广州大学
GUANGZHOU UNIVERSITY

Multi-frequency Study On The Mode Switching Of PSR J0614+2229

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Outline

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② Our Work

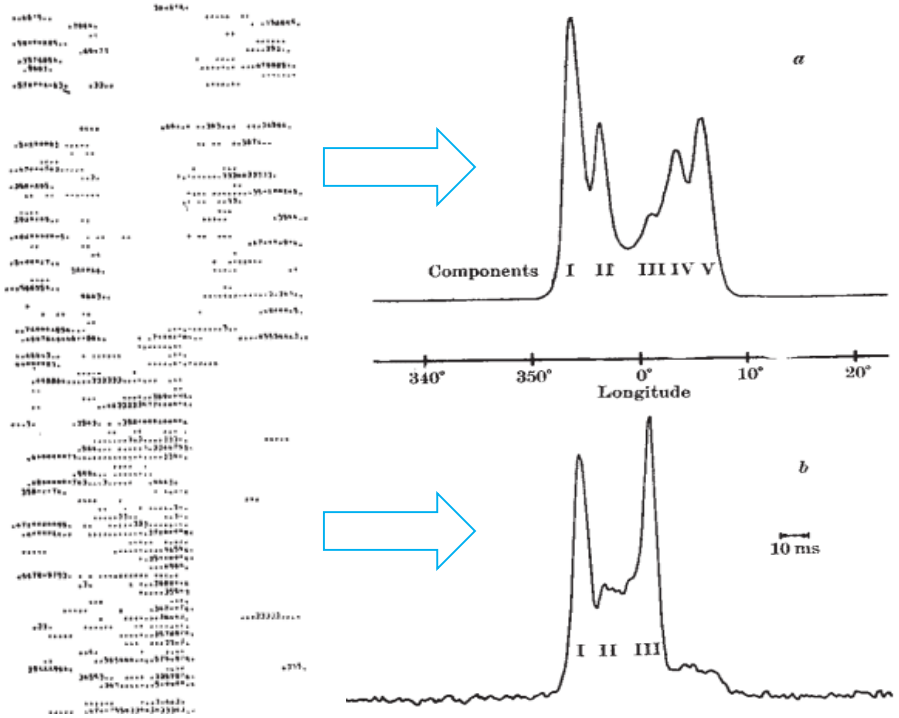
③ Summary

④ References

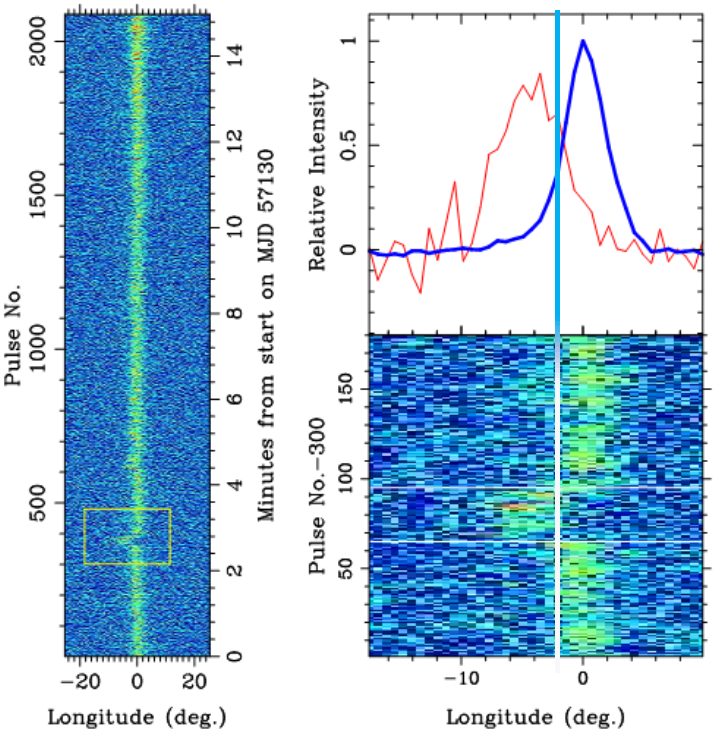
1. Background

- ~60 mode changing pulsars (hereafter MCPs) has been reported in 100+ papers (total no. of pulsars 2700+), ~5 MCPs with phase offset;

