Pulsar Observations

Pulsar Observatory for Students(POS) 2014

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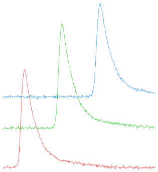
January 4, 2015



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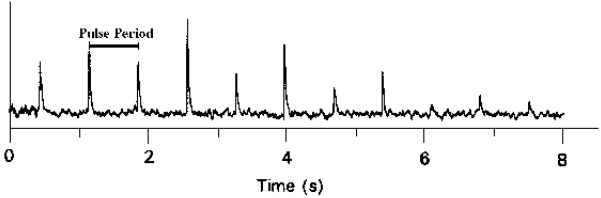
Pulsar Period

Pulsars are rapidly rotating neutron stars.The time between consecutive pulses is called it's period. This period is pretty much constant for all pulsars with deviations of the order of $\sim 10^{-15}$.Hence a pulsar can easily be characterised by it's period and therefore it becomes quite important to find the pulsar period.



The period of pulsars ranges from order of *ms* to 10s.

Methods of finding the period

- **Manual Counting** In this method we just take a definte number of consecutive pulses and divde the time period by the number of pulses to get a *crude estimate* on the period.
- **Fast Fourier Transform(FFT)** The FFT of the time series of the pulsar is performed. The pulsar signal being period with a constant period shows up as strong component in the freqency spectrum. On the other hand the noise being random does not produce strong signatures in the spectrum.
  `This method is the most accurate as the position of the peak can be found precisely upto` μ *sec* `level.`

Pulsar period for $B0329 + 54$

This is quite a strong pulsar($1500mJy$) and it's period can be estimated from manual counting alone. However for the sake for precision, an FFT was performed on the time series.

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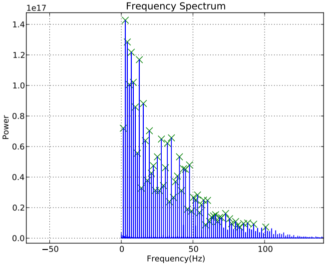

The fundamental was observed at 1.39994 ± 0.00004Hz which corresponded to a timperiod of 0.714316 ± 0.00002s.

An even more accurate estimate can be found by fitting the harmonics on a straight line.

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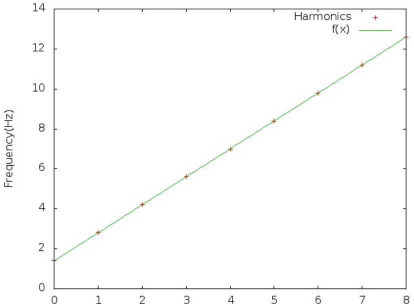
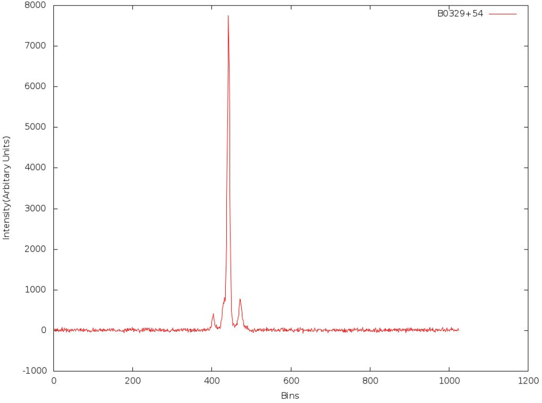


The slope of the fit corresponds to the frequency. Using this method the period was found to be 714.572 ± 0.000021ms.

Profile

We can test our estimate of the period by folding the data at the value we have obtained.



As the pulse peak is quite prominent, we can be assured that our estimate is accurate.

Pulsar period for $B0833-45$

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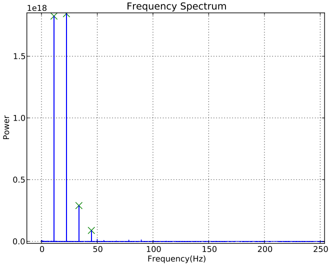

The fundamental was observed at 11.18622Hz which corresponded to a timperiod of 89.3957ms.

Since Vela is a strong pulsar we can see distinctly prominent peaks in the spectrum and noise is pretty much absent.

We can repeat the same analysis of fitting the harmonics to find the time period.

