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The ATNF Pulsar Catalogue

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ABSTRACT

We have compiled a new and complete catalog of the main properties of the 1509 pulsars for which published information currently exists. The catalog includes all spin-powered pulsars as well as anomalous X-ray pulsars and soft gamma-ray repeaters showing coherent pulsed emission, but excludes accretion-powered systems. References are given for all data listed. We have also developed a new web interface for accessing and displaying either tabular or plotted data with the option of selecting pulsars to be displayed via logical conditions on parameter expressions. The web interface has an "expert" mode giving access to a wider range of parameters and allowing the use of custom databases. For users with locally installed software and database on unix or linux systems, the catalog may be accessed from a command-line interface. C-language functions to access specified parameters are also available. The catalog is updated from time to time to include new information.

Subject headings: pulsars: general — astronomical databases: catalogs

1. Introduction

Since the discovery of the first pulsar, announced by Hewish et al. (1968), the number of known pulsars has grown to more than 1500. About half of these have been discovered in the past few years by surveys carried out using the multibeam receiver on the Parkes 64-m radio telescope (Manchester et al. 2001; Edwards et al. 2001; Morris et al. 2002; Kramer et al. 2003; Hobbs et al. 2004). Although most known pulsars were discovered at radio frequencies, recent X-ray observations have resulted in the discovery of a number of pulsars (e.g., Halpern & Holt 1992; Marshall et al. 1998); some of these have been subsequently detected at radio wavelengths, others have not. All of these pulsars are powered by the rotational kinetic energy of the underlying neutron star.

There exists another group of pulsars, detected at X-ray and gamma-ray wavelengths, which are evidently isolated neutron stars, spinning down in much the same way as ordinary pulsars, but where the pulsed emission is too luminous to be powered by the spin-down energy (e.g., Kouveliotou et al. 1998; Torii et al. 1998) These pulsars, known as anomalous X-ray pulsars (AXPs) or soft gamma-ray repeaters (SGRs), have long pulse periods but very rapid spin-down rates implying ultra-strong

magnetic fields. The X-ray emission in these so-called "magnetars" is believed to be powered by relaxation of the strong magnetic fields (e.g., Thompson & Duncan 1996). Because these systems are similar in most respects to ordinary pulsars, we have included them in the catalog. In contrast, accretion-powered X-ray pulsars are quite different, with pulse periods covering a wide range from milliseconds to minutes and often being quite unstable on short timescales. Several hundred of these systems are known and catalogs of their properties exist (e.g., Bildsten et al. 1997), so we decided not to include them in the present catalog.

The last published pulsar catalog (Taylor et al. 1993) contained 558 radio pulsars. Various groups have privately maintained and updated this catalog over the past decade. However, with the recent rapid increase in the number of known pulsars, even the best of these was seriously incomplete. We have taken the version of the catalog maintained by the ATNF, Jodrell Bank Observatory and by other members of our pulsar collaboration as the basis for a new catalog. We have extensively searched the pulsar literature over the past decade for details of new and previously known pulsars and built up a database containing full bibliographic information. The catalog currently contains data for 1509 pulsars.

To make the catalog available to the wider community, we have developed a versatile web interface which allows both tabulation and plotting of selected data. A total of 67 different pulsar parameters are pre-defined. Custom variables may be defined as functions of pulsar parameters and tabulated or plotted. Data can be selected using logical conditions on parameter expressions or distance from a specified location. The web interface also has an "expert" mode of operation which allows access to a wider range of parameters and the ability to use one or more custom databases, either replacing or merged with the public database. All functions of the web interface except plotting are available using a command-line interface to the catalog program PSRCAT. This interface has been tested on Macintosh OS and various flavours of linux and unix systems. C-language functions which extract parameters from the database are also available.

2. The catalog database

The catalog database is an ascii text file with a keyword–value structure based on the system originally developed at the University of Massachusetts (Manchester & Taylor 1972). In addition to the keyword and value, most observed parameters have additional fields for the error and reference key. The available parameters, their keywords and units are listed in Table 1 for basic parameters and Table 2 for expert-mode parameters. Table 3 shows the format of the database entry for a representative (binary) pulsar. Errors refer to the last quoted digit of the associated parameter. Data for a given pulsar must start with the pulsar name (PSRB if it exists, otherwise PSRJ) and must be terminated with a line beginning with "@", but otherwise the parameter order is immaterial.

Table 1. Basic Parameters

Keyword	Parameter Description
Name and Position Parameters:	
Name	Pulsar name. The B1950 name if it exists, otherwise the J2000 name.
JName	Pulsar name based on J2000 coordinates
RAJ	Right ascension (J2000) (hh:mm:ss.s)
DecJ	Declination (J2000) (+dd:mm:ss)
PMRA	Proper motion in the right ascension direction (mas yr^{-1})
PMDec	Proper motion in declination (mas yr^{-1})
PX	Annual parallax (mas)
PosEpoch	Epoch at which the position is measured (MJD)
ELong	Ecliptic longitude (deg.)
ELat	Ecliptic latitude (deg.)
PMElong	Proper motion in the ecliptic longitude direction (mas yr^{-1})
PMElat	Proper motion in ecliptic latitude (mas yr^{-1})
GL	Galactic longitude (deg.)
GB	Galactic latitude (deg.)
RAJD	Right ascension (J2000) (deg.)
DecJD	Declination (J2000) (deg.)
Timing and Profile Parameters:	
P0	Barycentric period of the pulsar (s)
P1	First time derivative of barycentric period
F0	Barycentric rotation frequency (Hz)
F1	First time derivative of barycentric rotation frequency (s^{-2})
F2	Second time derivative of barycentric rotation frequency (s^{-3})
F3	Third time derivative of barycentric rotation frequency (s^{-4})
PEpoch	Epoch of period or frequency (MJD)
DM	Dispersion measure (cm^{-3} pc)
DM1	First time derivative of dispersion measure (cm^{-3} pc yr^{-1})
RM	Rotation measure (rad m^{-2})
W50	Width of pulse at 50% of peak (ms).[a]
W10	Width of pulse at 10% of peak (ms).[a]
Tau_sc	Temporal broadening of pulses at 1 GHz due to interstellar scattering (s)
S400	Mean flux density at 400 MHz (mJy)
S1400	Mean flux density at 1400 MHz (mJy)
SPINDX	Measured spectral index
Binary System Parameters:	
Binary	Binary model[b]
T0	Epoch of periastron (MJD)
PB	Binary period of pulsar (days)
A1	Projected semi-major axis of pulsar orbit, $a_1 \sin i$ (s)
OM	Longitude of periastron, ω (deg.)

Table 1—Continued

Keyword	Parameter Description
Ecc	Eccentricity, e
Tasc	Epoch of ascending node (MJD)
Eps1	$e \sin\omega$ - ELL1 binary model
Eps2	$e \cos\omega$ - ELL1 binary model
MinMass	Minimum companion mass ($i = 90°$, $M_{NS} = 1.35\ M_\odot$)
MedMass	Median companion mass ($i = 60°$)
Distance Parameters:	
Dist	Best estimate of the pulsar distance (kpc)
Dist_DM	Distance based on the Taylor & Cordes (1993) electron density model.[c]
DMsinb	'Vertical' component of DM: DM sin GB (cm^{-3} pc)
ZZ	Distance from the Galactic plane, based on Dist
XX	X-Distance in X-Y-Z Galactic coordinate system (kpc)
YY	Y-Distance in X-Y-Z Galactic coordinate system (kpc)
Associations and Survey Parameters:	
Assoc	Names of associated objects[d]
Survey	Surveys that detected the pulsar (discovery survey first).[e]
OSurvey	Surveys that detected the pulsar as binary-encoded integer.[e]
Date	Date of discovery publication.
Type	Type codes for the pulsar.[f]
NGlt	Number of glitches observed for the pulsar
Derived Parameters:	
R_Lum	Radio luminosity at 400 MHz (mJy kpc^2)
R_Lum14	Radio luminosity at 1400 MHz (mJy kpc^2)
Age	Characteristic age (yr)
BSurf	Surface dipole magnetic flux density (G)
Edot	Spin down energy loss rate (erg s^{-1})
Edotd2	Energy flux at the Sun (erg s^{-1} kpc^{-2})
PMTot	Total proper motion (mas yr^{-1})
VTrans	Transverse velocity - based on Dist (km s^{-1})
P1_i	Period derivative corrected for Shklovskii effect
Age_i	Characteristic age from P1_i (yr)
BSurf_i	Surface magnetic dipole from P1_i (G)
Edot_i	Spin down energy loss rate from P1_i (erg s^{-1})
B_LC	Magnetic field at light cylinder (G)

[a]Pulse widths are a function of both observing frequency and observational time resolution, so quoted widths are indicative only.