Phase stable



Phase offset



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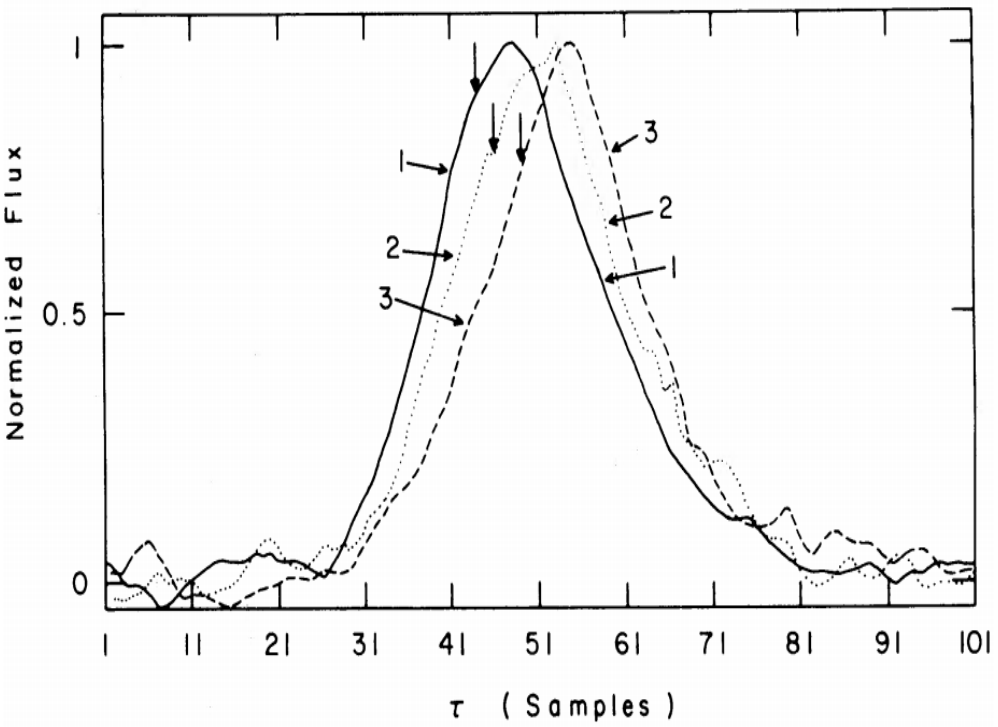
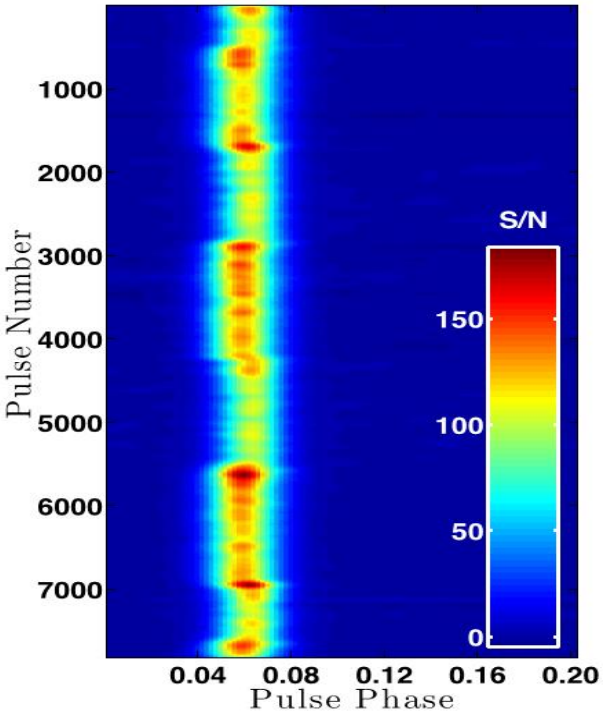


Ferguson & Boriakoff 1980



Rajwade et al. 2016

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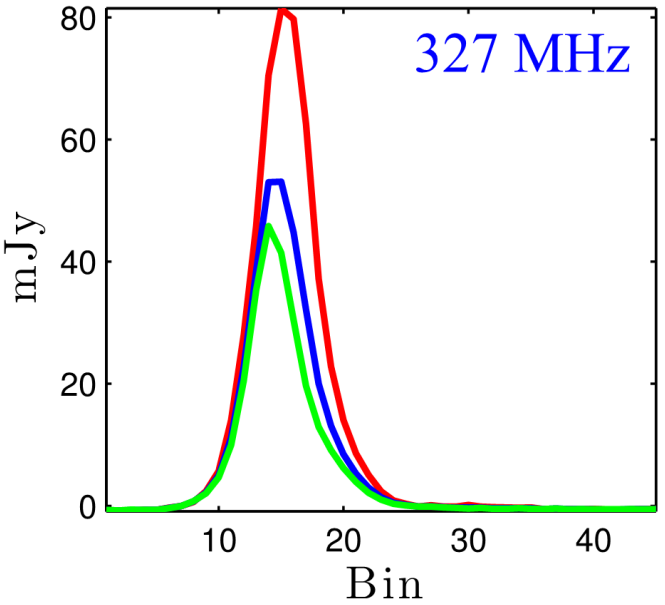

