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The Green Bank Northern Sky Survey: Discovery of a New Neutron Star–Neutron Star Binary

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1. The Survey

We have surveyed 15,900 deg^2 of the northern sky for millisecond pulsars at 370 MHz with the Green Bank 140ft telescope.[1] The telescope was driven along lines of constant declination such that a given point on the sky was observed for two minutes. A Fourier transform spectrometer synthesized 512-channel spectra across 40 MHz in each of two polarizations. Total intensity levels were boxcar averaged at intervals of 256 μs, quantized to 1 bit, and written to tape. Data were processed with the Cray C90 of the Pittsburgh Supercomputer Center. The flux limit of the survey was 8 mJy for slow pulsars. A further 1500 deg^2 were observed with 20 MHz bandwidth, yielding 71% the usual sensitivity.

Eighty-four slow pulsars were detected, of which six were previously unknown. Three recycled pulsars were detected: the relativistic binary B1534+12; the neutron star–white dwarf binary J1022+1001, discovered nearly simultaneously at Arecibo; and J1518+4904, a previously unknown pulsar with a 41 ms rotation period.

2. PSR J1518+4904: A Neutron Star–Neutron Star Binary

Follow-up observations of J1518+4904 showed it to be in a 8.6 day, eccentric orbit ($e = 0.249$), probably with a neutron star companion. Through extensive timing observations of this pulsar over the past year we have measured the standard Keplerian orbital parameters (Table 1) and the precession of the orbit, $\dot{\omega} = 0.0111 \pm 0.0002$ deg/yr. Under general relativity, this implies that the sum of the pulsar mass, m_1, and the orbital companion mass, m_2, is $2.62 \pm 0.07\,M_\odot$. The Keplerian mass function adds the constraints $m_1 < 1.7\,M_\odot$ and $m_2 > 0.9\,M_\odot$.

This system is significantly wider than the prototypical double neutron star binary system of PSR B1913+16, so it emits far less gravitational radiation. Orbital decay will be difficult to detect. Under general relativity the coalescence time of the binary is 2.4×10^{12} years.

[1] The 140 foot telescope is a facility of the National Radio Astronomy Observatory, operated by Associated Universities, Inc., for the National Science Foundation.

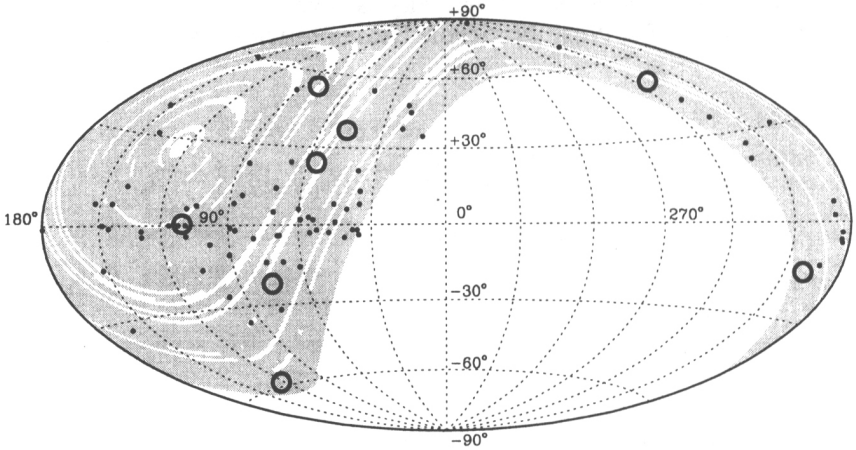

Figure 1. Survey coverage in galactic coordinates. Sky successfully observed in the survey is indicated by by shading, newly discovered pulsars are denoted by open circles, and known pulsars "re-discovered" in the survey are denoted by dots.

Table 1. Parameters of PSR J1518+4904

Pulse Period (ms)	40.9349882687(3)
Pulse Period Derivative	$< 1 \times 10^{-19}$
Right Ascension (J2000)	$15^{h}18^{m}16\overset{s}{.}797(2)$
Declination (J2000)	$+49°04'34\overset{''}{.}26(7)$
Epoch (MJD)	49820.00
Dispersion Measure (pc cm^{-3})	11.612(1)
Orbital Period (days)	8.6340049(1)
Projected Semi-Major Axis (light sec)	20.044004(4)
Eccentricity	0.2494849(3)
Angle of Periastron	$342\overset{\circ}{.}45979(6)$
Time of Periastron (MJD)	49818.540945(2)
Rate of Advance of Periastron (deg/yr)	0.0111(2)

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