[b]Normally a binary model defined by the pulsar timing program TEMPO

[c]In "Long" or "Publication quality" modes, lower limits from the distance model are preceded by a '+' sign.

[d]See Table 4

[e]See Table 5

[f]See Table 6

Table 2. Expert Parameters

Keyword	Parameter Description
Name and Position Parameters:	
Bname	Pulsar name based on B1950 coordinates
Alias	Alternative name
PML	Proper motion in the Galactic longitude direction (mas yr^{-1})
PMB	Proper motion in Galactic latitude (mas yr^{-1})
Timing and Profile Parameters:	
F4	Fourth time derivative of barycentric rotation frequency (s^{-5})
F5	Fifth time derivative of barycentric rotation frequency (s^{-6})
F6	Sixth time derivative of barycentric rotation frequency (s^{-7})
F7	Seventh time derivative of barycentric rotation frequency (s^{-8})
F8	Eighth time derivative of barycentric rotation frequency (s^{-9})
F9	Ninth time derivative of barycentric rotation frequency (s^{-10})
FA	Tenth time derivative of barycentric rotation frequency (s^{-11})
FB	Eleventh time derivative of barycentric rotation frequency (s^{-12})
FC	Twelfth time derivative of barycentric rotation frequency (s^{-13})
DM2	Second time derivative of dispersion measure (cm^{-3} pc yr^{-2})
DM3	Third time derivative of dispersion measure (cm^{-3} pc yr^{-3})
DM4	Fourth time derivative of dispersion measure (cm^{-3} pc yr^{-4})
DM5	Fifth time derivative of dispersion measure (cm^{-3} pc yr^{-5})
DM6	Sixth time derivative of dispersion measure (cm^{-3} pc yr^{-6})
DM7	Seventh time derivative of dispersion measure (cm^{-3} pc yr^{-7})
DM8	Eighth time derivative of dispersion measure (cm^{-3} pc yr^{-8})
DM9	Ninth time derivative of dispersion measure (cm^{-3} pc yr^{-9})
Interim	Interim timing solution
S600	Mean Flux Density at 600 MHz (mJy)
S925	Mean Flux Density at 925 MHz (mJy)
S1600	Mean Flux Density at 1600 MHz (mJy)
SI414	Spectral index between 400 and 1400 MHz
Binary Parameters:	
OMDOT	Periastron advance (deg yr^{-1})
PBDOT	First time derivative of binary period
A1DOT	Rate of change of projected semi-major axis
ECCDOT	Rate of change of eccentricity (s^{-1})
GAMMA	Relativistic time dilation term (s)
T0_2	Epoch of periastron [2nd orbit] (MJD)
PB_2	Binary period of pulsar [2nd orbit] (days)
A1_2	Projected semi-major axis of orbit [2nd orbit] (s)
OM_2	Longitude of periastron [2nd orbit] (deg)
OMDOT_2	Periastron advance [2nd orbit] (deg yr^{-1})

Table 2—Continued

Keyword	Parameter Description
ECC_2	Eccentricity [2nd orbit]
PBDOT_2	1st time derivative of binary period [2nd orbit]
T0_3	Epoch of periastron [3rd orbit] (MJD)
PB_3	Binary period of pulsar [3rd orbit] (days)
A1_3	Projected semi-major axis of orbit [3rd orbit] (s)
OM_3	Longitude of periastron [3rd orbit] (deg)
OMDOT_3	Periastron advance [3rd orbit] (deg yr^{-1})
ECC_3	Eccentricity [3rd orbit]
PBDOT_3	1st time derivative of binary period [3rd orbit]
PPNGAMMA	PPN parameter gamma
SINI	Sine of inclination angle i
SINI_2	Sine of inclination angle [2nd orbit]
SINI_3	Sine of inclination angle [3rd orbit]
MTOT	Total system mass ($M_\odot$)
M2	Companion mass ($M_\odot$)
M2_2	Companion mass [2nd orbit] ($M_\odot$)
M2_3	Companion mass [3rd orbit] ($M_\odot$)
DTHETA	Relativistic deformation of the orbit
XOMDOT	Rate of periastron advance minus GR prediction (deg yr^{-1})
XPBDOT	Rate of change of orbital period minus GR prediction
DR	Relativistic deformation of the orbit
A0	Aberration parameter A0
B0	Aberration parameter B0 (s)
BP	Tensor multi-scalar parameter β'
BPP	Tensor multi-scalar parameter β''
MASSFN	The pulsar mass function ($M_\odot$)
UPRMASS	90% confidence upper companion mass limit, $i = 26^\circ$ ($M_\odot$)
MINOMDOT	Minimum OMDOT, assuming $i = 90^\circ$ and $M_{NS} = 1.4M_\odot$ (deg yr^{-1})
Other Timing Parameters:	
TRES	RMS timing residual (μs)[a]
NTOA	Number of TOAs in timing fit[a]
START	Epoch of start of fit (MJD)[a]
FINISH	Epoch of end of fit (MJD)[a]
CLK	Terrestrial time standard[a]
EPHEM	Solar system ephemeris[a]
TZRMJD	Reference TOA[a] (MJD)
TZRFRQ	Frequency of reference TOA[a] (MHz)
TZRSITE	One-letter observatory code for reference TOA[a]
NSPAN	Polyco span[a] (min)
NCOEF	Number of coefficients in polyco[a]

All data values have an associated reference key for the source of the value and its error. The keys refer to a BIBTEX bibliography database and are used to create a bibliography which currently has more than 360 entries. The complete bibliography may be listed from both the command-line and web interfaces.

Up to about 1993, pulsars were given a name based on their coordinates in the Besselian 1950 system. At that time the J2000 coordinate system was introduced and, following this, most pulsars were given names based on their J2000 coordinates. For consistency, pulsars with B1950 names have been given a new name based on their J2000 coordinates. However, recently discovered pulsars are not given a B1950 name. In accordance with IAU specifications[1], names explicitly include the equinox letter, e.g., PSR B0833−45 or PSR J0835−4510. Note however, that positions can only be given in J2000 or ecliptic coordinates; B1950 coordinates are not supported. The parameter PosEpoch is the epoch of the position, expressed as a Modified Julian Day (MJD = JD − 2400000.5). If this parameter is not explicitly in the database, it is taken to be the epoch of the pulse period (PEpoch).

Pulse timing parameters are closely related to the timing analysis program TEMPO[2]. Binary parameters, in particular, depend on the exact definition in this program. The Blandford & Teukolsky (1976) BT binary model is the most commonly used description. However for binary systems with circular or near-circular orbits the ELL1 model (Wex 2000) is more appropriate and, for binary systems where relativistic effects are important, the DD model (Damour & Deruelle 1986) provides a more exact treatment. Other binary models are also supported – see the TEMPO documentation for more details.

Some pulsars, especially young pulsars, occasionally suffer a sudden decrease in pulse period, commonly known as a "glitch". The parameter NGlt is the total number of observed glitches in a given pulsar. There is provision in expert mode for entering and accessing parameters for one glitch, based on the glitch model in TEMPO. These parameters are defined by:

$$\nu(t) = \nu_0(t) + \Delta\nu_p + \Delta\dot{\nu}_p t + \Delta\nu_d \exp(-t/\tau_d), \quad (1)$$

where ν is the pulse frequency, ν_0 is its value at the glitch epoch (GLEP, $t = 0$) extrapolated from pre-glitch data, $\Delta\nu_p$ (GLF0) and $\Delta\dot{\nu}_p$ (GLF1) are the permanent changes in ν and $\dot{\nu}$ at the time of the glitch, $\Delta\nu_d$ (GLF0D) is the decaying part of the frequency increment at the time of the glitch, and τ_d (GLTD) is the decay timescale. For $t < 0$, $\Delta\nu_p$, $\Delta\dot{\nu}_p$ and $\Delta\nu_d$ are all zero. TEMPO also provides a pulse phase increment at $t = 0$ (GLPH) to allow for error in the assigned glitch epoch.