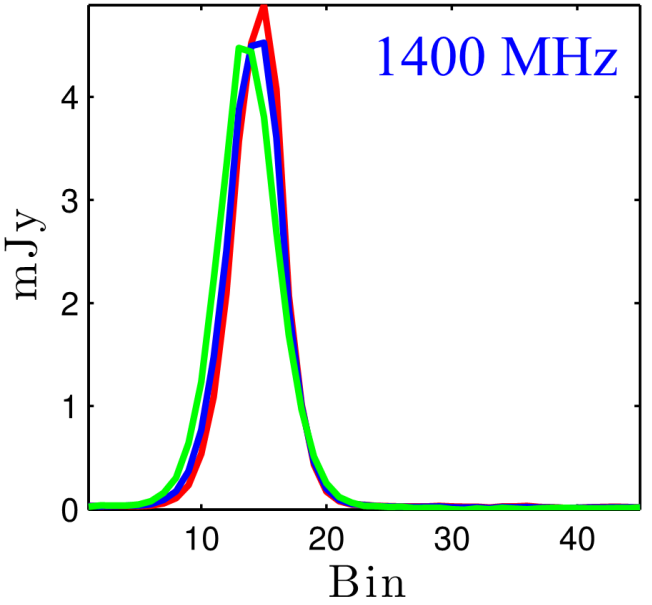

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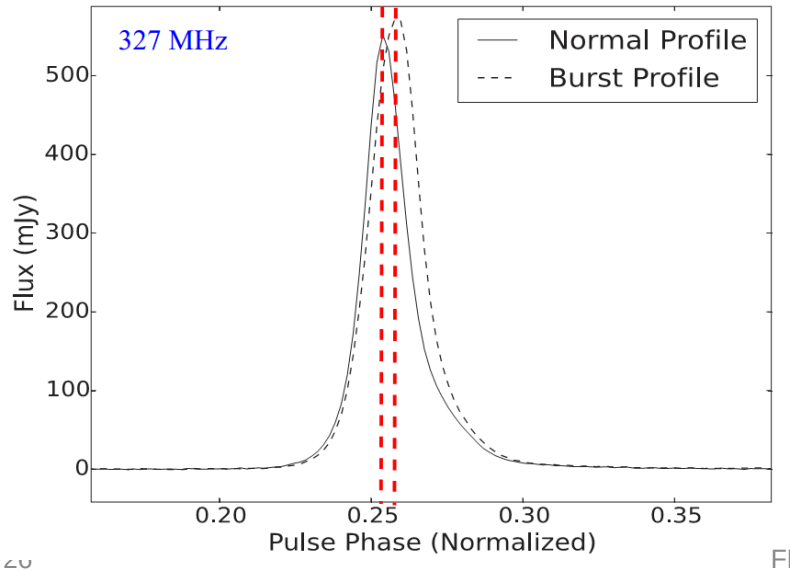
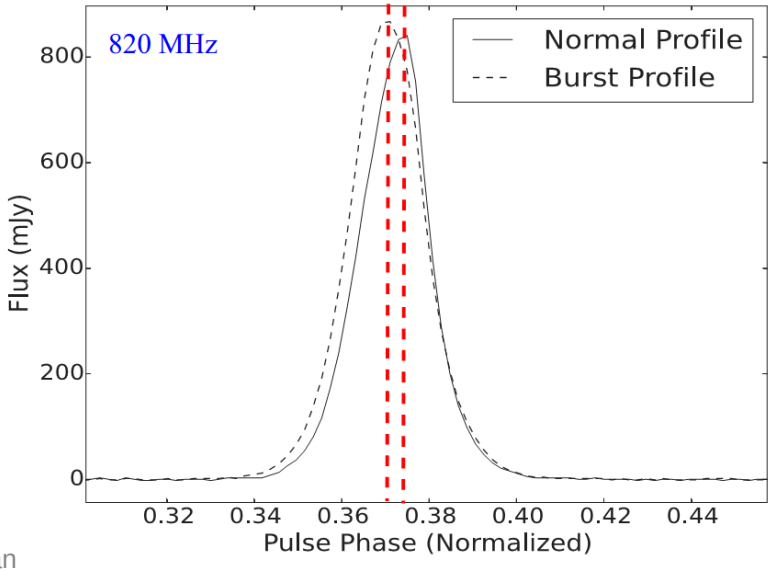
- Rajwade et al. (2016) noticed that the relationship between pulse phase and flux inverted at 0.8 GHz in MJD 56756 compared with 0.3/0.1 GHz.

