Binary Radio Pulsars
ASP Conference Series, Vol. 328, 2005
F. A. Rasio and I. H. Stairs

Parkes Observations of Globular Cluster Pulsars

M. Bailes, J. Zhu, S. Richter

Swinburne Centre for Astrophysics & Supercomputing, Mail # 31, PO Box 218, Hawthorn, VIC 3122, Australia; mbailes@swin.edu.au

Abstract. Follow-up observations of pulsars from the Swinburne intermediate latitude survey with the Parkes radio telescope have caused us to question the association of PSR B1718−19 with the globular cluster NGC 6342 given the proximity of PSR J1721−1939 to the cluster. We have also found that the millisecond pulsar near the core of NGC 6624 has a large period second derivative, which would change the sign of the first derivative in about 6000 years. This is consistent with the pulsar experiencing a large gravitational perturbation from the cluster core.

1. Introduction

It is generally agreed that globular clusters represent some of the most ancient structures in the Universe. Star formation long-since ceased in these intriguing fossils of stellar evolution. Globular clusters have played a pivotal role in our understanding of stellar evolution. In the standard model, the last supernova occurred some 10 Gyr ago, and all of the neutron stars in clusters have a similar age.

The large-scale surveys of globular clusters that took place in the late 1980s and early 1990s discovered many pulsars in clusters. At least one of these was later found to be a chance superposition on the sky (Ter 5B; Lyne et al. 2000). Because of their relatively shallow depth, no large-scale unbiased survey has ever discovered a pulsar in a globular cluster, as most were already discovered in long integrations in the targeted surveys. The Parkes 70 cm survey did, however, detect some previously-known pulsars in globular clusters. So, pulsars in globular clusters would have eventually been discovered by the large-scale surveys even if the targeted surveys had not taken place.

One particularly interesting pulsar was found in the globular cluster NGC 6342 by Biggs et al. (1993). The 1-second pulsar was in a binary with an orbital period of only six hours, and a surprisingly high magnetic field strength of 10^{12} G. If this pulsar was formed 10 Gyr ago, any magnetic field decay must have been extremely limited.

The discovery of other pulsars in the same globular cluster can validate cluster membership. The most celebrated example of this was 47 Tuc D–L, confirming the existence of 47 Tuc C by Manchester et al. (1991) and eliminating 47 Tuc A and B from the cluster.

Long-term timing of cluster pulsars has proven to be extremely interesting in the case of PSR B1620−26, when Backer, Foster & Sallmen (1993) discovered that the period derivative was changing on extremely short (by millisecond pulsar standards) timescales. Follow-up timing has revealed the probable presence of a planetary companion.

When Biggs et al. (1993) discovered PSR B1820−30A, they noted that the pulsar's youth (just 25 Myr) was suspicious. Most millisecond pulsars have ages closer to several Gyr. The proximity of the pulsar to the cluster core made gravitational contamination of this pulsar's period derivative more probable. Since the age is taken to be $P/(2\dot{P})$, follow-up observations were commenced in 1995 at the Parkes radio telescope to keep track of this pulsar's period derivative.

2. PSR J1721−1939 and NGC 6342

The Swinburne Intermediate Latitude survey discovered 69 pulsars in a survey of galactic latitudes b between $5^o < \|b\| < 15^o$ (Edwards et al. 2001). In this latitude range there are many globular clusters. It is therefore not surprising to find chance coincidences of pulsars in the line of sight of globular clusters, particularly near the Galactic centre where there is a high density of globular clusters.

In a routine check of the Swinburne intermediate latitude survey pulsars, it was found that PSR J1721−1939 was near the cluster NGC 6342. Whilst there remains a strong possibility that this is merely coincidental, it is worth reviewing the possibility that the connection is genuine. In Table 1 we list the properties of the two nearest pulsars to NGC 6342, PSR B1718−19 and PSR J1721−1939, and which properties argue for cluster membership.