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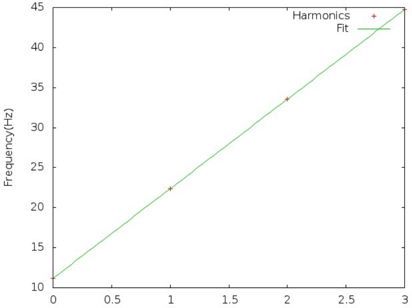
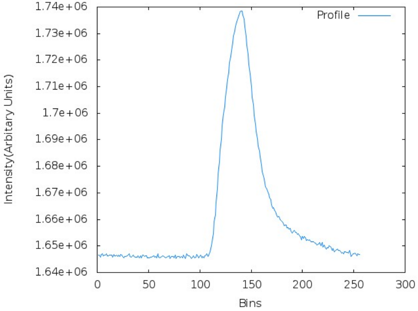


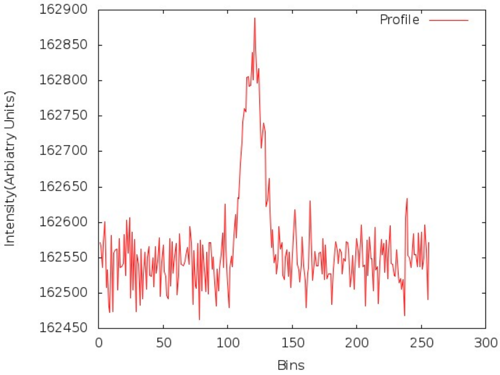
The slope of the fit corresponds to the frequency.Using this method the period was found to be 89.37971 ± 0.00042ms.

The profile folded with period seems pretty clean and we can be sure of our period estimate.



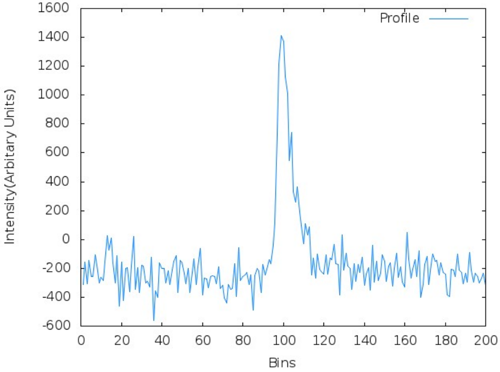
Pulsar period for $B0031-07$

This is a weak pulsar and hence it almost impossible to obtain it's period manually.So we have to resort to the FFT method. Using the FFT method along with some trial and error for the period, it was found to be 942.975 ± 0.001ms.
We can see that the peak is prominent in the profile and hence our estimate is in the right ballpark.



Pulsar period for $B2053 + 36$

This is a very weak pulsar and hence it almost impossible to obtain it's period manually.So we have to resort to the FFT method. Using the FFT method along with some trial and error for the period, it was found to be 221.518 ± 0.001ms. We can see that the peak is present in the profile.



The pulse from the pulsar is affected by the interstellar medium in mainly two ways:

- **Plasma dispersion** This leads to a **systematic** change in arrival time of the pulses as a function of frequency. This dispersion is used to determine the Dispersion Measure(DM) of a pulsar.
- **Scattering** This is because of random fluctutations in the electron density in the ISM.As a result,the refractive index changes and pulses at different frequency arrive differently.Therefore,the pulse profile is broadened and an exponential tail is generally observed.

Method of Analysis

- The pulse is so adjusted that only the tail is used as the data set.
- The tail is fit using the function $f(t) = ae^{\frac{-t}{\tau}} + b$ where τ is the scattering timescale.

τ for B0833-45

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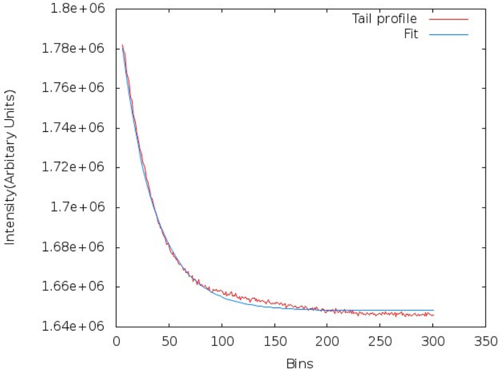

Using the fit,the τ was found to be around 11.13 ± 0.78ms.

τ for B2053+36

This pulsar was the weakest pulsar that was observed.It has a tail though it is not as expressed as the Vela pulsar.

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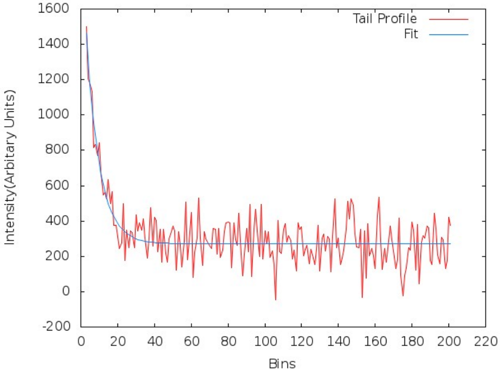

Using the fit,the τ was found to be around 8.02 ± 0.64ms.