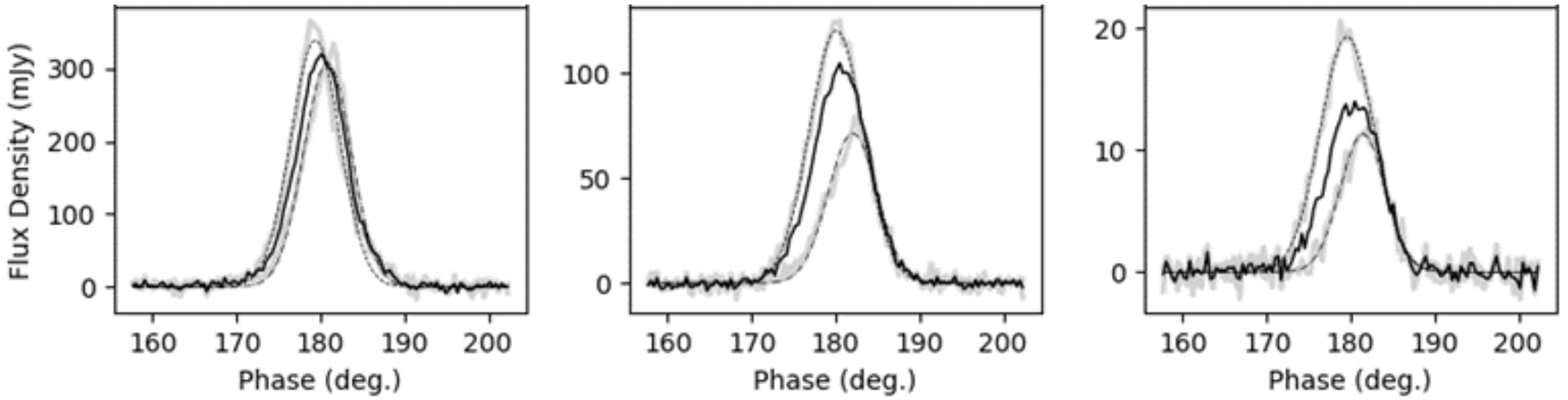




2. Our work

- We processed the longest observation from Parkes' historical data in 50cm, 20cm and10cm bands, and collected the data in the literature.

ID	MJD (d)	Receiver	ν (MHz)	$\Delta\nu$ (MHz)	$\Delta\nu_{\rm ch}$ (MHz)	$T_{\rm sub}$ (s)	$N_{\rm sub}$	$N_{\rm bin}$
2005a	53658.80926	5010CM	686	256	0.125	59.6209	51	1024
2005b	53667.80810	H-OH	1369	256	0.125	59.9563	18	1024
2005c	53658.80926	1050CM	3100	1024	1.0	59.6209	51	1024



2. Our work

- Spectral difference between two modes.

UT	MJD (d)	Telescope	ν (MHz)	$I_{\rm T}$ (mJy)	$I_{\rm A}$ (mJy)	$I_{\rm B}$ (mJy)	$I_{\rm A}/I_{\rm B}$	Ref.
2005 Oct. 15	53658.80926	Parkes	653	6.7(5)	7.0(4)	6.0(2)	1.2(1)	2005a
2005 Oct. 24	53667.80810	Parkes	1369	2.2(4)	2.6(1)	1.4(1)	1.9(1)	2005b
2005 Oct. 15	53658.80926	Parkes	3100	0.3(2)	0.40(5)	0.19(3)	2.1(4)	2005c
2009 Mar. 3-8	54893-54898	Arecibo	327	–	$0.28(^{2}_{2})$	$0.57(^{7}_{5})$	$0.49(^{7}_{5})$	SLR14
2009 Mar. 2-8	54892-54898	Arecibo	1400	–	$0.032(^{4}_{3})$	$0.032(^{4}_{3})$	$1.0(^{2}_{1})$	SLR14
2014 Apr. 9	56756	LOFAR	150	88(44)	–	–	–	RSL+16
2014 Apr. 9	56756	Arecibo	327	13.8(8)	11.1(1)	13.1(3)	0.85(2)	RSL+16
2014 Apr. 9	56756	Green Bank	820	16.1(1.7)	18.7(1.9)	16.4(2)	1.14(12)	RSL+16
2016 Jan.	57391	LOFAR	150	75(32)	–	–	–	GKK+17
2007-2016	–	Parkes	728	8.8(8)	–	–	–	JSK+18
2007-2016	–	Parkes	1382	3.3(2)	–	–	–	JSK+18
2007-2016	–	Parkes	3100	0.76(6)	–	–	–	JSK+18