Name	PSR B1718−19	PSR J1721−1939	cluster membership
Period (ms)	1004	404	J1721−1939
B (G)	1.3×10^{12}	2.3×10^{11}	J1721−1939
deg from core	0.04	0.17	B1718−19
Binary	yes	no	B1718−19
DM	76	103	neutral

As can been seen from the table, the large field and youth of PSR B1718−19 do not make the association with the cluster that strong, but the binarity and proximity to the core still make the association more likely than that of PSR J1721−1939. Both pulsars are, however, inside the tidal radius of the cluster.

But can we rule out the association of PSR J1721−1939 with NGC 6342? Other cluster pulsars have smaller ages, and larger magnetic field strengths. Parallax measurements are impossible at such distances.

If dispersion measure variations between pulsars less than a degree apart on the sky could exceed 25 units, there is even the chance that PSR J1721−1939 was rejuvenated by PSR B1718−19's current companion in the exchange interaction

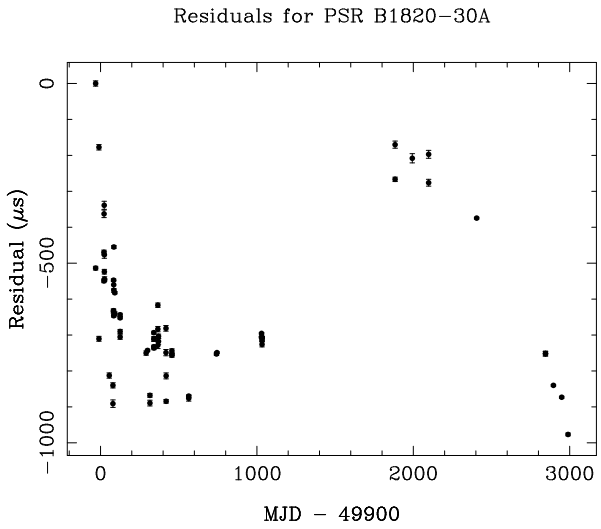

Figure 1. Evidence for a cubic term in the residuals of PSR B1820−30A after fitting for period and period derivative.

that created the PSR B1718−19 binary. This admittedly speculative suggestion was made to me by Steinn Sigurdsson on a ski lift during the conference.

3. Timing PSR B1820−30A

Figure 1 shows the Parkes timing history of PSR B1820−30A over the past 8 years or so. There is good evidence that this pulsar is not well described by a simple $P/\dot{P}$ law. We found that a cubic term gives a much better fit, and is consistent with that derived by Hobbs et al. (2004) from Jodrell Bank observations. We find $\dot{\nu} = -1.1445(1) \times 10^{-13}$ s^{-2} and $\ddot{\nu} = 6.1(4) \times 10^{-25}$ s^{-3}. The timescale for a sign change on the period derivative is only 6000 years. If we interpret both the period derivative and second derivative as being induced by the gravitational influence of a third object, we find that it is consistent with the gravity of the dense core that the pulsar is nearly coincident with. This pulsar is within an arc second of the cluster core.

4. Conclusions

- Long-term timing of pulsars in globular clusters gives a direct probe of the cluster gravitational potential.
- The cluster association of PSR B1718−19 with NGC 6342 is still uncertain.

Acknowledgments. I would like to thank Ben Stappers for commencing the timing of PSR B1820−30A at Parkes and the Swinburne staff who have been responsible for many recent observations. The Parkes telescope is operated as a National Facility by the CSIRO.

References

Backer, D. C., Foster, R. S. & Sallmen, S. 1993, Nature, 365, 817

Biggs, J. D., Bailes, M., Lyne, A. G., Goss, W. M., & Fruchter, A. S. 1993, MNRAS, 267, 125

Edwards, R. T., Bailes, M., van Straten, W. & Britton, M. C. 2001, MNRAS 328, 911

Lyne, A. G., Biggs, J. D., Bailes, M., & Harrison, P. A. 2000, Nature, 361, 47

Hobbs, G., Lyne, A. G., Kramer, M., Martin, P., & Jordan, C. 2004, MNRAS, 353, 1311

Lyne, A. G., Mankelow, A. G., Bell, J. F., & Manchester, R. N. 2000, MNRAS, 316, 491

Manchester, R. N., et al. 1991, Nature, 352, 219