# Two-Frequency Simultaneous Observations of Mode-changing Phenomena of PSR0329+54

Ali Esamdin[1,2,3], X.J. Wu[1,2] & X.Z. Zhang[4]

(1 *Urumqi Astronomical Observatory, NAO, CAS, Urumqi* 830011)
(2 *Department of Astronomy, Peking University, Beijing* 100871)
(3 *Chinese Academy of Sciences-Peking University Joint Beijing Astrophysics Center, Beijing* 100871)
(4 *National Astronomical Observatories, Chinese Academy of Sciences, Beijing* 100012)

**Abstract** Two-frequency simultaneous monitoring of pulsars were carried out using Urumqi 25-m telescope at 327 MHz and 610 MHz from 11th July to 21st August 2000. Two mode-changing data of PSR0329+54 were obtained. In this paper, the observed results of PSR0329+54 are presented and spectral behaviors in its normal and abnormal modes are briefly investigated.

**Key words** pulsar-mode change-spectrum

## 1 Introduction

The individual pulses of pulsars are highly variable in shape and intensity. Nevertheless, the integrated profiles of pulsars are well known for their long-term stability. Studies of the stability of integrated profiles have been carried out systematically (Helfand et al., 1975; Rankin et al., 1995). These studies show that a number of a few thousand pulses folded together often leads to a very stable profile. Despite this stability of pulsar integrated profiles, some pulsars shows distinct profile changes on time scales of minutes. Following the first identification of the profile changes in PSR 1237+25, such a phenomenon was first noticed by Backer (1970) and is now known as mode-changing. During a mode change, the pulsar switches from one stable profile to another on a time scale of less than a pulse period and remains in that mode for typically hundreds of periods before it returns back to the original. Pulsar mode-changing is often associated with a sudden change in pulse intensity (Rankin, 1986; Suleymanova et al., 1996).

Mode-changing is often observed for sources which exhibit rather complex profiles showing both the "cone" and "core" components (Rankin, 1983; Rankin, 1986; Lyne et al., 1988). The mode-changing phenomenon implies a reorganization of core and cone emission. So the whole pulsar profile is affected by the mode-changing rather than only certain pulse longitudes. There is no clear explanations for the origin of mode-changing, sometimes interpreted as a re-arrangement in the structure of the emitting region, e.g. a possible relationship between mode-changing and change in emission height (Bartel et al., 1982). Maybe it is related to the properties of the magnetosphere above the polar cap (Zhang et al., 1997). Further observations are very important to understand such a behavior of some of the pulsars.

The intensities of integrate pulsar profiles are changing all the time because of the interstellar scintillation (Rickett et al., 1977; Romani et al., 1986). There are two types of scintillation, the DISS and the RISS. The time scale of DISS ranges from seconds to minutes. The time scale of RISS ranges from days to months. So the best way of measuring the spectrum of pulsars is simultaneous observation at several frequencies. From 11th July to 21st

August 2000, the simultaneous monitoring was carried out at two frequencies (327 MHz and 610 MHz) using Urumqi 25 m radio telescope. A sample of 18 strong pulsars was observed. Two abnormal profiles and ten normal profiles of PSR0329+54 (all with high signal to noise ratio) were obtained. In this paper, the spectrum behaviors of PSR0329+54 in its normal mode and abnormal mode are briefly investigated.

## 2 Observations and Data Reduction

The data presented in this paper were obtained during two-frequency simultaneous monitoring of pulsars at 327 MHz and 610 MHz with the Urumqi 25-m radio telescope of NAO located at Nanshan observatory, Urumqi. System temperatures are 130 k and 110 k respectively.

At each frequency, the signal was sampled 2 ms intervals in a duration of 2000 s by a single-channel, single polarization data collecting system and recorded on hard disk. Then using our own compiled computer software the data were period-folded and the integrated pulse profiles at each frequency were obtained. The bandwidths of receivers were restricted to 1 MHz at 327 MHz and 2 MHz at 610 MHz because of dispersion of pulsar radio signal by interstellar medium.