A table of the basic glitch parameters for each pulsar known to glitch (NGlt > 0) may be accessed by clicking on the pulsar name. Parameters listed are the glitch epoch, the fractional change in pulse frequency, $(\Delta\nu_p+\Delta\nu_d)/\nu_0$, and the fractional change in frequency derivative ($\Delta\dot{\nu}_p-$

[1]See http://cdsweb.u-strasbg.fr/iau-spec.html

[2]See http://www.atnf.csiro.au/research/pulsar/tempo

Table 2—Continued

Keyword	Parameter Description
GLEP	Epoch of glitch
GLPH	Phase increment at glitch
GLF0	Permanent pulse frequency increment at glitch
GLFI	Permanent frequency derivative increment at glitch
GLF0D	Decaying frequency increment at glitch
GLTD	Time constant for decaying frequency increment
Distance Parameters:	
Dist_DM1	Distance based on NE2001 model (kpc)
Dist1	Best estimate of pulsar distance using Dist_DM1 as default
Dist_AMN	Lower limit on distance based on association or HI absorption (kpc)
Dist_AMX	Upper limit on distance based on association or HI absorption (kpc)
Dist_A	Distance based on association or HI absorption (kpc)
User-defined Parameters:	
PAR1	A user-defined catalog entry
PAR2	A user-defined catalog entry
PAR3	A user-defined catalog entry
PAR4	A user-defined catalog entry

[a]Available in command-line version only.

Table 3. A representative database entry

Keyword	Value	Error	Ref. Key
PSRJ	J1435−6100		clm+01
RAJ	14:35:20.2765	5	clm+01
DECJ	−61:00:57.956	7	clm+01
F0	106.97507197376	8	clm+01
F1	−2.80E−16	5	clm+01
PEPOCH	51270.000		
DM	113.7	6	clm+01
BINARY	ELL1		
TASC	51270.6084449	6	clm+01
PB	1.3548852170	18	clm+01
A1	6.184023	4	clm+01
EPS1	1.9E−6	12	clm+01
EPS2	1.03E−5	15	clm+01
START	50939.602		
FINISH	51856.205		
TRES	83.97		
NTOA	93		
CLK	UNCORR		
EPHEM	DE200		
TZRMJD	51293.55635374447232		
TZRFRQ	1374.000		
TZRSITE	7		
S1400	0.25	4	mlc+01
W50	1.1		mlc+01
DIST_DM	3.25		tc93
DIST_DM1	2.16		cl02
SURVEY	pksmb		
@----------			

$\Delta\nu_d/\tau_d)/\dot{\nu}_0$, where $\dot{\nu}_0$ is the value of $\dot{\nu}$ at $t = 0$, extrapolated from the pre-glitch data, and their estimated errors. Note that the simple exponential decay given by Equation 1 does not fully describe the post-glitch behaviour in many cases. Note also that, if the measured value of $\Delta\dot{\nu}$ is simply based on the observed pre- and post-glitch values of $\dot{\nu}$ or if the single exponential decay model is not accurate, the derived value may under-estimate the actual change in $\dot{\nu}$ at the time of the glitch.

The pulsar distance d (Dist) depends on other catalog parameters and is not itself a catalog entry. The default value is that derived from the dispersion measure (DM) using the Taylor & Cordes (1993) model for the Galactic distribution of free electrons, i.e., Dist = Dist_DM. However, if there is a measured annual parallax (PX), this takes precedence: $d = 1/\pi$ where π is the parallax. Next in priority order is a distance estimate (Dist_A) based on an association with another object (e.g., globular cluster or supernova remnant) or measurements of absorption by neutral hydrogen combined with a model for differential rotation of the Galaxy. The classes of associated objects given in the catalog (with keyword Assoc) are listed in Table 4. If Dist_A exists, Dist is set equal to that. If there are only distance limits (Dist_AMN, Dist_AMX), then Dist is set equal to the DM-derived distance if it lies between these limits or to the nearest limit if it doesn't. Dist_A and the limits Dist_AMN and Dist_AMX are available in expert mode. Dist_DM1, a distance estimate based on the NE2001 Galactic electron-density model (Cordes & Lazio 2002) and the associated Dist1 are also available in expert mode. The Galactocentric coordinate system (XX, YY, ZZ) is right-handed with the Sun at (0.0, 8.5 kpc, 0.0) and the ZZ axis directed toward the north Galactic pole.

The major pulsar surveys and their associated labels are listed in Table 5. The keyword Survey gives labels for those surveys which have detected a pulsar, with the discovery survey listed first. All but 150 of the nearly 1500 pulsars have been discovered in one of the major surveys listed; the remainder are listed under "misc". The parameter OSurvey is an octal-coded integer with each survey associated with a particular bit of the binary word.

Pulsar types are listed in Table 6. Types AXP, HE and NR are explicitly listed in the catalogue with keyword Type. All pulsars in a binary system with a measured orbital period are listed under

Table 4. Association Types

Label	Description
EXGAL	External galaxy
GC	Globular cluster
GRS	Gamma-ray source
OPT	Optical identification
SNR	Supernova remnant
XRS	X-ray source

Table 5. Pulsar Surveys

Survey Label	Survey Name	Octal Code	Number Detected	Number Discovered
ar1	Arecibo Survey 1	4	49	41
ar2	Arecibo Survey 2	400	24	6
ar3	Arecibo Survey 3	2000	63	25
ar4	Arecibo Survey 4	20000	87	62
gb1	Green Bank Northern Survey	20	50	31
gb2	Princeton-NRAO Survey	40	83	34
gb3	Green Bank Short-Period Survey	200	86	20
gb4	Green Bank Fast Pulsar Survey	10000	8	5
jb1	Jodrell Bank A Survey	2	51	45
jb2	Jodrell Bank B Survey	100	62	42
misc	···	400000	150	150
mol1	1st Molonglo Survey	1	35	35
mol2	2nd Molonglo Survey	10	224	155
pks1	Parkes 20-cm Survey	1000	100	46
pks70	Parkes Southern-Sky Survey	4000	298	101
pksmb	Parkes Multibeam Survey	40000	880	592
pksgc	Parkes Globular Cluster Survey	200000	10	10
swmb	Swinburne Multibeam Survey	100000	170	69

type BINARY, and all pulsars which are not type NR are listed under type RADIO.

3. Derived Parameters

Both the web and command-line versions of the program allow display of various parameters derived from catalog parameters as listed in Table 1. The radio "luminosities" R_Lum and R_Lum14, commonly used in pulsar evolution and distribution studies, are simply defined as Sd^2, where S is S400 or S1400 (in mJy) for R_Lum and R_Lum14, respectively, and d is the pulsar distance (Dist) in kpc. The pulsar characteristic age (Age) is defined by

$$\tau_c = P/(2\dot{P}), \tag{2}$$

where P is the pulsar period (P0) and $\dot{P}$ is its first time derivative (P1).

Based on pulsar spin-down due to magnetic-dipole radiation, the surface dipole magnetic flux density BSurf is conventionally defined to be

$$B_s = \left(\frac{3Ic^3P\dot{P}}{8\pi^2R_N^6}\right)^{1/2} = 3.2\times10^{19}(P\dot{P})^{1/2}\ \mathrm{G}, \tag{3}$$

where I is the neutron-star moment of inertia, assumed to be 10^{45} g cm^2, R_N is the neutron-star radius, taken to be 10^6 cm, c is the velocity of light and P is the pulsar period in seconds (Manchester & Taylor 1977). For a pure dipole field with the magnetic axis perpendicular to the rotation axis, this is the field strength at the magnetic equator; the field strength at the magnetic pole is a factor of two higher. The magnetic flux density at the light-cylinder radius $R_{LC} = cP/(2\pi)$ (B_LC) is computed assuming a dipole field:

$$B_{LC} = B_s(R_N/R_{LC})^3 = 3.0\times10^8P^{-5/2}\dot{P}^{1/2}\ \mathrm{G}. \tag{4}$$

The rate of loss of rotational kinetic energy (Edot) is given by

$$\dot{E} = -I\Omega\dot{\Omega} = 4\pi^2I\dot{P}P^{-3}\ \mathrm{erg\ s^{-1}} \tag{5}$$

Table 6. Pulsar Types

Label	Description
AXP	Anomalous X-ray pulsar or pulsating soft gamma-ray repeater
BINARY	Pulsar with one or more stellar or planetary companions
HE	Spin-powered pulsar with pulsed emission from radio to infrared or higher frequencies
NR	Spin-powered pulsar with pulsed emission only at infrared or higher frequencies
RADIO	Pulsars with pulsed emission in the radio band

where $\Omega = 2\pi/P$. The parameter Edotd2 is $\dot{E}d^{-2}$, where d is the pulsar distance. This is proportional to the spin-down energy flux at the Earth and is a good indicator of the detectability of high-energy, particularly gamma-ray, pulsed emission.