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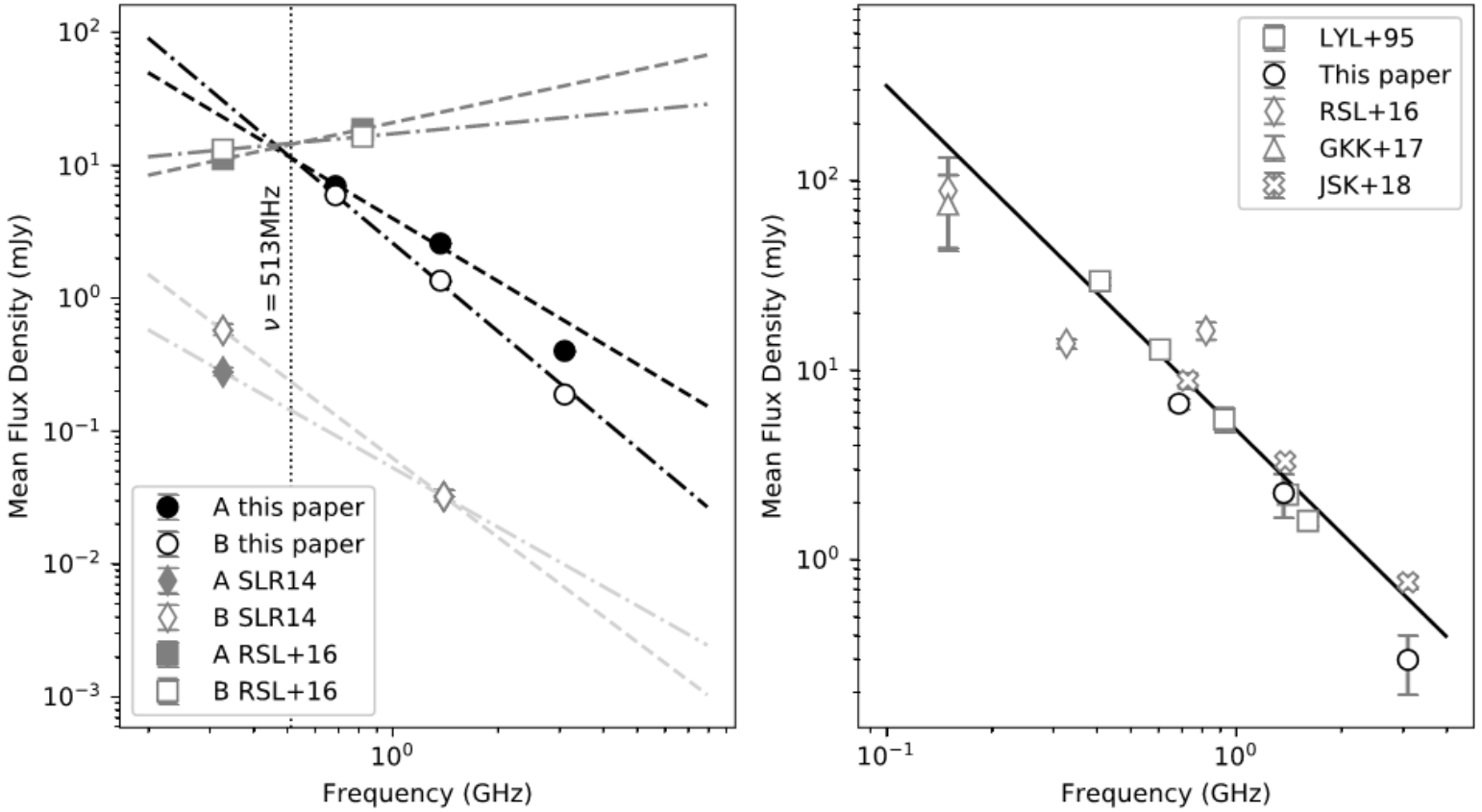


