Estimation of the Period of pulsar

1 Introduction

Pulsars are rapidly rotating neutron stars. As a star runs out of fuel to create energy, the outer core will come out as a supernova explosion. If the mass of the star left in the core after the supernova is more than the Chandrasekhar limit and less than that to form a black hole, it will become a neutron star with high rotational frequency. The radius of the neutron star is found to be »10-15 km. As the original star shrinks to a neutron star, the angular momentum will be conserved. As a result, the large slowly rotating star will leave behind a small star with high rotational frequency. The magnetic flux density of original star also gets conserved, which results in a highly magnetised star (B » 10_{12} Gauss). The pulsar emission is coming from the open field lines at the poles. Most of the pulsars are not axisymmetric (rotation and magnetic axis along the same line). So, in general, we observe at least one pulse from one of the poles as the pulsar emission region crosses the observer's line of sight. The difference of arrival time between each pulse is the period, in which pulsar completes one rotation about its rotation axis. The observed pulsar period varies from <10 ms to 10 s. The period gets stretched as the pulsar ages due to the loss of rotational kinetic energy. This decrease in period is 10_{-15} for normal pulsars and10_{-20} for millisecond pulsars. This is one of the main reasons why millisecond pulsars have been in use for high precision timing experiments. For more information, refer Lyne and Smith (1998).

2 Analysis Procedure

The data recorded from the ORT is in plain binary. To make it useful for the analysis purpose, we have to convert it into a standard format through the pulsar pipeline, which is available at ORT.

To find the period of the pulsar, we have to dedisperse the pulsar with the provided DM (or estimated in the previous experiment) and estimate the period from the single pulses seen in the dedispersed time series. For weak pulsars, one may use known estimates of the period. If the period that has been assumed is not correct, the pulse will drift when the time series is folded modulo period and this drift can be used to obtain a better period. The analysis described below assumes the pulse to be modeled as a combination of Guassians to estimate the drift in its position. The rate of this drift then provides an estimate of the correction to the period.

The step by step procedure of the analysis is given below.
1. Open a terminal and go to the folder where your data is saved.
   For example cd /scratch1/POS12 B4/02Dec2012/
2. To analyse the data, change the source to 'tcsh' by giving the following commands.
   $ tcsh
   $ source /scratch/soft/bin/path
3. Get the time stamp in MJD. The timestamp file is recorded with the data and gives time in IST. Ignore the seconds and add 1 to the minutes. This is the start time of acquisition. Convert this to UTC and then MJD.
4. Convert the data to filterbank format
   acqch1fft input file −o output file.fil −nacc < > −mjd < >

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The value of −nacc will determine the sampling time of the data. A value of 16 will sample the data at 1 ms. −mjd is the Modified Julian Date (MJD) of the beginning of the observation. Find out the MJD of your observation, before analysing the data, upto 12 decimal places.

5. Use the command 'dedisperse' to dedisperse the data as given below.

   dedisperse input file.fil −d <DM> −nobaseline > outputfile.tim

   Where, <DM> is the DM of your pulsar.

   You can find the value of all pulsars parameters from the psrcat.db file, which is downloadable from the link **http://www.atnf.csiro.au/people/pulsar/psrcat/download.html**

6. For visualising the data as a timeseries, use the command 'reader' as follows

   reader input file.tim > output file.asc

7. You can plot the time series using GNUPLOT. Type 'gnuplot' in the command line. then use the following to plot the data.

   plot 'outputfile.asc' w l

   'w l' is the command for plotting the data with line.

8. Now, we are ready to fold the data. Fold the data with a rough period (in milliseconds) as given to you using the following code.

   fold input file.tim −p <period> −n <No. of bins> −nobaseline -d < > > output file.subint.prof

   Give the rough period of the pulsar provided to you or found from the time series after -p. Give the number of data points (bins) to which you wish to fold the data after -n (Usually give in multiples of 2). Give the number of periods you want to fold after -d.

9. Repeat the above procedure for all the files of the pulsar you observed.

10. After folding the data, fit it with a Gaussian function using GNUPLOT by defining the Gaussian function as follows

    f(x)=a*exp(- ((x-b)**2/(2*c**2)))

    Give the average values of a,b,c to fit it to the pulse profile.

    fit f(x) 'file.subint.prof' via a,b,c

    This will fit the pulse with the Gaussian function. Note down the value of b with it's error. Also check the value of chi square, which will be given as WSSR in GNUPLOT after fitting. If you wish to see the fit, plot it using the following command

    plot 'file.subint.prof' w l title "profile" , f(x) title "fit"

11. Repeat the same for all the profiles and create a '.txt' file with the time of observation (in MJD or seconds) as the first column, the middle point of the profile (b) as the second column (in seconds) and the error in the profile center fit as the third column.

12. Plot the data file you have now created using the following code

    plot 'file name.txt' w p

13. Fit your data with a line by defining the equation of line.

    f(x)=m*x+b

    Fit the data using the fit command.

    fit f(x) 'file name.txt' us 1:2 via m,b

    Find out the value of m i.e., slope. This will be in units of ms s^{-1}. Note down the error and the chi square value.

14. Multiply the value of m with the period that you have taken to analyze and add or subtract the result from the rough period to find the exact period of the pulsar with error.

15. Repeat the same analysis for all the pulsars you observed.

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3 Observations Log

Serial No.	Pulsar Name	HA	Time of Observations	Name of Recorded Data file for the source
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

4 Analysis Log and Plots

Slope of the fit = ms s^{-1}

Period of the pulsar PSR = ms

5 Results

Period of the Pulsar PSR = ms

6 Sources of Error in the experiment

7 Discussion and Conclusions