Proper motions are expressed in milliarcseconds (mas) on the sky per year and may be entered in either J2000 coordinates (μ_α, μ_δ) or ecliptic coordinates. The proper motion in the other coordinate system is computed from the entered values. Proper motions in Galactic coordinates are also available in expert mode. Galactic proper motions are computed from the entered values and are corrected for the effects of Galactic rotation assuming a flat rotation curve with a rotation velocity of 225 km s^{-1} (cf. Harrison et al. 1993). The total proper motion (PMTot) is given by

$$\mu = (\mu_\alpha^2 + \mu_\delta^2)^{1/2}, \tag{6}$$

also in mas yr^{-1}, and the corresponding transverse velocity (VTrans) is given by

$$v_T = \mu d. \tag{7}$$

As first pointed out by Shklovskii (1970), a large transverse velocity can introduce a significant kinematic term into observed period derivatives:

$$\dot{P}_s = v_T^2 P/(cd). \tag{8}$$

The *intrinsic* period derivative (P1_i),

$$\dot{P}_i = \dot{P} - \dot{P}_s, \tag{9}$$

is a better measure of the actual slow-down rate of the pulsar and can be significantly less than the measured value, especially for nearby millisecond pulsars. For example, for PSR J0437−4715, the measured $\dot{P}$ is about 5.7×10^{-20} whereas $\dot{P}_i$ is just one third of this value. Likewise, Age_i, BSurf_i and Edot_i, derived with $\dot{P}$ replaced by $\dot{P}_i$, are better measures of the actual values of these quantities.

The catalog interfaces allow definition, listing and (for the web interface) plotting of up to four "custom" parameters (C1 – C4), that is, parameters which are algebraic combinations of other parameters (including other custom parameters). These (and all other) entries are case insensitive. Available operators and functions are listed in Table 7.

Updates to the public database are made from time to time to correct any errors and to include recently published data. The database file is maintained under Concurrent Versions System (CVS)[3] control; the CVS version number of the current file is displayed on the web interface and may be accessed from the command-line interface.

[3]See http://www.cvshome.org/

4. The web interface

The main user interface to the catalog is provided by the interactive web page[4]. This web page provides access to most catalog parameters and to a range of derived parameters, with facilities for both tabular and plotted outputs. An extensive tutorial on the operation of the web interface may be accessed either from a link at the top of the main page (which creates a new browser page) or via links to individual sections of the tutorial. Documentation on parameter definitions and units can be accessed either by a link at the top of the main page or, for individual parameters, by clicking on the parameter name.

Parameters for tabular output may be selected from the displayed list. Output values are typically of variable length, but all consist of a single ascii string or number with no spaces. By default, null values are represented by an asterisk, but it is possible for the user to select a null character or string. These properties facilitate free-format reading of tabular values with a space delimiter. The list may be sorted in either ascending or descending order by any parameter, ascii or numeric, with a default of the J2000 name. It is possible to select a "No header" option which omits the column headings and also the space after every fifth line. This facilitates selecting and pasting of tabular output into a text editor for use in other applications.

Five different output formats are available:

1. **Short without errors:** Lists parameters with a fixed format and a precision which is often less than the available precision but more than adequate for most applications needing input data. No errors or reference keys are listed.

2. **Short with errors:** Identical to "short" except that, when available, errors are listed in exponential notation.

3. **Long with last-digit error:** Gives all values to the full available precision, lists the error in the last quoted digit and the reference key for each data value.

4. **Long with error:** Similar to "Long with last-digit error" except that the error is quoted in exponential notation.

5. **Publication quality:** Similar to "Long with last-digit error" except that the error is given in parentheses at the end of the value and the reference keys are collected on the right-hand side of the line.

Fig. 1 shows a small segment of a typical tabular output in the default "Long with last-digit error" format. Reference keys are all linked to the appropriate part of the bibliography database giving full reference information for the relevant publication. The reference associated with a pulsar

[4]http://www.atnf.csiro.au/research/pulsar/psrcat

name is to the paper in which the discovery of the pulsar was announced. The pulsar name itself is linked to the European Pulsar Network web page[5] which gives spectra and mean-pulse polarization profiles for a large number of pulsars, to the NASA Astrophysics Data System (ADS)[6] listing publications which refer to this pulsar, and to a table of glitch parameters for this pulsar (if known to glitch).

The web interface also provides an interactive plotting facility. Any (numeric) parameter may be plotted against any other parameter or as a histogram on either linear or logarithmic scales. The main pulsar types (binary, high-energy, AXP, other) are identified by different symbols. Fig. 2 shows a typical plot. It is possible to zoom into a selected region of the plot. Pulsars within a selected region are identified by name in a side box and clicking on a name draws crossed lines through the point for that pulsar. If only an x-coordinate is entered, a histogram for the distribution of that parameter is plotted. The number of boxes in the histogram can be interactively adjusted and clicking on a box identifies the pulsars in that box.

The list of pulsars for which data is tabulated or plotted may be limited in various ways. Data can be displayed for just selected pulsars by entering the pulsar names in a box. Wild-card entries with "*" and "?" are supported and both B1950 and J2000 names are checked for a match. For example, "b1933+1?" will match PSRs B1933+16, B1933+17 and B1933+15 whereas "j004*+*" will match PSRs J0040+5716 and J0048+3412. Displayed data can also be limited by logical conditions on parameter functions as well as several special functions. Table 8 lists the available logical operators and special functions. Finally, only pulsars within a nominated (spherical) angle of a given position (expressed in celestial or Galactic coordinates) can be listed or plotted.

Parameters for one or more named pulsars can be output as a table containing keywords, values (to full precision), and errors (in exponential notation) in "ephemeris" format, that is, a line for each parameter. Three output options are provided: short mode lists those parameters which are normally needed for a TEMPO input parameter file (in the format that TEMPO expects), long mode lists all available parameters and selected mode lists those parameters which are selected in the check boxes as for normal tabular output.

A system for user feedback is available, with a log being kept of all comments received. We greatly appreciate constructive feedback and, provided the sender's email address is supplied, comments will be acknowledged.

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[5]http://www.mpifr-bonn.mpg.de/div/pulsar/data/archive.html

[6]http://adsabs.harvard.edu/abstract_service.html

Table 7. Valid algebraic operators and functions for parameter expressions

Operators		Functions		Functions	
+	addition	acos(a)	inverse cosine	sin(a)	sine of angle in radians
−	subtraction	asin(a)	inverse sine	sind(a)	sine of angle in degrees
∗	multiplication	atan(a)	inverse tangent	sinh(a)	hyperbolic sine
/	division	atan2(a, b)	inverse tangent	sqr(a)	square
∗∗	Raise to power	cos(a)	cosine of angle in radians	sqrt(a)	square root
=	assignment	cosd(a)	cosine of angle in degrees	tan(a)	tangent of angle in radians
		cosh(a)	hyperbolic cosine	tand(a)	tangent of angle in degrees
		exp(a)	exponential	tanh(a)	hyperbolic tangent
		ln(a)	logarithm to base 2	fabs(a)	absolute value
		log(a)	logarithm to base 10	fmod(a, b)	modulus of a with respect to b
		log10(a)	logarithm to base 10		

