Single Pulses of Millisecond Pulsar PSR J0437−4715

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Abstract Properties of single pulses of millisecond pulsar PSR J0437−4715 have been investigated. We examined and found no evidences for nulling, giant pulses, or giant micropulses. The gated pulse profiles show a relative variation among the flux densities of main peak and other components. The investigation of stability of pulses suggests the pulse profile is easy to be stable.

Single pulse studies have long been concerned as a key to understanding the structure of pulsar emission region. Most of previous works has been done with regards to normal pulsars, and few millisecond pulsars (MSPs) are bright enough for such investigations. PSR J0437−4715 is one of the brightest MSP with a low dispersion measure of 2.6469 cm^{-3} pc, thus it is an ideal source for single pulse investigations. Our data were obtained at 1517 MHz using Parkes 64 m telescope with a sampling time of 0.08 ms and total bandwidth of 256 MHz.

1 Nulling and Giant Pulses

Pulse nulling takes place when the pulse power drops dramatically for some periods, while giant pulses are very luminous pulses occational occuring at some pulse periods. Normalized flux density distribution is plotted in Fig.1. According to Ritchings (1976), an increasing fraction of noise probability distribution centred on zero energy has to be subtracted from the observed probability distribution until some portion of the ′residual′ distribution either became negative or no longer remained smooth. This particular value of the fraction is adopted as an upper limit of probability for pulse nulling. We got the upper limit of 0.61%. In addition, there is apparently not many luminous pulses in Fig.1.

2 Giant Micropulses

Giant micropulses are not so luminous as giant pulses, they are very narrow and high intensity pulses (Johnston et al. 2001). We investigated giant micropulses by checking the distribution of the signal-to-noise ratio (SNR). We take the ratio between the highest flux density in each single pulse and the noise level of off-pulse window and show the statistical results in Fig.2. One can see that the distribution is similiar to a χ^2 distribution with a mean about 10. The highest SNR less than 80 suggests there is no evidence for giant micropulses. The 1-bit sampling may affect this distribution.

3 Gated Pulse Profiles

Single pulses have been grouped into 9 groups according to SNRs, then 9 gated pulse profiles have been obtained. The normalized profiles are shown in Fig.3. The SNRs of single pulses are increasing from bottom to top. One can see that the width of main peaks are

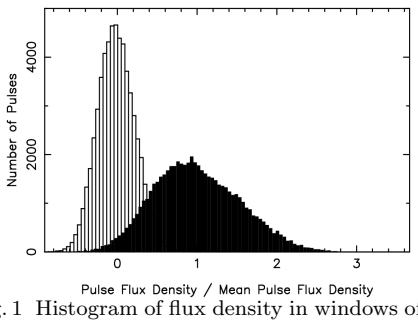

Fig. 1 Histogram of flux density in windows of on-pulses(shaded) and off-pulses

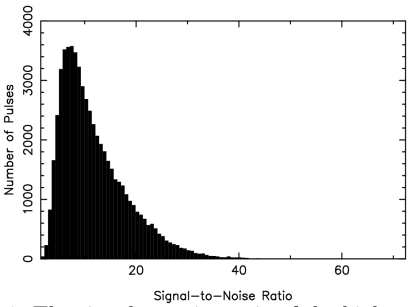

Fig. 2 The signal-to-noise ratio of the highest flux density in each period

narrowing with increasing of the SNR, and the side components get relatively weaker from bottom to top after main peaks are scaled to the unit.

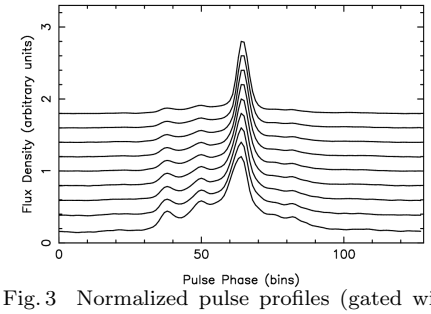

Fig. 3 Normalized pulse profiles (gated with the SNR). The SNRs are increasing from bottom to top

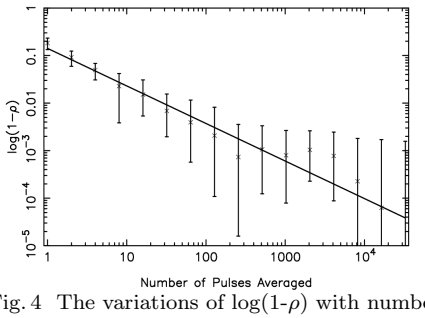

Fig. 4 The variations of log(1-ρ) with number of periods included in the subaverage

4 Stability of Average Profiles

The stabilization rate of average profile is studied by coefficients of cross correlations between the global profile and subaveraged profiles. Rathasree & Rankin (1995) studied over two dozen normal pulsars, and found the range of slopes for normal pulsars $-0.19 \sim -0.98$. From our linear fitting in Fig.4, the slope for PSR J0437−4715 is -0.8 ± 0.06, so it is a pulsar easy to have stabilized profile.

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