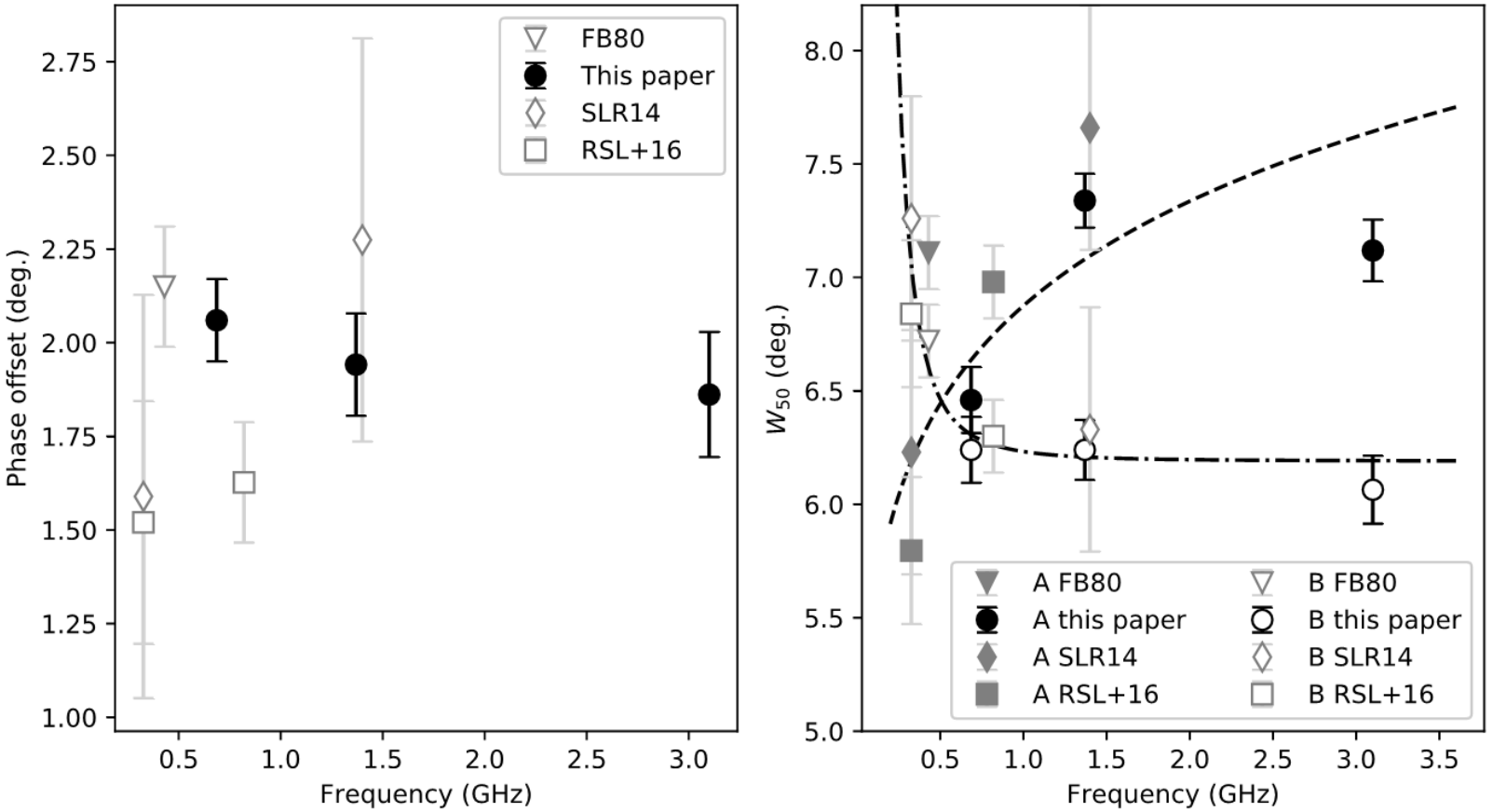
2. Our work

- Frequency dependence of phase offset and pulse width.

ν (MHz)	$\Delta\Phi$ (deg.)	$\Delta\mu$ (deg.)	$W_{50,\mathrm{A}}$ (deg.)	$W_{50,\mathrm{B}}$ (deg.)	Ref.
686	2.81(16)	1.44(14)	9.46(15)	6.24(15)	2005a
1369	–	1.94(13)	7.34(12)	6.24(13)	2005b
3100	–	1.86(17)	7.12(14)	6.06(15)	2005c
430	2.15(16)	–	5.15(16)	4.73(16)	FB80
327	1.59(54)	–	6.23(54)	7.26(54)	SLR14
1400	2.27(54)	–	7.66(54)	6.33(54)	SLR14
327	1.52(32)	–	5.80(32)	6.84(32)	RSL+16
820	1.63(16)	–	6.98(16)	6.30(16)	RSL+16

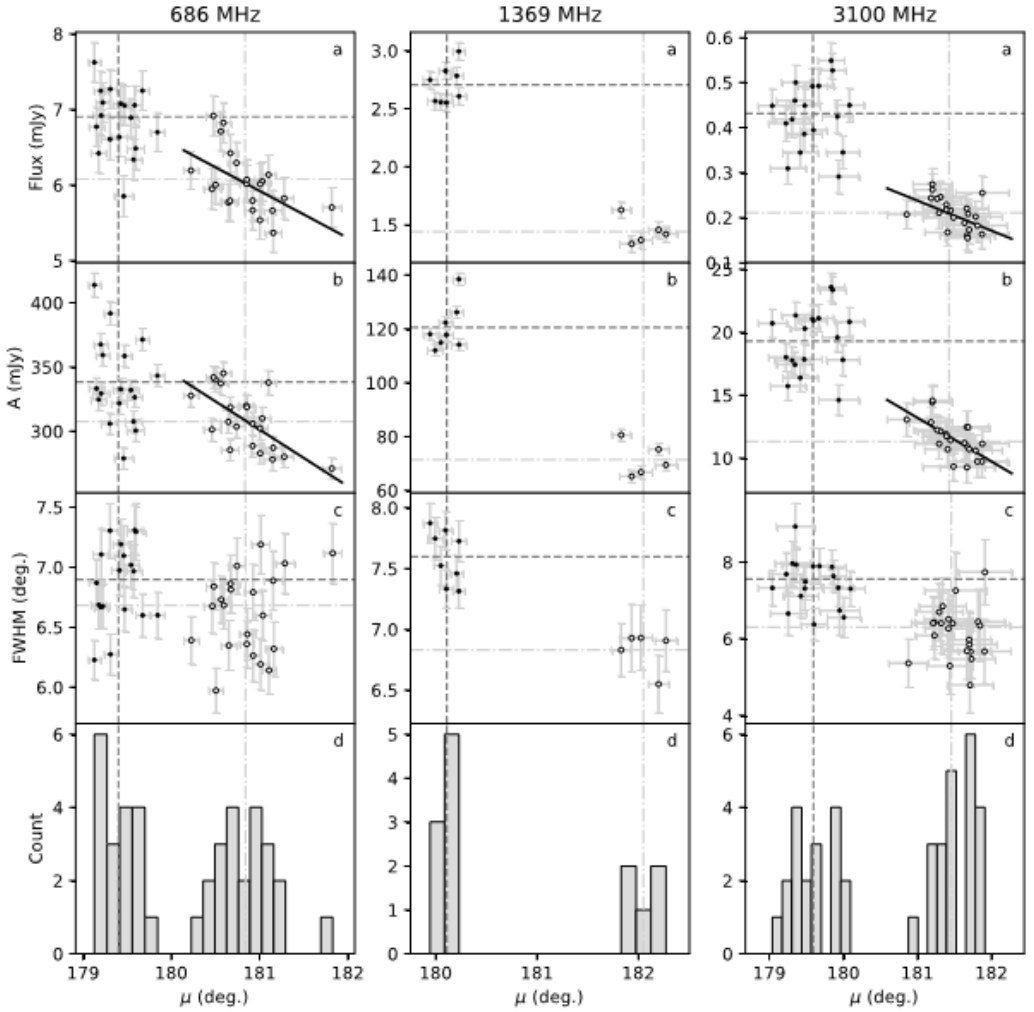
2. Our work

- Frequency dependence of phase offset and pulse width.