Table 8. Logical operators and functions for pulsar selection

Logical Operators		Functions	
==	equality	exist(x)	existence of value for parameter x
!=	inequality	error(x)	returns value of error for parameter x
!	logical not	type(t)	pulsar of type t
&&	logical and	assoc(s)	Assoc contains string s
||	logical or	survey(s)	Survey contains string s
<	less than	discovery(s)	discovery survey contains string s
<=	less than or equal to	ref(p, s)	reference for parameter p contains string s
>	greater than	hms(s)	Convert from hr:min:sec string s to decimal degrees
>=	greater than or equal to	dms(s)	Convert from deg:min:sec string s to decimal degrees

#	NAME		Gl (deg)	Gb (deg)	F0 (Hz)			DM (cm^-3 pc)			SURVEY
1	B1222-63	mlt+78	300.13	-1.41	2.3831210694	18	nmc81	415.1	5	hfs+04	mol2,pks70,pksmb
2	J1159-7910	lml+98	300.41	-16.55	1.9044925943	11	dsb+98	59.24	2	dsb+98	pks70
3	J1236-5033	ebvb01	300.58	12.25	3.39259321569	5	ebvb01	105.02	11	ebvb01	swmb
4	J0113-7220	ckm+01	300.62	-44.69	3.06858581302	10	ckm+01	125.49	3	ckm+01	misc
5	B1232-55	mlt+78	300.62	7.53	1.56682392	3	nmc81	100	20	nmc81	mol2,swmb
6	J1231-6303	kbm+03	300.64	-0.27	0.7400630079	4	kbm+03	301	10	kbm+03	pksmb
7	B1237-41	mlt+78	300.69	21.41	1.9522019243	5	nmc81	44.1	12	nmc81	mol2
8	J1232-6501	clm+01	300.91	-2.22	11.32734917043	4	clm+01	239.4	5	clm+01	pksmb
9	J1233-6312	kbm+03	300.91	-0.41	1.7706655597	13	kbm+03	414	13	kbm+03	pksmb
10	J1233-6344	kbm+03	300.97	-0.94	1.32119257131	13	kbm+03	495	9	kbm+03	pksmb
11	J1235-6354	kbm+03	301.23	-1.09	3.89441988715	19	kbm+03	439.9	19	kbm+03	pksmb
12	J1237-6725	kbm+03	301.58	-4.59	0.47371495060	4	kbm+03	179	3	kbm+03	pksmb
13	J1244-5053	ebvb01	301.76	11.97	3.63362703526	6	ebvb01	109.95	12	ebvb01	swmb
14	J1243-5735	kbm+03	301.88	5.26	2.1221290457	8	kbm+03	270.6	19	kbm+03	pksmb
15	B1236-68	mlt+78	301.88	-5.69	0.7681033625	3	nmc81	94.3	3	hfs+04	mol2,pks70,swmb,pksmb
16	J0100-7211	lfmp02	301.93	-44.92	0.183828	1	lfmp02	*	0	*	misc
17	B1240-64	lvw69a	302.05	-1.53	2.57412898765	4	smd93	297.25	8	hfs+04	mol1,mol2,pks1,pks70,pksmb
18	J1245-6238	mlc+01	302.23	0.21	0.43800223922	4	mlc+01	336.2	20	mlc+01	pksmb
19	J0057-7201	ckm+01	302.24	-45.10	1.3548989114	4	ckm+01	27	5	ckm+01	misc
20	J1248-6344	kbm+03	302.64	-0.87	5.0419709708	3	kbm+03	433.3	15	kbm+03	pksmb
21	J1249-6507	kbm+03	302.77	-2.25	2.30178801032	16	kbm+03	215	4	kbm+03	pksmb
22	J1252-6314	mlc+01	303.08	-0.37	1.21456613923	8	mlc+01	278.4	13	mlc+01	pksmb
23	J1253-5820	mld+96	303.20	4.53	3.913950584488	11	dsb+98	100.584	4	dsb+98	pks70,pksmb
24	J1254-6150	kbm+03	303.30	1.02	5.4199894818	3	kbm+03	95	3	kbm+03	pksmb
25	J1255-6131	kbm+03	303.47	1.35	1.51981774632	7	kbm+03	206.5	17	kbm+03	pksmb
26	J0045-7319	wmh+91	303.51	-43.80	1.07959193868	4	kbm+96	105.4	7	kjb+94	misc
27	B1256-67	mlt+78	303.69	-4.83	1.5075474245	7	nmc81	94.7	9	hfs+04	mol2,pks70,pksmb
28	J1301-6310	kbm+03	304.06	-0.33	1.50641057305	10	kbm+03	86.1	12	kbm+03	pksmb
29	J1301-6305	mlc+01	304.10	-0.24	5.4192289772	16	mlc+01	374	3	mlc+01	pksmb
30	J1302-63	nj98	304.11	-0.90	3.07008076	10	nj98	875	10	nj98	misc,pksmb
31	J1302-6313	kbm+03	304.16	-0.38	1.0332220002	5	kbm+03	500	21	kbm+03	pksmb
32	B1259-63	jlm+92	304.18	-0.99	20.937123215	4	mjl+95	146.72	3	mjl+95	pks1,pksmb
33	J1303-6305	mlc+01	304.24	-0.24	0.43353073142	7	mlc+01	343	3	mlc+01	pksmb
34	B1302-64	mlt+78	304.41	-2.09	1.7493314882	13	nmc81	505.0	3	hfs+04	mol2,pks1,pks70,pksmb
35	B1303-66	jlm+92	304.46	-3.46	2.11404659562	4	jml+95	436.9	2	jml+95	pks1,pksmb
36	J1305-6256	mlc+01	304.53	-0.12	2.0910399795	5	mlc+01	967	3	mlc+01	pksmb
37	J1305-6203	mlc+01	304.56	0.77	2.3377494233	4	mlc+01	470.0	15	mlc+01	pksmb
38	J1306-6242	kbm+03	304.69	0.12	1.01843145175	10	kbm+03	480	6	kbm+03	pksmb
39	J1309-6526	kbm+03	304.76	-2.63	2.51071975157	13	kbm+03	340	4	kbm+03	pksmb
40	J1307-6318	mlc+01	304.78	-0.50	0.20151428910	8	mlc+01	374	8	mlc+01	pksmb
41	J1309-6415	mlc+01	304.87	-1.46	1.6143260283	7	mlc+01	574	5	mlc+01	pksmb

Fig. 1.— A typical tabular output from the PSRCAT web interface in the (default) long format with last-digit errors. This list was limited to pulsars with Galactic longitude l in the range 300° to 305° and sorted in order of increasing l. Note the "null" character for the unmeasured dispersion measure for the AXP J0100-7211.

