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Six Years of PSR B1853+01 Timing Observations

Abstract

We summarize the first six years of timing observations of PSR B1853+01, a young pulsar associated with the W44 supernova remnant. Our analysis has revealed two major rotational events: a step increase in the pulsar's period derivative, and a glitch. In addition, PSR B1853+01 exhibits large dispersion measure variations.

I Introduction

PSR B1853+01 was discovered in a search for pulsars in supernova remnants (SNR) with the 305-m Arecibo radio telescope (Wolszczan, Cordes & Dewey 1991). The pulsar's location within W44, and the agreement between the ages and distances of the pulsar and the SNR provided an early indication of their association. Further observations using the VLA (Frail et al. 1996) have detected a synchrotron nebula within W44 powered by the spin-down energy loss of the pulsar, as well as a cometary structure resulting from the pulsar's motion through the SNR. These observations constrain a transverse velocity of the pulsar to be between 300 and 500 km s^{-1}. This is consistent with the $\geq$ 200 km s^{-1} velocity which would be expected if the pulsar originated at the center of W44. Moreover, ASCA observations indicate synchrotron X-ray emission coincident with PSR B1853+01 (Harrus, Hughes & Helfand 1996). These observations point unambiguously to the association of PSR B1853+01 and the W44 SNR.

II Analysis of Timing Observations

We have timed PSR B1853+01 at approximately monthly intervals with the 305-m Arecibo radiotelescope and the 40 MHz, 3-level correlation spectrometer. Observations were conducted at 430 MHz and 1400 MHz, with dual-frequency data covering a 3-year period between 1992 and 1994. The detected, time-tagged input signals were folded at the topocentric pulse period, and cross-correlated with a high signal-to-noise pulse template to measure pulse arrival times (TOA). A conversion of the TOAs to the

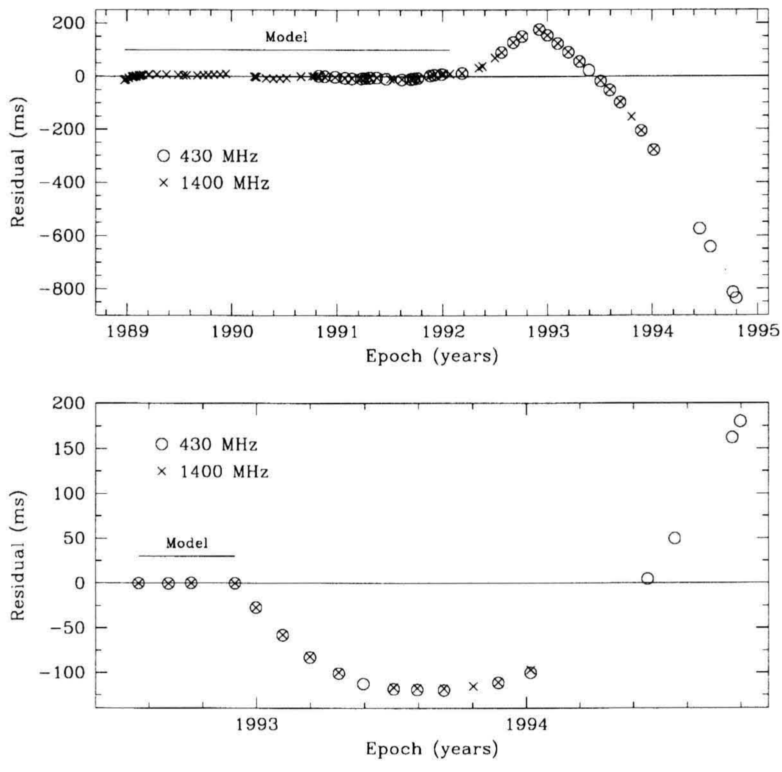

Figure 1. *Top:* Timing residuals for PSR J1853+01 at both observing frequencies, with the first 2.5 years of observations used as a model. *Bottom:* Timing residuals for PSR J1853+01 beginning in mid-1992, showing a large glitch. The timing model used here is based on the four observations previous to the glitch, during which the pulsar's spin parameters were relatively stable.

Solar System barycenter and the fits of timing models to data were performed with the standard timing package TEMPO.

PSR B1853+01 displays noisy rotational behavior. Figure 1 shows the residuals of the pulsar with respect to two different timing models. The first 2.5 years of observations are characterized by the timing noise typical of a young pulsar. In early 1992, an increase in the spin down rate of $\Delta\dot{P}/\dot{P} = 1 \times 10^{-3}$ was observed. After the spin parameters stabilized in late 1992, a glitch occurred. The values of $\Delta P/P = -1 \times 10^{-8}$ and $\Delta\dot{P}/\dot{P} = 7 \times 10^{-4}$ characterizing the fractional changes in the pulsar's spin parameters during this event are comparable to those of the Crab pulsar glitches (Lyne, Pritchard & Smith 1993). A recovery time scale for this

Table 1: Post-Glitch Parameters of PSR B1853+01

Parameter	Value
P (s)	0.26743520591(3)
$\dot{P}$ (10^{-15} s s^{-1})	208.477(1)
Epoch (MJD)	49535.4
α (J2000)	18 56 10.76(2)
δ (J2000)	01 13 28.0(6)
DM (pc cm^{-3})	96.6(3)

rotational discontinuity remains undetermined, because the pulsar's spin parameters following the glitch did not stabilize before the break in timing observations toward the end of 1994.

In young glitching pulsars, discontinuous changes in rotation period are usually followed by an exponential decay back toward the pre-glitch period (Shemar and Lyne 1996). However, in PSR B1853+01, either very little of the initial change in period has recovered, or a possible recovery trend has been concealed by the increased and unstable post-glitch value of $\dot{P}$. While glitches are common in young pulsars, PSR B1853+01's pre-glitch $\dot{P}$ increase, as well as its post-glitch $\dot{P}$ evolution make its rotational history untypical. Table 1 shows the best-fit values of the pulsar's spin parameters following the glitch.

In addition to the TOA measurements, changes in the dispersion measure (DM) of PSR B1853+01 were monitored at all epochs for which dual frequency data were available. The DM shows large, nonlinear variations, with an average rate of change $\Delta\mathrm{DM}/\Delta t = -0.07$ cm^{-3} pc yr^{-1}. A study of the propagation phenomena along the line of sight to this pulsar will be presented elsewhere.

Acknowledgements

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