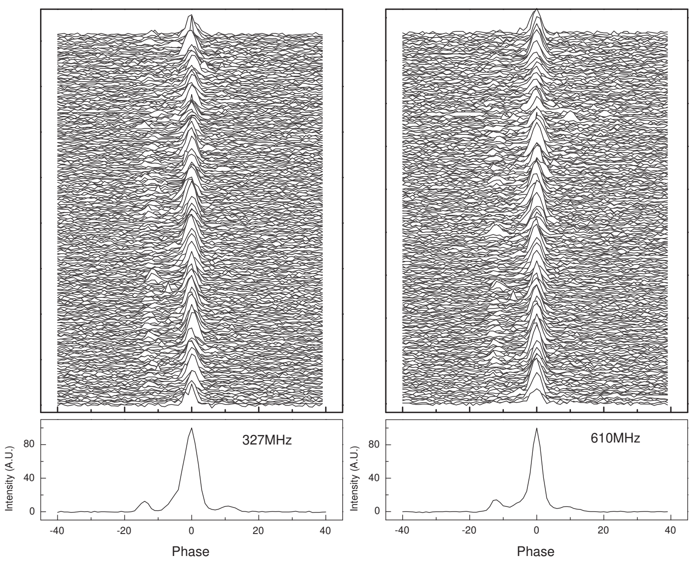


Fig. 1 One of the two-frequency profiles of PSR0329+54 in abnormal mode. Data were simultaneously obtained at 327 MHz and 610 MHz at 22:56 in 18th July 2000(BT) using Urumqi 25-m telescope. The top panel of each diagram shows 250 individual pulses. The bottom panel presents the integrated profiles gotten at each frequency.

## 3 Results

Twelve high signal to noise ratio integrated profiles of PSR0329+54 were obtained during our observation, among them two profiles in abnormal modes were found. Abnormal and normal profiles obtained during our simultaneous observations are displayed in Figure 1 and 2.

In one observational duration of 2000 s, nearly 2800 individual pulses are gotten. In

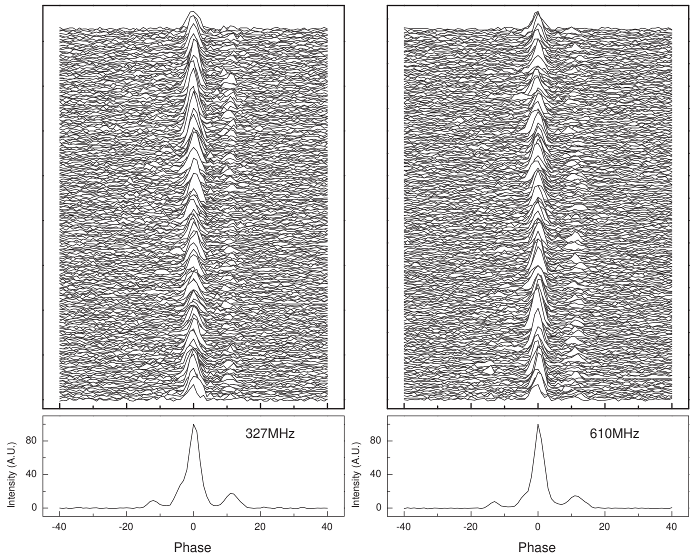


Fig. 2 Two-frequency profiles of PSR0329+54 in normal mode. Data were simultaneously obtained at 327 MHz and 610 MHz using Urumqi 25-m telescope at 00:17 in 12th July 2000(BT).

Figure 1 and 2, the top panel of each diagram shows 250 individual pulses of them. The bottom panel presents the integrated profile that is obtained by summing all individual pulses gotten in one observational duration. The horizontal axis of bottom panel is phase of pulse expressed in degrees and the vertical axis is relative flux density in arbitrary units.

The observed and derived parameters at two frequencies, pulse widths, relative flux densities and relative spectral indices of leading and trailing component are listed in Table 1. Listed are time of observation (Beijing time), pulse widths at 50% of the peak amplitude ($w_{50}$), relative intensities of three components, relative spectral indices of leading and trailing components. We set the peak intensities of all profiles at two frequencies are 100. That means we simply set all relative spectral indices to zero.

## 4 Discussion and Conclusion

Figure 3 displays the observed relative spectral indices of leading and trailing components of PSR0329+54 when all of the spectral indices of the central components of twelve observations are set to be 0.

Figure 3 shows that, when PSR0329+54 is in its normal mode, the spectrum of leading and trailing component are a little bit flatter than the spectrum of the central component, and the spectrum of trailing component is steeper than the leading one. The spectrum of leading component get a little bit steep and the spectrum of trailing component get flat in abnormal mode.