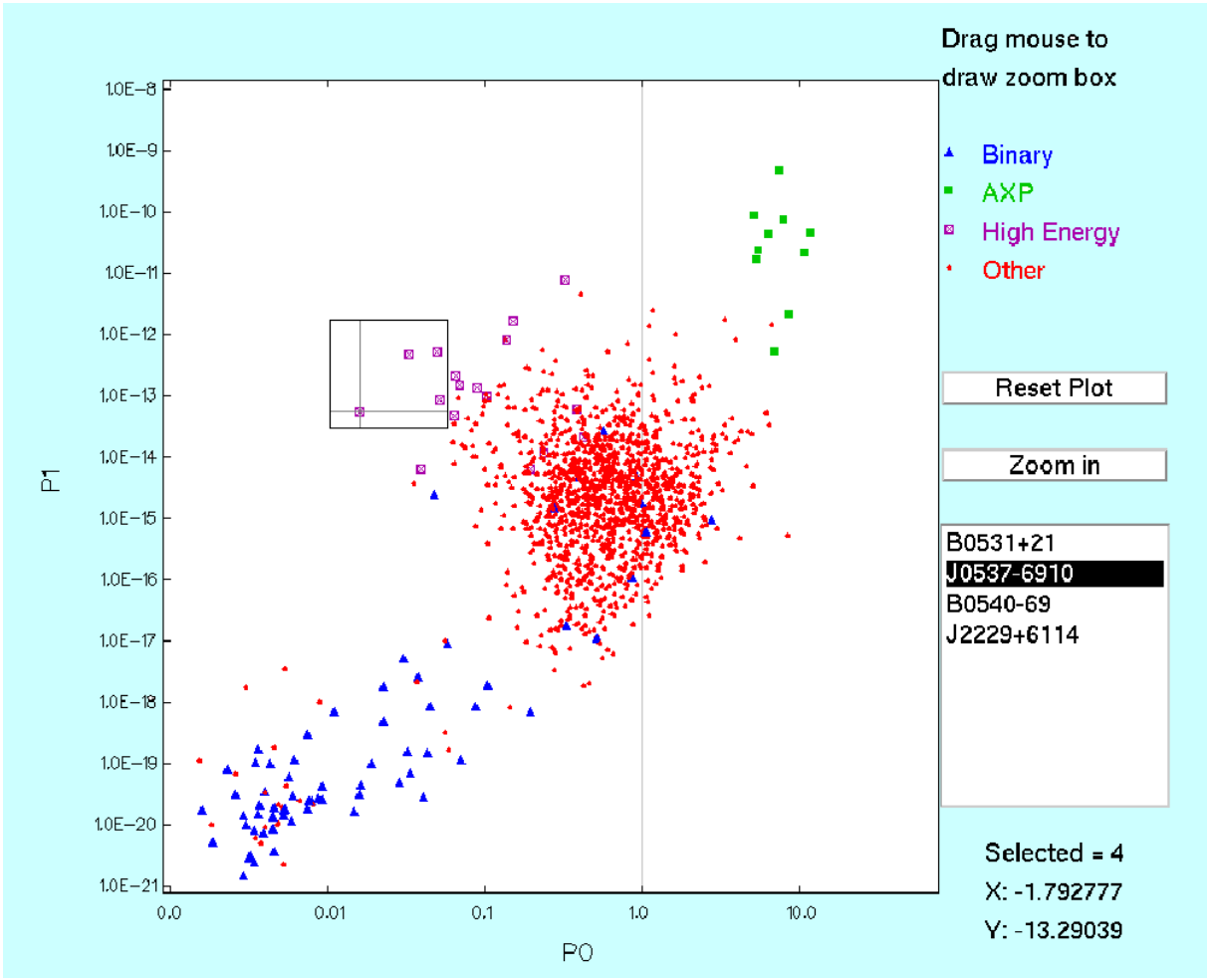

Fig. 2.— A plot of pulse period versus period derivative on logarithmic scales produced by the PSRCAT web interface.

5. Features for experts

An "expert" version[7] of the web interface provides access to many other parameters in the catalog database and to many derived parameters which are less frequently used. These additional parameters are listed in Table 2. Additional parameters are displayed on the web interface with a more compact set of check boxes and additional documentation is provided for these parameters.

The expert-mode interface also provides for use of custom databases. The user may upload one or more database files (which must conform to the PSRCAT data format standard) to the ATNF host computer. These files may then be used either in place of the public database file or merged with it. Parameter values in a merged file overwrite existing values for that parameter and new parameters are added to the database. Uploaded files may be either deleted at the end of the session or left for later use. In plots, data from merged files are highlighted with a heavy cross.

An alternative name may be associated with a pulsar using the ALIAS keyword. Subsequent merged files may use the alternative name rather than the original name.

Four user-defined parameters, PAR1 - PAR4, may be included in the uploaded files. They may be accessed, listed, used in expressions or plotted in the same way as any other parameter.

5.1. Command-line interface

All tabular functions of the web interface are available directly on the command line on linux and unix systems with the program PSRCAT. The "-h" option gives a full list of the available options and "-p" lists keywords for all available parameters which include and extend the "expert-mode" parameters of the web interface. A further argument "<str>" on the "-p" option lists only those keywords containing "<str>".

The current versions of the PSRCAT program and public database (psrcat.db) may be downloaded from the ATNF pulsar home page[8]. The program is written in the C language and is complete in the sense that no other libraries are required to compile it. The program makes use of the freely available Evaluate[9] software. Gnu[10] ¡compilers are preferred.

Two environment variables are used by the program: PSRCAT_FILE and PSRCAT_RUNDIR. PSRCAT_FILE gives the full path to and name of the default database file; it may be over-ridden using the "-db_file <path/filename>" option. The "-all" option of PSRCAT merges all files "obs*.db" in the PSRCAT_RUNDIR directory with the default database file. Other files may be merged with

[7]http://www.atnf.csiro.au/research/pulsar/psrcat/expert.html

[8]http://www.atnf.csiro.au/research/pulsar/

[9]http://www.parsifalsoft.com/examples/evalexpression/

[10]http://www.gnu.org/

the default database file using "-merge <path/filename>" option. Several files can be merged using "-merge "<file1> <file2>"". Parameters in later files overwrite the same parameters in earlier files, including the main database file.

5.2. C functions

Along with the source code for the catalog software, we provide two simple "C" functions that enable a user to obtain catalog parameters using their own software. The function "callPsrcat_val" is used to obtain a numerical parameter value, its error and reference from the catalog, and "callPsrcat_string" is used to obtain a textual parameter (such as SURVEY or ASSOC). Both functions require the file name of the catalog (or "public" if the publically available catalog file is to be used), the pulsar name and the parameter label. Full descriptions of these routines are available when downloading the catalog software in a "README" file.

6. Tables and Figures

The catalog interfaces allow production of many types of parameter lists. To illustrate this, we give two tables listing relevant parameters for two categories of pulsars, those with high-energy (optical, X-ray or gamma-ray) pulsed emission, and those associated with globular clusters. The web interface also provides facilities for basic $x-y$ plots and histograms. However, many users will wish to create files containing custom lists for input into their own plotting programs or for other manipulation. We give two plots of general interest based on files produced in this way. Obviously, these figures and tables represent only a tiny part of what may be produced, but they illustrate the capabilities of the catalog facility.

Table 9 lists pulsars of type HE (radio pulsars which also have detectable high-energy pulsations), type NR (spin-powered pulsars detectable only at high energies) and type AXP (which includes pulsating soft gamma-ray repeaters). The table lists database entries selected by each of the three types, e.g., "type(nr)", and displayed in short format with options "-nohead -nonumber". In most cases, the association was established by the discovery paper; where this is not the case, the reference key for the paper establishing the association is given in square brackets. Doubtful associations are followed by "(?)". To maintain the requirement that a single entry contains no spaces, spaces in names of associated objects are replaced by an underscore.

Table 9. Pulsars of Type AXP, HE or NR

Name	J2000 Name	Period (s)	Age (yr)	B_s (G)	Association
Radio pulsars having high-energy pulsations (Type HE):					
J0205+6449	J0205+6449	0.065686	5.37e+03	3.61e+12	SNR:3C58
J0218+4232	J0218+4232	0.002323	4.76e+08	4.29e+08	···
J0437−4715	J0437−4715	0.005757	1.59e+09	5.81e+08	···
B0531+21	J0534+2200	0.033085	1.24e+03	3.78e+12	SNR:Crab[ccl+69]
B0540−69	J0540−6919	0.050354	1.67e+03	4.97e+12	EXGAL:LMC,SNR:0540−693
B0656+14	J0659+1414	0.384891	1.11e+05	4.66e+12	SNR:Monogem_Ring[tbb+03]
B0823+26	J0826+2637	0.530661	4.92e+06	9.64e+11	···
B0833−45	J0835−4510	0.089328	1.13e+04	3.38e+12	SNR:Vela
B0950+08	J0953+0755	0.253065	1.75e+07	2.44e+11	···
B1046−58	J1048−5832	0.123671	2.03e+04	3.49e+12	···
B1055−52	J1057−5226	0.197108	5.35e+05	1.09e+12	···
J1105−6107	J1105−6107	0.063193	6.33e+04	1.01e+12	···
J1124−5916	J1124−5916	0.135314	2.87e+03	1.02e+13	SNR:G292.0+1.8
B1509−58	J1513−5908	0.150658	1.55e+03	1.54e+13	SNR:G320.4−1.2
J1617−5055	J1617−5055	0.069357	8.13e+03	3.10e+12	···
B1706−44	J1709−4429	0.102459	1.75e+04	3.12e+12	SNR:G343.1−2.3(?)[mop93]
B1800−21	J1803−2137	0.133617	1.58e+04	4.28e+12	SNR:G8.7−0.1(?)[kw90]
B1821−24	J1824−2452	0.003054	2.99e+07	2.25e+09	GC:M28
B1823−13	J1826−1334	0.101466	2.14e+04	2.79e+12	···
J1930+1852	J1930+1852	0.136855	2.89e+03	1.03e+13	SNR:G54.1+0.3
B1929+10	J1932+1059	0.226518	3.10e+06	5.18e+11	···
B1937+21	J1939+2134	0.001558	2.35e+08	4.09e+08	···
B1951+32	J1952+3252	0.039531	1.07e+05	4.86e+11	SNR:CTB80
J2124−3358	J2124−3358	0.004931	3.80e+09	3.22e+08	···
J2229+6114	J2229+6114	0.051624	1.05e+04	2.03e+12	···
Non-Radio (Type NR) Pulsars:					
J0537−6910	J0537−6910	0.016115	4.98e+03	9.20e+11	EXGAL:LMC,SNR:N157B
J0633+1746	J0633+1746	0.237093	3.42e+05	1.63e+12	GRS:Geminga
J0635+0533	J0635+0533	0.033856	···	···	OPT:Be−star
J1210−5209	J1210−5209	0.424129	3.36e+05	2.95e+12	SNR:G296.5+10.0
J1811−1925	J1811−1925	0.064667	2.33e+04	1.71e+12	SNR:G11.2−0.3
J1846−0258	J1846−0258	0.323598	7.22e+02	4.85e+13	SNR:Kes75
Anomalous X-ray pulsars and Soft gamma-ray repeaters (Type AXP):					
J0100−7211	J0100−7211	5.439868	5.73e+03	2.89e+14	EXGAL:SMC,XRS:CXOU_J0110043.1−721134
J0142+61	J0142+61	8.688330	7.02e+04	1.32e+14	XRS:4U_0142+61
J0525−6607	J0525−6607	8.047000	1.96e+03	7.32e+14	SNR:N49(?),SGR_0526−66
J1048−5937	J1048−5937	6.452077	2.68e+03	5.02e+14	XRS:1E_1048.1−5937
J1708−4008	J1708−4008	10.999035	8.96e+03	4.68e+14	XRS:1RXS_J170849.0−400910