2. Our work

- Correlation between the peak amplitude and phase for mode B.



2. Our work

- 脉冲辐射的偏振位置角(PPA)可以由RVM模型描述:
- 经典RVM模型和SGP点;

$$\tan(\psi-\psi_0)=\frac{\sin\alpha\sin(\phi-\phi_0)}{\sin\zeta\cos\alpha-\cos\zeta\sin\alpha\cos(\phi-\phi_0)}$$

$$\left(\frac{d\psi}{d\phi}\right)_{\max}=\left(\frac{d\psi}{d\phi}\right)_{\phi_0}=\frac{\sin\alpha}{\sin\beta}$$

- 相对论性RVM模型;

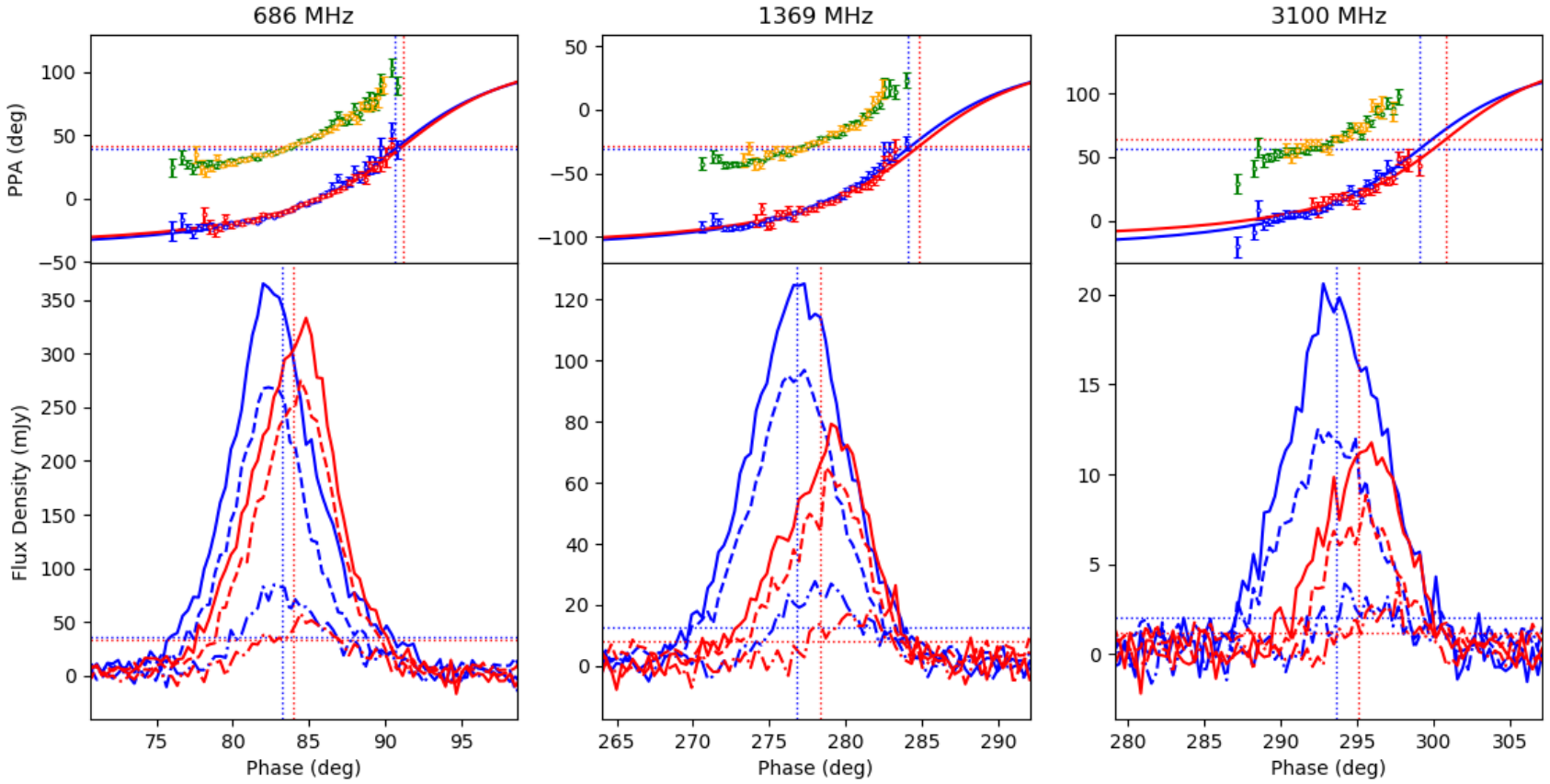
$$\tan(\psi_{\rm r}-\psi_\omega+\Delta\psi_{\rm J})\approx\frac{\sin\alpha\sin(\phi_{\rm obs}-\phi_{\rm f}+\Delta\phi_{\rm r})}{\sin\zeta\cos\alpha-\cos\zeta\sin\alpha\cos(\phi_{\rm obs}-\phi_{\rm f}+\Delta\phi_{\rm r})}$$

