

# A survey of Nulling pulsars with Giant Meterwave radio Telescope

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## Abstract

Several pulsars show sudden cessation of pulsed emission, which is known as pulsar nulling. In this paper, we are reporting nulling behaviour of 15 pulsars among which five were discovered recently in Parks Multibeam Survey and never reported any nulling behaviour. We are also reporting refined nulling fraction for four known nulling pulsar where only an upper limit was available earlier. We are presenting first time results on reduction in the pulsed energy during the null phase for all our samples. The main aim of this study is to bring out the fact that nulling fraction does not quantify nulling in full detail as pulsar with similar nulling fraction exhibit different nulling behaviour.

## 1 Introduction

The abrupt cessation of pulsed radio emission for several pulse periods, exhibited by some pulsars, has remained unexplained despite the discovery of this phenomenon in many radio pulsars. This phenomenon, called pulse nulling, was first discovered in four pulsars in 1970. Subsequent studies have revealed pulse nulling in about 100 pulsars to date [1–6]. The degree and form of pulse nulling varies from one pulsar to another. On one hand, there are pulsars such as PSR B0826-34 [7], which null most of the time. In contrast, pulsars such as PSR B0809+74 show a small degree of nulling [8]. Pulse nulling is frequent in pulsars such as PSR B1112+50, while it is very sporadic in PSR B1642-03 [3]. The fraction of pulses with no detectable emission is known as the nulling fraction (NF) and is a measure of the degree of nulling in a pulsar. However, the NF does not specify the duration of individual nulls, nor does it specify how the nulls are spaced in time.

Pulsar nulling remained an open question even after 40 years since it was first reported. Various attempts have been made to understand pulsar nulling as a general property of peculiar type of pulsars. Most of these studies were carried out by comparing NF for sample of pulsars with their various other parameters. Ritchings [3] reported that pulsar NF has a weak correlation with the period of pulsar. It was reported that NF is more in long period pulsars compared to competitively short period pulsars. Pulsar period is directly related to the age of the pulsar so Ritchings concluded that the pulsar die with increasing fraction of nulling in them as it gets older. However, subsequent studies have not shown any sign of such correlation [4,6]. Rankin [13] suggested a correlation which is more towards profile classification. It was reported [13] that pulsar with conal emission seems to null more than single core component pulsars. This kind of correlation can be expected if nulling is simply geometrical effect of emission beam and not complete cessation of pulsar emission. Biggs [4] compared NF with eight pulsar parameters but found no strong correlation. Only two weak correlations were found with NF, a correlation with the age of the pulsar and an anti-correlation with the angle  $\alpha$  (i.e. angle between rotation and magnetic axis). Wang et al [6], by using NF as comparison parameter, has reported that there is no correlation between NF and profile morphological classes as claimed by Rankin [13]. From all these studies no strong claim can be made about any relation of pulsar nulling with any of the parameters. However, if nulling is seen only in handful of pulsars, it can be some sort of intrinsic property which needs to be investigated. One of the common things of all the above studies was that NF was used as a comparison parameter.

In this paper we are reporting observations of 15 nulling pulsars carried out using Giant Meterwave Radio Telescope at 325 and 610 MHz. Among these, five were discovered in Parks multibeam pulsar survey (hereafter; PKSMB) [9–11] which have no previous reported nulling behaviour. We are refining known values of NF for five of the known nulling pulsars. Along with that, we are also reporting reduction in the pulse energy during the null phase for all our samples. Section 2 describes the obtained results. In section 3 we discuss our final conclusions.

## 2 Results

We used method given by Ritchings [3] to estimate NF for our sample pulsars. To obtain sufficient signal to noise ratio (S/N), subsequent pulses were added for pulsar with low intensity single pulses (i.e. Number in the parenthesis of Column 10 in Table 1). Pulses, affected by spurious interference, were removed for the NF analysis. Number of pulses used are shown in Column 10.

Table 1: Below Table represents basic parameters along with the obtained NF and  $\eta$  (reduction in the pulse energy during the null phase) for our samples. Column 6 gives NF obtained in this study (using Ritchings[3] method) while column 9 gives obtained values of  $\eta$ . The number in the parenthesis gives 3 standard deviation error bars. Column 8 gives NF estimated independently from counting separated null and burst (normal) pulses. Column 10 gives number of pulses used in the analysis with subintegrated pulses to improve S/N given in the bracket. Column 7 gives NF estimated in the pervious studies with their references given in the super-script.

