*Pulsar Astronomy — 2000 and Beyond*
*ASP Conference Series, Vol. 202, 2000*
*M. Kramer, N. Wex, and R. Wielebinski, eds.*

# The Proper Motions of Young Pulsars

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**Abstract.** We report on a project to determine the proper motions of a sample of 13 young pulsars. Sky positions are measured with phase referencing using two elements of the MERLIN array, giving a baseline of 198km. This technique involves the concurrent observation of each pulsar with one or more extra-galactic reference sources located in the same primary beam. At an observing wavelength of 21 cm, this allows the measurement of pulsar positions to an accuracy greater than 1 mas.

## 1. Introduction

A project is underway at Jodrell Bank Observatory to determine the proper motions of a sample of 13 young pulsars. This will allow the calculation of their velocities, from which birth velocities of these objects may be inferred. Hence the hypothesis of Lyne & Lorimer (1994), that pulsars have mean birth velocities of 400-500 km/s, may be directly tested. Young, bright pulsars were selected for this experiment. Additionally, suitable phase reference sources had to lie in close proximity to each pulsar. The sample also includes two pulsars which may be associated with supernova remnants. The determination of their proper motions, and hence velocities, will hopefully enable us to ascertain whether these are true associations or chance geometric alignments.

Observations of the sample sources are made at a frequency of 1.42 GHz, using a phase referencing technique with MERLIN *(Multi Element Radio Linked Interferometer Network)*(Thomasson 1986). This instrument provides a resolution of 150 mas, allowing relative position measurements with errors of approximately 1 mas to be made. From this, proper motions of less than 1 mas/year can be measured using time baselines of only a few years.

## 2. Technique and Preliminary Results

This method is chosen over timing methods because young pulsars tend to display a high level of timing noise, as well as glitches, which would make proper motion determination almost impossible.

The proper motion is measured by finding the change of phase, with time, between the pulsar and a number of reference sources lying in the same primary beam of the interferometer. The choice of reference sources is therefore crucial to the experiment, as these need to be strong point sources which have no

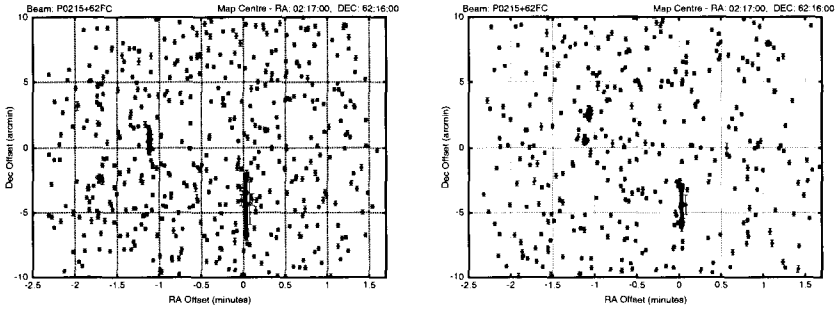


Figure 1. Two data sets produced using on and off pulse gates. The plot on the left shows the two reference sources only, whilst that on the right also contains the pulsar signal.

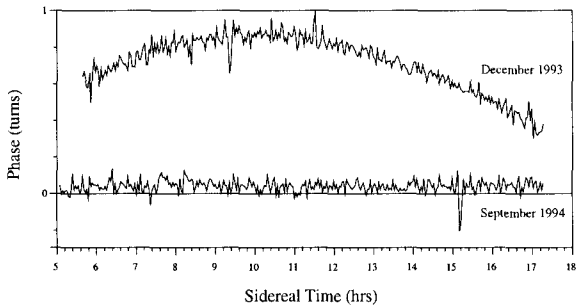


Figure 2. Differences in phase between the pulsar and reference source at two different epochs.

significant proper motions themselves. The first part of the project therefore involves a search for suitable reference sources for each pulsar in the sample. Although it is desirable to have two or more reference sources per pulsar, in practice the search has yielded this for only 20% of the pulsar sample.

The data are taken using a gating mode which allows the on-pulse data to be collected separately from the off-pulse data. This produces two data sets, only one of which contains the pulsar signal, with a greatly enhanced signal to noise ratio (see Figure 1). Figure 2 shows the difference in phase between the high velocity pulsar PSR1133+16 and its reference source, for two observations separated by 9 months, with both traces plotted with respect to the later observation. The sinusoid apparent in the earlier trace is due to the known proper motion of the pulsar of 0.3 arcseconds per year.

## References

Lyne, A. G. and Lorimer, D. R. 1994, Nature, 369, 127
Thomasson, P. 1986, RAS Quarterly Journal, 27, 413