Globular clusters are rich breeding grounds for millisecond pulsars due to exchange reactions in the dense cluster core resulting in the capture of an old neutron star by an evolving star. Subsequent mass transfer leads to spin-up of the neutron star and reduction in the effective magnetic field strength and hence a small value of $\dot{P}$. Pulsars associated with globular clusters may be extracted from the catalog using the logical condition "assoc(gc)"; Table 10 lists some relevant parameters for pulsars extracted in this way. For many of these pulsars the observed value of $\dot{P}$ is negative; this is a consequence of acceleration of the pulsar in the gravitational field of the cluster (e.g., Freire et al. 2003) and does not represent a speeding up of the pulsar.

Table 9—Continued

Name	J2000 Name	Period (s)	Age (yr)	B_s (G)	Association
J1808−2024	J1808−2024	7.494782	2.81e+02	1.80e+15	SNR:G10.0−0.3(?),SGR_1806−20
J1809−1943	J1809−1943	5.539220	4.26e+03	3.42e+14	XRS:XTE_J1810−197
J1841−0456	J1841−0456	11.765730	4.51e+03	7.06e+14	SNR:Kes73,XRS:1E_1841−045
J1845−0256	J1845−0256	6.971270	···	···	SNR:G29.6+0.1,XRS:AX_J1845.0−0300
J1907+0919	J1907+0919	5.168918	1.05e+03	6.42e+14	SNR:G42.8+0.6(?),SGR_1900+14
J2301+5852	J2301+5852	6.978948	2.28e+05	5.88e+13	SNR:CTB109,XRS:1E_2259.1+586

Table 10. Pulsars in Globular Clusters

Name	J2000 Name	Association	Period (s)	Period Derivative	Binary Period (d)	Med. Comp. Mass ($M_\odot$)
B0021−72C	J0024−7204C	GC:47Tuc	0.005757	−4.98e−20	–	–
B0021−72D	J0024−7204D	GC:47Tuc	0.005358	−3.43e−21	–	–
B0021−72E	J0024−7204E	GC:47Tuc	0.003536	9.85e−20	2.2568	0.18
B0021−72F	J0024−7204F	GC:47Tuc	0.002624	6.45e−20	–	–
B0021−72G	J0024−7204G	GC:47Tuc	0.004040	−4.21e−20	–	–
B0021−72H	J0024−7204H	GC:47Tuc	0.003210	−1.83e−21	2.3577	0.19
B0021−72I	J0024−7204I	GC:47Tuc	0.003485	−4.58e−20	0.2298	0.01
B0021−72J	J0024−7204J	GC:47Tuc	0.002101	−9.79e−21	0.1207	0.02
B0021−72L	J0024−7204L	GC:47Tuc	0.004346	−1.22e−19	–	–
B0021−72M	J0024−7204M	GC:47Tuc	0.003677	−3.84e−20	–	–
B0021−72N	J0024−7204N	GC:47Tuc	0.003054	−2.18e−20	–	–
J0024−7204O	J0024−7204O	GC:47Tuc	0.002643	3.03e−20	0.1360	0.02
J0024−7204P	J0024−7204P	GC:47Tuc	0.003643	···	0.1472	0.02
J0024−7204Q	J0024−7204Q	GC:47Tuc	0.004033	3.40e−20	1.1891	0.21
J0024−7204R	J0024−7204R	GC:47Tuc	0.003480	···	0.0662	0.03
J0024−7204S	J0024−7204S	GC:47Tuc	0.002830	−1.20e−19	1.2017	0.10
J0024−7204T	J0024−7204T	GC:47Tuc	0.007588	2.93e−19	1.1262	0.20
J0024−7204U	J0024−7204U	GC:47Tuc	0.004343	9.52e−20	0.4291	0.14
J0024−7204V	J0024−7204V	GC:47Tuc	0.004810	···	–	–
J0024−7204W	J0024−7204W	GC:47Tuc	0.002352	···	0.1330	0.14
J0514−4002A	J0514−4002A	GC:NGC1851	0.004991	···	18.7850	1.11
B1310+18	J1312+1810	GC:M53	0.033163	···	255.8000	0.35
B1516+02A	J1518+0205A	GC:M5	0.005554	4.12e−20	–	–
B1516+02B	J1518+0204B	GC:M5	0.007947	−3.33e−21	6.8585	0.13
B1620−26	J1623−2631	GC:M4	0.011076	6.70e−19	191.4428	0.33
B1639+36A	J1641+3627A	GC:M13	0.010378	···	–	–
J1701−3006B	J1701−3006B	GC:NGC6266	0.003594	−3.49e−19	0.1445	0.14
J1701−3006C	J1701−3006C	GC:NGC6266	0.003806	−3.18e−20	0.2150	0.08
J1701−3006D	J1701−3006D	GC:NGC6266	0.003418	···	1.1180	0.14
J1701−3006E	J1701−3006E	GC:NGC6266	0.003234	···	0.1600	0.03
J1701−3006F	J1701−3006F	GC:NGC6266	0.002295	···	0.2000	0.03
B1718−19	J1721−1936	GC:NGC6342	1.004037	1.62e−15	0.2583	0.13
J1740−5340	J1740−5340	GC:NGC6397	0.003650	1.68e−19	1.3541	0.22
B1744−24A	J1748−2446A	GC:Ter5	0.011563	−3.40e−20	0.0756	0.10
B1745−20	J1748−2021	GC:NGC6440	0.288603	4.00e−16	–	–
J1748−2446C	J1748−2446C	GC:Ter5	0.008436	−6.06e−19	–	–
B1802−07	J1804−0735	GC:NGC6539	0.023101	4.67e−19	2.6168	0.35
J1807−2459	J1807−2459	GC:NGC6544	0.003059	···	0.0711	0.01
B1820−30A	J1823−3021A	GC:NGC6624	0.005440	3.38e−18	–	–
B1820−30B	J1823−3021B	GC:NGC6624	0.378596	3.21e−17	–	–

With either the web or command-line interfaces, it is simple to produce lists of parameters and to copy these to a file to be used as input to other programs for custom plotting or other purposes. As an example, Fig. 3 shows the distribution of all known pulsars in Galactic coordinates. Most high-energy pulsars are young (median characteristic age $\sim 2 \times 10^4$ yr) and hence are concentrated along the Galactic plane, whereas most millisecond pulsars are very old (median characteristic age $\sim 4 \times 10^9$ yr) and have therefore had time to migrate away from their region of birth. They are therefore more widely distributed in Galactic latitude.