J2000 Name	B1950 Name	Period (S)	DM (pc/cm <sup>3</sup> )	S1420 (mJy)	NF (%)	Known NF (%)	iNF (%)	$\eta$ -	N (Sub-integration) -
J0814+7429	B0809+74	1.292241	06.1	10.0	0.95(0.35)	1.42(0.02) [8]	1.25	172.0 (0.5)	3739 (1)
J0820-1350	B0818-13	1.238130	40.9	7.0	0.88(1.82)	1.01(0.01) [8]	1.35	4.2 (0.2)	3341 (1)
J0837-4135	B0835-41	0.751624	147.2	16.0	1.7(1.2)	$\leq 1.2$ [4]	1.04	15.7 (0.2)	3335 (1)
J1115+5030	B1112+50	1.656439	9.2	3.0	63.6 (5.9)	60 (5) [3]	55.2	44.7 (0.2)	2634 (1)
J1639-4359	-	0.587559	258.9	0.92	0	-	-	-	13034(9)
J1701-3726	-	2.454609	303.4	2.9	19 (6)	$\geq 14$ [6]	16.6	6.4 (0.2)	2464 (1)
J1715-4034	-	2.072153	254.0	1.60	$\geq 19$	-	4.0	0.8 (0.1)	1591 (16)
J1725-4043	-	1.465071	203.0	0.34	-	-	-	-	2481 (24)
J1738-2330	-	1.978847	99.3	0.48	$\geq 87$	-	66.2	5.3 (0.3)	2178 (5)
J1901+0413	-	2.663080	352.0	1.10	0	-	-	-	2605 (24)
J2022+2854	B2020+28	0.343402	24.6	38	0.15 (1.6)	$\leq 3$ [3]	0.08	2.5 (0.2)	8039 (1)
J2022+5154	B2021+51	0.529196	22.6	27.0	1.4(0.7)	$\leq 5$ [3]	0.52	2.6 (0.2)	1326 (1)
J2037+1942	B2034+19	2.074377	36.0	-	$\geq 46$	44 (4) [12]	27.5	6.4 (0.1)	1618 (3)
J2113+4644	B2111+46	1.014685	141.3	19.0	20.5 (4.1)	12.5 (2.5) [3]	14.6	14.9 (0.3)	6208 (1)
J2321+6024	B2319+60	2.256488	94.6	12.0	29(1)	25 (5) [3]	32.3	115.8 (0.4)	1795 (1)

Figure 1 shows NLH and BLH for 8 of our sample pulsars. From Table 1 and Figure 1, it can be seen that PSRs J0814+7429, J0820-1350, J0837-4135 and J2022+2854 has NF of around 1% but their NLH and BLH are completely different from each other. For example, PSR J0814+7429 has various peak in the BLH while other three pulsar shows gradual distribution. PSRs J0814+7429 and J0820-1350 has distribution of various null lengths while PSRs J0837-4135 and J2022+2854 shows only single and double period nulls. The NLH of PSR J0837-4135 has around 95% of nulls having length of 1 period only while for PSR J2022+2854 null pulses are divided in 60% and 40% among single and double period nulls respectively. This kind of difference is not only seen in pulsars with small NF but also in moderate NF pulsars. For example, PSRs J2321+6024 and J2037+1942 has iNF of 27% and 31% but their NLH/BLH are different. PSR J2037+1942 has null pulses of length up to 10 periods while PSR J2321+6024 shows null pulses of length up to 25 periods.