Because leading and trailing component of PSR0329+54 are mainly contributed by cone emission and central component are due to core emission, such a result implies core emission of PSR0329+54 may affect the trailing component in normal mode. In abnormal mode, such affection vanishes and the leading component is affected by core emission instead. However, because of the large errors of our observed data, further observations are needed.

**Table 1 Observed and derived parameters of twelve observations**

| Time (BT) | $W_{50}$ (Deg) | C | $L_{327}$ | $L_{610}$ | $\alpha_L$ | $F_{327}$ | $F_{610}$ | $\alpha_F$ |
|---|---|---|---|---|---|---|---|---|
| Jul.12 00:17 | 3.9/3.2 | 100 | 5.6 | 8.5 | 0.67 | 11.6 | 12.9 | 0.18 |
| Jul.16 19:16 | 3.9/3.2 | 100 | 6.1 | 9.9 | 0.78 | 11.5 | 13.3 | 0.21 |
| ⋆ Jul.18 22:56 | 3.9/3.1 | 100 | 12.5 | 16.1 | 0.41 | 6.6 | 9.1 | 0.52 |
| Jul.19 01:53 | 3.8/3.2 | 100 | 5.4 | 8.6 | 0.74 | 11.4 | 12.3 | 0.12 |
| Jul.23 01:11 | 4.0/3.2 | 100 | 6.5 | 9.5 | 0.59 | 11.8 | 13.7 | 0.23 |
| Jul.24 15:14 | 3.9/3.1 | 100 | 5.9 | 8.7 | 0.63 | 12.1 | 12.9 | 0.11 |
| Jul.28 18:24 | 3.9/3.2 | 100 | 5.6 | 8.5 | 0.65 | 11.7 | 13.1 | 0.18 |
| ⋆ Jul.29 16:58 | 3.9/3.1 | 100 | 12.4 | 16.5 | 0.43 | 6.2 | 8.8 | 0.56 |
| Jul.30 23:26 | 3.8/3.2 | 100 | 5.1 | 8.5 | 0.81 | 10.3 | 12.6 | 0.32 |
| Jul.31 08:29 | 3.9/3.2 | 100 | 5.1 | 8.3 | 0.78 | 11.5 | 12.5 | 0.15 |
| Aug.15 13:21 | 4.1/3.2 | 100 | 5.7 | 8.5 | 0.63 | 10.9 | 12.2 | 0.18 |
| Aug.16 23:47 | 4.1/3.1 | 100 | 5.7 | 8.7 | 0.66 | 11.4 | 13.1 | 0.22 |

The symbol ⋆ indicate the integrated profiles of PSR0329+54 in abnormal mode. L = Leading component, C = Central component, F = Following component.

$\alpha_L$ and $\alpha_F$ are relative spectral indices of leading and trailing component respectively.

In column 2, the number above and below the slash are the parameters at 327 MHz and 610 MHz respectively.

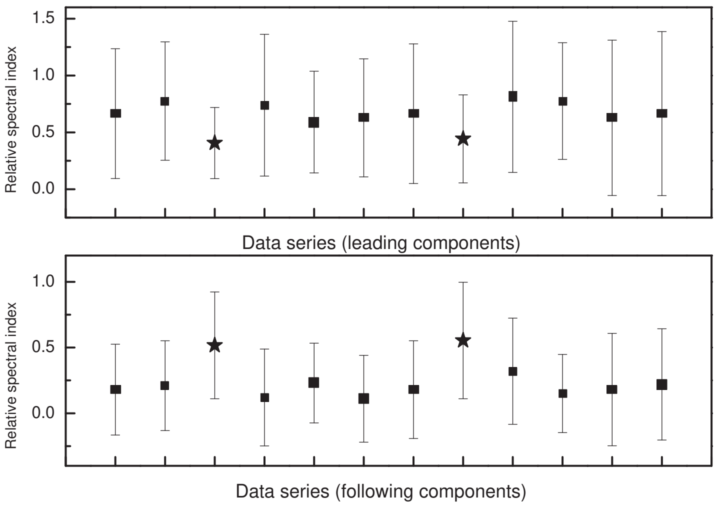


Fig. 3 The relative spectral indices of leading (top panel) and trailing components (bottom panel) of PSR0329+54 when all of the central component's spectral indices of twelve data are zero. The black-square points are the results of normal mode and the star points are the results of abnormal mode.

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