Behaviour

The post-glitch behaviour of $\dot{\nu}(t)$ is modelled by:

$$\begin{aligned}\dot{\nu}(t - T_G) &= \dot{\nu}_0 + \ddot{\nu}_0(t - T_G) + \sum_i \Delta\dot{\nu}_i \exp(-(t - T_G)/\tau_i) \\ &\quad + \Delta\dot{\nu}_{nl}\left[1 - \frac{1}{1 + e^{-(t-T_G)/\tau_{nl}}\left(e^{t_0/\tau_{nl}} - 1\right)}\right], \qquad (1)\end{aligned}$$

where T_G is the glitch epoch and subscript nl refers to a "non-linear" recovery component of the form discussed by Alpar *et al.* (1989). The results of a preliminary fit of this model to all five glitches are given in table 1. The "baseline model" describes the long-term behaviour; no single simple model provides an adequate fit to all three of the longer inter-glitch eras observed (Flanagan 1996). The immediate post-glitch behaviour (the "transients" in table 1) are modelled with simple exponentials; three such components are required for the larger and better-observed glitches of 1988 and 1991. Following Alpar *et al.* (1993), a model incorporating common timescales for all five glitches was also fitted. The data are consistent with a recovery described by at least three exponential decays of $\Delta\dot{\nu}$, over timescales 50±20 d, 5±2 d and 0.49±0.08 d, following each of the most recent five glitches. In addition, the moment of inertia $I_i = \Delta\dot{\Omega}_i\tau_i/\Delta\Omega_c I$ associated with the 5 d component is $(5\pm3)\times10^{-3}$. The data are inconsistent with the 0.49 d recovery being associated with the same moment of inertia (as defined here) at every glitch.

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Table 1. Model Parameters.

		1985	1988	1991	1994	1994A
baseline model:						
$\dot{\nu}(T_G)$ 10^{-13} Hz s^{-1}		-155.54(3)	-156.45(3)	-156.62(4)	-156.54(3)	-156.59(3)
$\ddot{\nu}_0$ 10^{-22} Hz s^{-2}			+9.3(7)	+8.3(2)		
$\Delta\dot{\nu}_{nl}/\dot{\nu}$	%		+0.11(2)			
τ_{nl}	days		9(6)			
t_0	days		468(6)			
$\Delta\dot{\nu}/\dot{\nu}$	%	+0.87(2)				
τ	days	760(40)				
transients:						
$\Delta\dot{\nu}_1/\dot{\nu}$	%		+0.26(4)	+0.35(6)		
τ_1	days		70(20)	49(6)		
$\Delta\dot{\nu}_2/\dot{\nu}$	%	+1.8(3)	+1.2(5)	+2.3(7)		+0.4(2)
τ_2	days	6.8(4)	5(1)	4.9(6)		6(7)
$\Delta\dot{\nu}_3/\dot{\nu}$	%		+16(6)	+40(10)		
τ_3	days		0.53(9)	0.59(4)		

The components listed in column 1 are those of eqn. 1.
T_G is the glitch epoch.
Errors are 2-σ in the least significant digit quoted.

References

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