## 3 Conclusions

In conclusion, we are reporting nulling behavior of 15 pulsars out of which 5 were recently discovered in PKSMB. We have also refined NF value for 4 pulsars where previously only an upper limit was possible to obtain. We have compared NLH and BLH of various pulsars and tried to show that pulsar with similar NF have different spread. It can be concluded from this study that clearly NF is not the only parameter which quantifies nulling behavior. The NLH and BLH needs to be incorporated while comparing various pulsar parameters in order to understand nulling in full detail. It can also be concluded that previous studies (as mentioned in section 1) were not able to find any strong

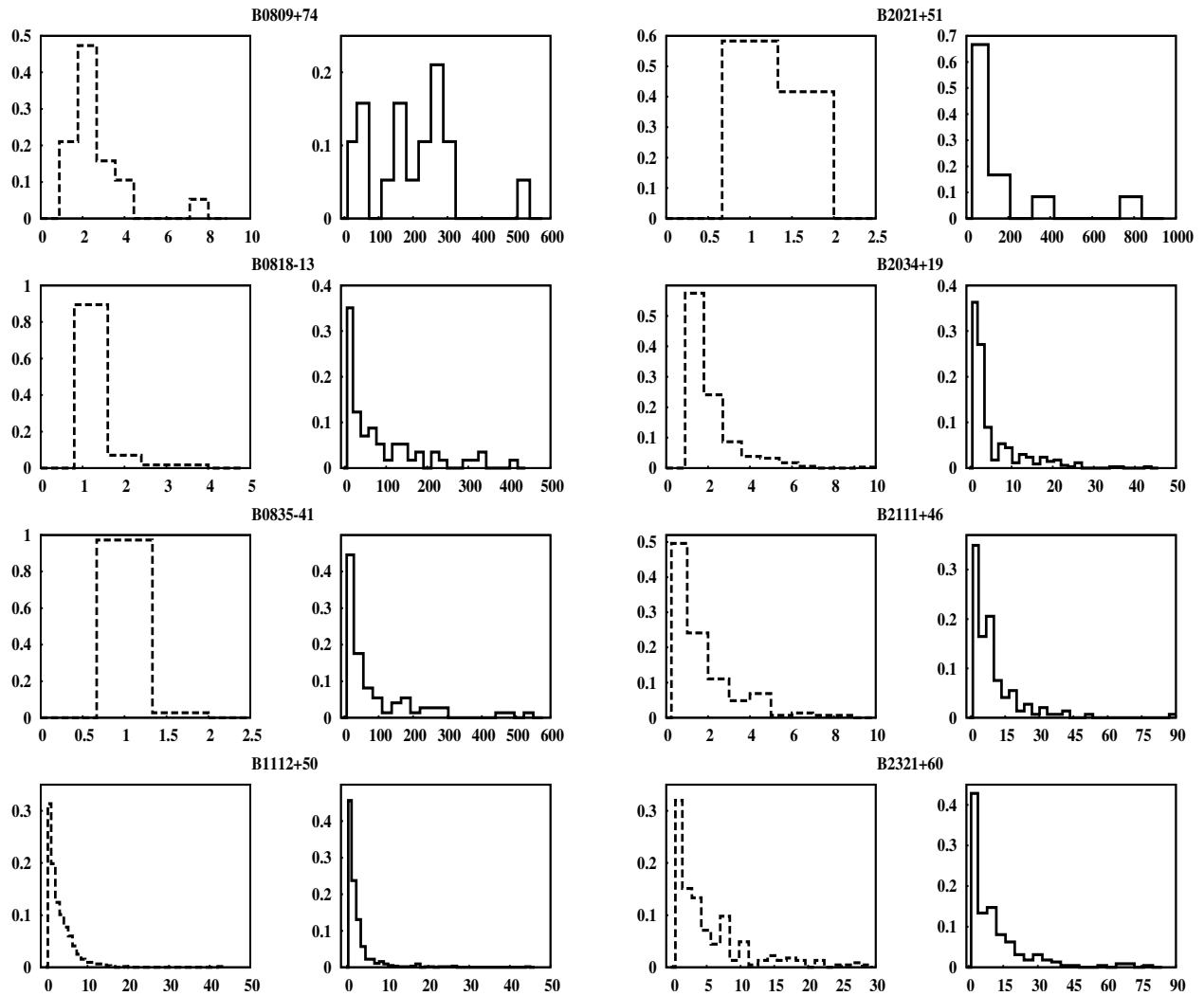


Figure 1: Null and burst length histogram of eight pulsars from our sample. The continuous line shows histogram of typical burst lengths, while dash line shows typical null lengths for respective pulsar.

correlations because only NF was used as comparison parameter. Our study shows that nulling needs to be quantify in taking NLH and BLH under consideration.

## 4 References

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