As another example, we show in Fig. 4 a histogram of the distribution of pulsar periods for all known pulsars, divided into binary pulsars, high-energy pulsars, AXPs and single radio pulsars using the Type keyword. This plot shows the clear dichotomy between millisecond pulsars and so-called "normal" pulsars. Binary pulsars predominantly have periods in the millisecond range whereas all AXPs are at the other end of the histogram with periods in the range 5 – 12 s. High-energy emitters are generally young and most have periods in the range 30 – 150 ms.

7. Conclusions

We have compiled an up-to-date pulsar catalog based on data from published papers and developed web and command-line interfaces to access both the catalog data and parameters derived from them. Full bibliographic information is provided for all data contained in the catalog. Supporting documentation and a mechanism for user feedback are also provided. Both the database and the software associated with the command-line interface are freely available for research purposes. The catalog will be updated at intervals to include recently published material and to correct any errors brought to our attention. An "expert-mode" web interface is also provided, which gives access to a wider range of parameters and allows use of custom databases.

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Table 10—Continued

Name	J2000 Name	Association	Period (s)	Period Derivative	Binary Period (d)	Med. Comp. Mass ($M_\odot$)
B1821−24	J1824−2452	GC:M28	0.003054	1.61e−18	–	–
B1908+00	J1910+0004	GC:NGC6760	0.003619	···	0.141	0.02
J1910−5959A	J1910−5959A	GC:NGC6752	0.003266	3.07e−21	0.837	0.22
J1910−5959B	J1910−5959B	GC:NGC6752	0.008358	−7.99e−19	–	–
J1910−5959C	J1910−5959C	GC:NGC6752	0.005277	2.20e−21	–	–
J1910−5959D	J1910−5959D	GC:NGC6752	0.009035	9.63e−19	–	–
J1910−5959E	J1910−5959E	GC:NGC6752	0.004572	−4.37e−19	–	–
B2127+11A	J2129+1210A	GC:M15	0.110665	−2.10e−17	–	–
B2127+11B	J2129+1210B	GC:M15	0.056133	9.56e−18	–	–
B2127+11D	J2129+1210D	GC:M15	0.004803	−1.07e−17	–	–
B2127+11E	J2129+1210E	GC:M15	0.004651	1.78e−19	–	–
B2127+11F	J2129+1210F	GC:M15	0.004027	3.20e−20	–	–
B2127+11G	J2129+1210G	GC:M15	0.037660	2.00e−18	–	–
B2127+11H	J2129+1210H	GC:M15	0.006743	2.40e−20	–	–
B2127+11C	J2130+1210C	GC:M15	0.030529	4.99e−18	0.335	1.13
J2140−2310A	J2140−2310A	GC:M30	0.011019	−5.18e−20	0.170	0.11
J2140−23B	J2140−23B	GC:M30	0.012986	···	–	–

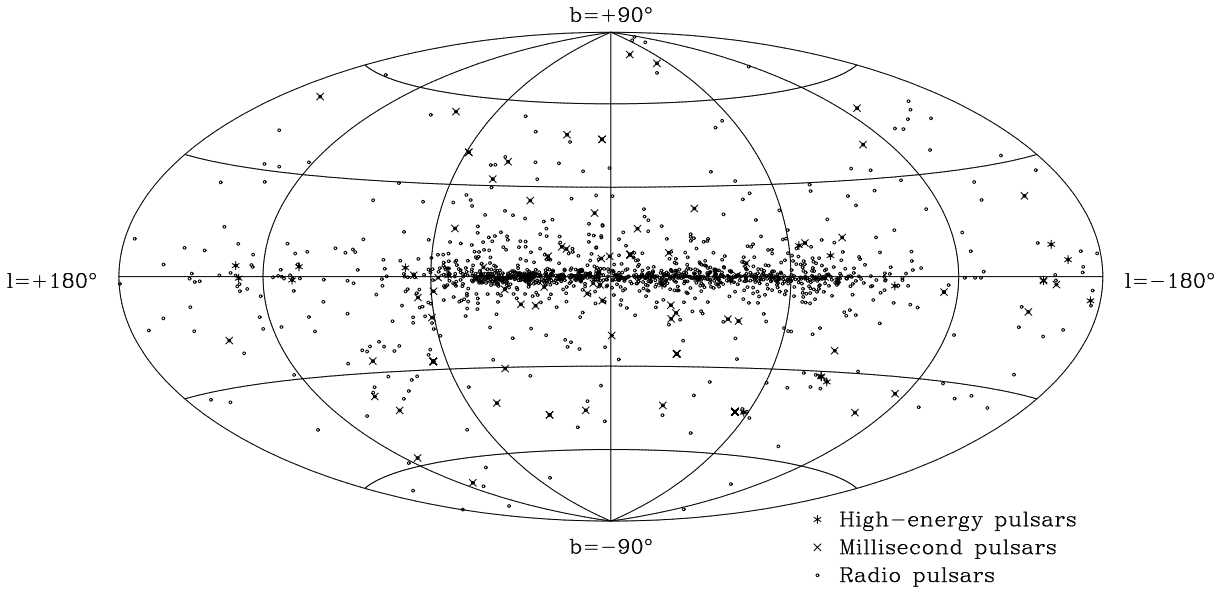

Fig. 3.— Distribution of pulsars on an Hammer-Aitoff equal-area projection in Galactic coordinates with the Galactic Center at the center of the plot.

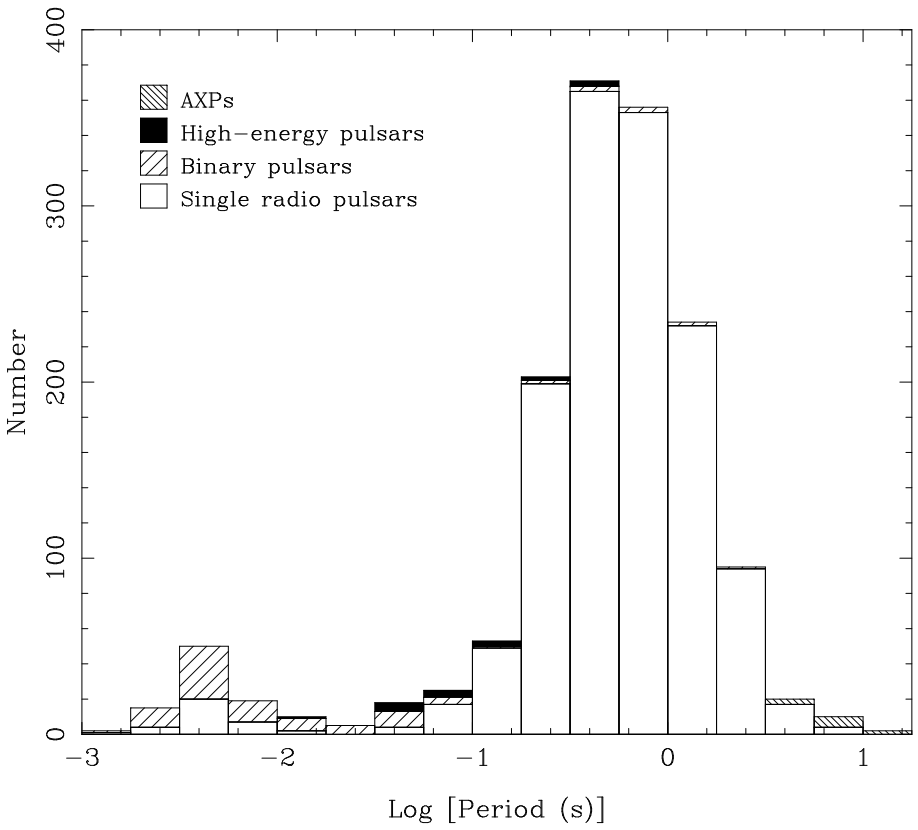

Fig. 4.— Distribution of pulse periods for all known pulsars, with binary pulsars, spin-powered pulsars with high-energy (optical, X-ray or gamma-ray) pulsed emission and AXPs separately identified.

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