Astrometry of Southern Pulsars

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Abstract. A preliminary determination of the proper motion and parallax of the Vela pulsar was made using phase-referencing VLBI. The measured proper motion in right ascension and declination are respectively, $\mu_{\alpha'} = -49.8 \pm 0.2 \, \mathrm{mas\,yr^{-1}}$ and $\mu_\delta = 30.5 \pm 0.1 \, \mathrm{mas\,yr^{-1}}$. The parallax of Vela was calculated to be $\pi_{\mathrm{Vela}} = 3.16 \pm 0.33 \, \mathrm{mas}$, which corresponds to a distance of $D_{\mathrm{Vela}} = 316^{+37}_{-29} \, \mathrm{pc}$.

1. Observations & Data Reduction

Multiple-epoch observations of the Vela pulsar were conducted using elements of the Australian and South African Long Baseline Array (LBA), as shown in Table 1. Phase-referencing observations were performed every 2.5 min between Vela and extragalactic source Vela-G. Vela-G was phase referenced by Vela at 2.3 GHz, and Vela was phase referenced by Vela-G at 8.4 GHz. Single frequency Mark-III data were correlated at Penticton, Canada, while dual frequency S2 data were correlated at ATNF's LBA correlator in Sydney. The LBA correlator can bin products in up to 32 period-synchronous time bins. Vela's pulse width at 2.3 GHz is 2.5 bins, and at 8.4 GHz it is ≈ 1 bin. The S2 data was processed using an ATNF customized version of NRAO's Astronomical Image Processing Software (AIPS). Using standard VLBI techniques, the data for the phase reference source for each epoch were delay and phase-calibrated, and solutions were applied to the target source. The relative offset between the target source and phase-reference source was measured for each epoch. This allows the position of the target source to be measured over time.

2. Results & Discussion

The motion of the Vela pulsar has a proper motion and parallax component. The parallax is a time-variable projection of the Earth's orbit onto the sky, tracing a sinusoid in RA and Declination through time. The proper motion and parallax contributions were determined from an unwieghted, least squares minimization. The caculated proper motions in right ascension and declination are $\mu_\alpha \equiv \dot{\alpha}\cos\delta = -49.8 \pm 0.2 \, \mathrm{mas\,yr^{-1}}$ and $\mu_\delta = 30.5 \pm 0.1 \, \mathrm{mas\,yr^{-1}}$, respectively. The parallax of Vela: $\pi_{\mathrm{Vela}} = 3.16 \pm 0.33 \, \mathrm{mas}$, which corresponds to a distance of $D_{\mathrm{Vela}} = 316^{+37}_{-29} \, \mathrm{pc}$. The tangential velocity of the Vela pulsar is $v_{\mathrm{T}} = 104 \, \mathrm{km\,s^{-1}}$

The proper motion agrees reasonably well with that of Bailes et al. (1989). The distance of 316 pc is much less than early estimates of 400-600 pc found by

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Table 1.   Observational parameters

Expt	Epoch	Rec. mode	Freq. (GHz)	Telescopes
V041A	25 Apr 1993	Mk-III	2.3	DSS43,Parkes,Hobart, Hartbeesthoek
V041C	18 Jun 1994	Mk-III	2.3	DSS43,DSS45,Parkes, Hobart,Hartbeesthoek
V041G	22 Apr 1995	Mk-III	2.3/8.4	DSS43,Hobart
V041L	17 Jul 1996	Mk-III/S2	2.3/8.4	DSS43,Hobart
V041M	23 Nov 1996	Mk-III/S2	2.3/8.4	DSS43,Hobart
V041O	26 May 1997	S2	2.3/8.4	DSS43,Hobart
V041P	26 Mar 1998	S2	2.3/8.4	DSS43,Hobart
V041S	17 Feb 1999	S2	2.3/8.4	DSS43,Hobart

DSS43 & DSS45 are at Tidbinbilla

Milne (1968), Prentice & ter Haar (1969), and Davies (1969). Recent estimates using a variety of techniques have had average values in the range 230–290 pc (Ogelman et al. 1989; Oberlack et al. 1994; Jenkins & Wallerstein 1995; Cha, Sembach, & Danks 1999), which are consistant with the results presented here.

References

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