

Estimation of flux density of pulsar

1 Introduction

Pulsars are very weak sources in the sky. The brightness of radio source, such as radio pulsars, is measured by comparing the intensity received from the pulsar against that received from a well known radio source, much in the same way we measure the weight of household things by comparing them against known weights. The unit usually used for specifying the flux density of a radio source is Jansky, named after the First Radio Astronomer, Carl Jansky. One Jansky is 10^{-26} W cm⁻² Hz. The flux density of some radio sources, such as 3c48 and 3C147, have been measured repeatedly over a long period of time and is very well known. One can use this known flux density to obtain a scaling factor from observations of such sources (known as radio calibrators) with a radio telescope, such as ORT. The scaling factor is then used to convert the output of the radio telescope, while observing any other source, to the flux density of the source being observed.

Pulsars usually are weak sources with a flux density 10 mJy. A handful of pulsars have much higher flux density and can be detected in a short observations with sensitive telescope, such as ORT. This experiment involves observations of some such pulsars.

2 Aim of the experiment

The aim of this experiment is to (a) observe a calibrator source and a few pulsars with ORT (b) use the calibrator data to estimate the required calibration (scaling factor or counts/Jy) (c) apply the calibration to pulsar data and estimate the pulsed and continuum flux density of the pulsar. Calibration can also be done by estimate the root-mean-square (RMS) of the time series to estimate the counts/Jy and then use this to estimate the flux density of the pulsar. ORT will be used to carry out observations of a select list of calibrators and pulsars (given in Section ??).

The data are analysed with a pulsar pipeline using the procedure given in Section 4. The experiment also involves an interpretation of the results obtained, which the experimenter has to explain in the sheets provided at the end of this procedure.

3 Observations Log

Serial No.	Source Name	HA	Time of Observation	Name of Recorded data file for the source
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1.

2.

3.

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4 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.

There are two kinds of flux density we are interested in, pulsed flux density and mean flux density. Mean flux density is equivalent to the flux density from a continuum source and is the standard quantity to find the strength of the signal.

The estimation of flux density can be done in different ways. The method we follow with our observation is as follows.

Point the telescope at a calibrator source whose flux density is known (Eg: 3C147, 3C119, etc.). Now point the telescope at an off source where no radio source is there by changing the declination. Find out the difference in counts of the calibrator source and the off-source and divide it by the flux density of the calibrator source to get the counts/Jy. Use this to find out the peak and mean flux density of the pulsar.

The pulsed flux is the area under the pulse. To estimate the mean flux density, you have to divide the pulsed flux density by the number of bins across the profile.

The step by step analysis of the procedure 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 <>`
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 analyzing the data, up to 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>` gives the DM of your pulsar.
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 GNU PLOT. 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 the period which you have calculated (in milliseconds) as given to you using the following code.
`fold input file.tim -p <period> -n <bin number> -nobaseline > output file.sub.prof`

9. Similarly do the same analysis as above for obtaining the *.tim files of the calibrator and offsource datas with the sampling rate of 1 ms or more. Plot the data using GNUPLOT and find their mean values by following the below script.

```
f(x)=mean y
```

```
fit f(x) 'file name.tim' u 1:2 via mean y
```

Note down the mean value of calibrator source and offsource to find the counts per Jansky during the time of observation.

10. To find out the mean flux density, you can scale the pulsed flux to the total number of bins in the profile and divide the value by counts per Jansky to obtain the mean flux density.

5 Analysis Log and Plots

Flux density of the calibrator source = Jy

Counts per Jansky of calibrator = counts Jy⁻¹

Continuum flux density = mJy

6 Results

Flux density of PSR B =

mJy

7 Sources of Error in the experiment

8 Discussion and Conclusions