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Discovery of Eight Recycled Pulsars – The Swinburne Intermediate Latitude Pulsar Survey

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Abstract. We have conducted a pulsar survey of intermediate Galactic latitudes ($5° < |b| < 15°$) at 20 cm. The survey has been highly successful, discovering 58 new pulsars, eight of which are recycled, in only ~14 days of integration time. One pulsar has a very narrow (2° FWHM) average profile for the pulsar's period (278 ms). The six new recycled binary systems provide valuable information on the formation of white dwarf pulsar binaries. Two systems have massive white dwarf companions (> 0.57 $M_\odot$ and > 1.2 $M_\odot$), while another has a low mass (~ 0.2 $M_\odot$) companion in a 23.3-d orbit, residing the well-known orbital period "gap".

1. The Swinburne Intermediate Latitude Pulsar Survey

Full details of the observing hardware and analysis procedures are available in Edwards et al. (2000). Briefly, 265-s pointed observations were made with the 64-m Parkes radiotelescope using the sensitive new 21 cm 13-beam receiver. The backend system includes twenty-six filterbanks, each with ninety-six channels and a total bandwidth of 288 MHz, centred at a sky frequency of 1374 MHz. Detected filterbank outputs are summed in polarisation pairs and one-bit digitised with an integration time of 125 μs. Data is recorded on magnetic tape for offline processing on the Swinburne supercluster, a network of 64 Compaq Alpha workstations, using standard techniques (e.g. Manchester et al. 1996).

The survey area has been observed and processed to a completeness of 90% and has been highly successful with a minimal investment of telescope time, discovering 58 new pulsars to date. Of these, eight are recycled, six of which are in binary systems with circular orbits, indicating white dwarf companions.

2. Discovery Highlights

We have discovered a pulsar with a period of 278 ms and an average pulse profile only $W \simeq 2\overset{\circ}{.}1$ FWHM. Rankin (1990) observed that the distribution of pulsar profile widths for core-type pulsars is well fit by the constraint $WP^{1/2} > 2\overset{\circ}{.}45$, where P is the pulsar period in seconds. The newly discovered pulsar J1410–7407[1], however, has $WP^{1/2} = 1\overset{\circ}{.}1$. Preliminary polarimetric results at 660 MHz

[1] Pulsar name is subject to change due to the present uncertainty in its position

and 1400 MHz indicate that the profile has two components, furthering the discrepancy between the observed component widths of this pulsar and other long-period systems.

The orbital period distribution of low mass binary pulsars previously appeared to include a "gap" (Camilo 1994) in the range $12.4 < P_{\rm orb}$ (d) < 56.3. A number of authors (e.g. Kulkarni 1995, Tauris 1996) have suggested that this gap separates those systems that evolved with significant angular momentum losses from those that did not. Systems with an orbital period less than the so-called "bifurcation period", $P_{\rm bif}$=1–2 days, undergo orbital contraction during mass transfer due these losses. The newly discovered binary system J1618–3919[1] has an orbital period of 23.3 days, placing it in the middle of the "gap". Further to the considerations above, we suggest that there is a narrow range of initial orbital periods (significantly longer than $P_{\rm bif}$) over which (for increasingly close orbits) angular momentum losses quickly become significant. This results in an under-density of systems with final orbits in the range of 7 – 60 days, particularly around the upper end of this range (the former "gap"). The distribution around $P_{\rm bif}$ appears fairly even.

The mass functions of two of the new recycled binary systems indicate that the companion is a massive CO or ONeMg white dwarf – for J1757–5322 $M_{\rm WD} > 0.57$ $M_\odot$, whilst for J1157–5112 $M_{\rm WD} > 1.2$ $M_\odot$. Five recycled binary pulsars with massive white dwarfs were previously known (see e.g. Arzoumanian, Cordes & Wasserman 1999). It has been suggested that the evolution of these systems included a deep common envelope phase (van den Heuvel 1994). PSR J1757–5322 is in a very close 11-hour orbit (with an orbital separation of $a \simeq 3.1$ $R_\odot$) and may be explained by this model only if an energy source other than orbital decay largely powers envelope ejection. J1157–5112, on the other hand, is only marginally compatible with the model of van den Heuvel (1994) due to the relatively wide 3.5-day orbit ($a \simeq 13.5$ $R_\odot$).

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