- 辐射高度。

$$\Delta\phi_{\rm r}\approx-\frac{2r}{R_{\rm lc}}$$

2. Our work

- 偏振


686 MHz
1369 MHz
3100 MHz
PPA (deg)
Flux Density (mJy)
Phase (deg)
Phase (deg)
Phase (deg)

2. Our work

- 辐射区域
- 辐射区高度变化：-70 ± 40 km、-110 ± 70 km、-270 ± 150 km

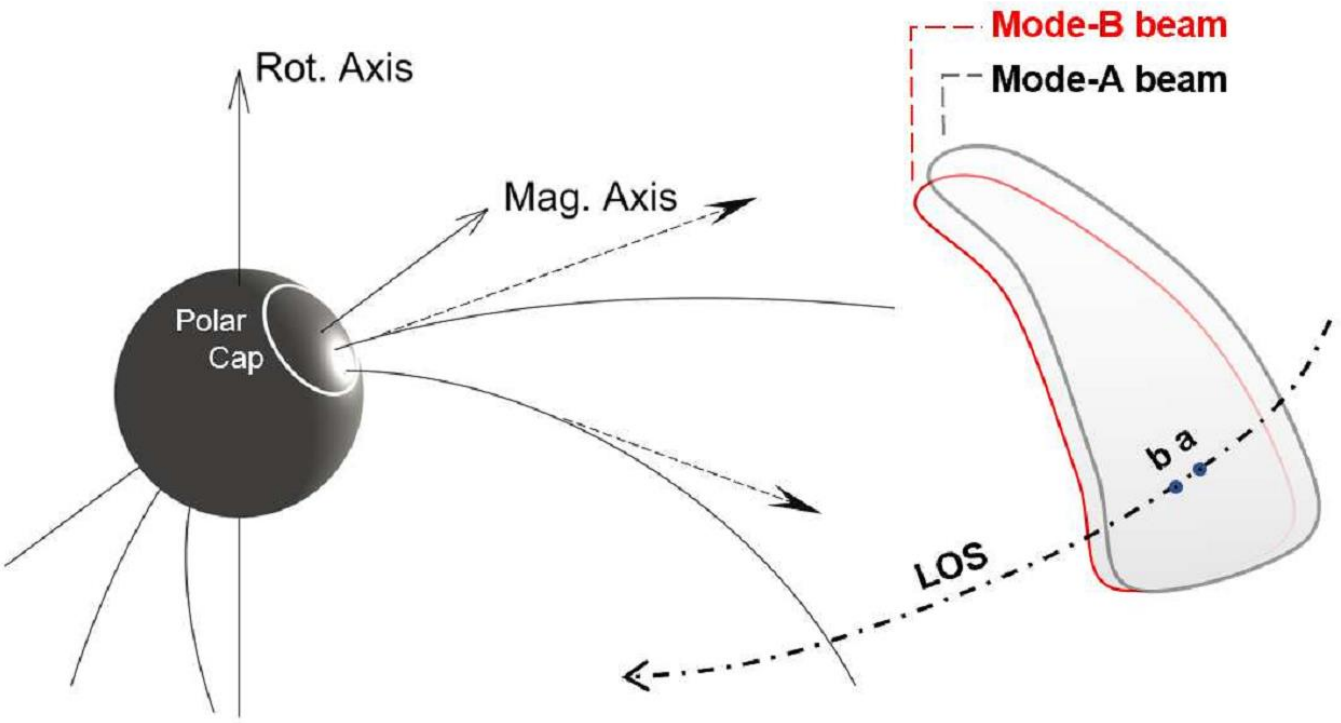
表 4.1 脉冲星 PSR J0614+2229 辐射窗口参数

Freq/MHz	Mode	$L_{10}/^\circ$	$R_{10}/^\circ$	$\phi_{\rm prof}/^\circ$	$\phi_0/^\circ$	$\psi_0/^\circ$	$r_{\rm BCW}$/ km
686	A	76.0(6)	90.5(1.1)	83.3(6)	90.7(2)	39.3(9)	520(40)
686	B	77.6(5)	90.2(5)	83.9(4)	91.2(2)	41.7(9)	510(30)
1369	A	269.8(7)	283.8(5)	276.8(4)	284.1(2)	-30.8(9)	510(30)
1369	B	271(2)	284(1)	278(1)	284.9(5)	-28(2)	480(80)
3100	A	287(1)	300.5(8)	293.8(7)	299.1(5)	57(2)	370(60)
3100	B	289(2)	300.3(9)	294.6(9)	301(1)	64(6)	450(90)

注：括号中为参数末位的误差值。

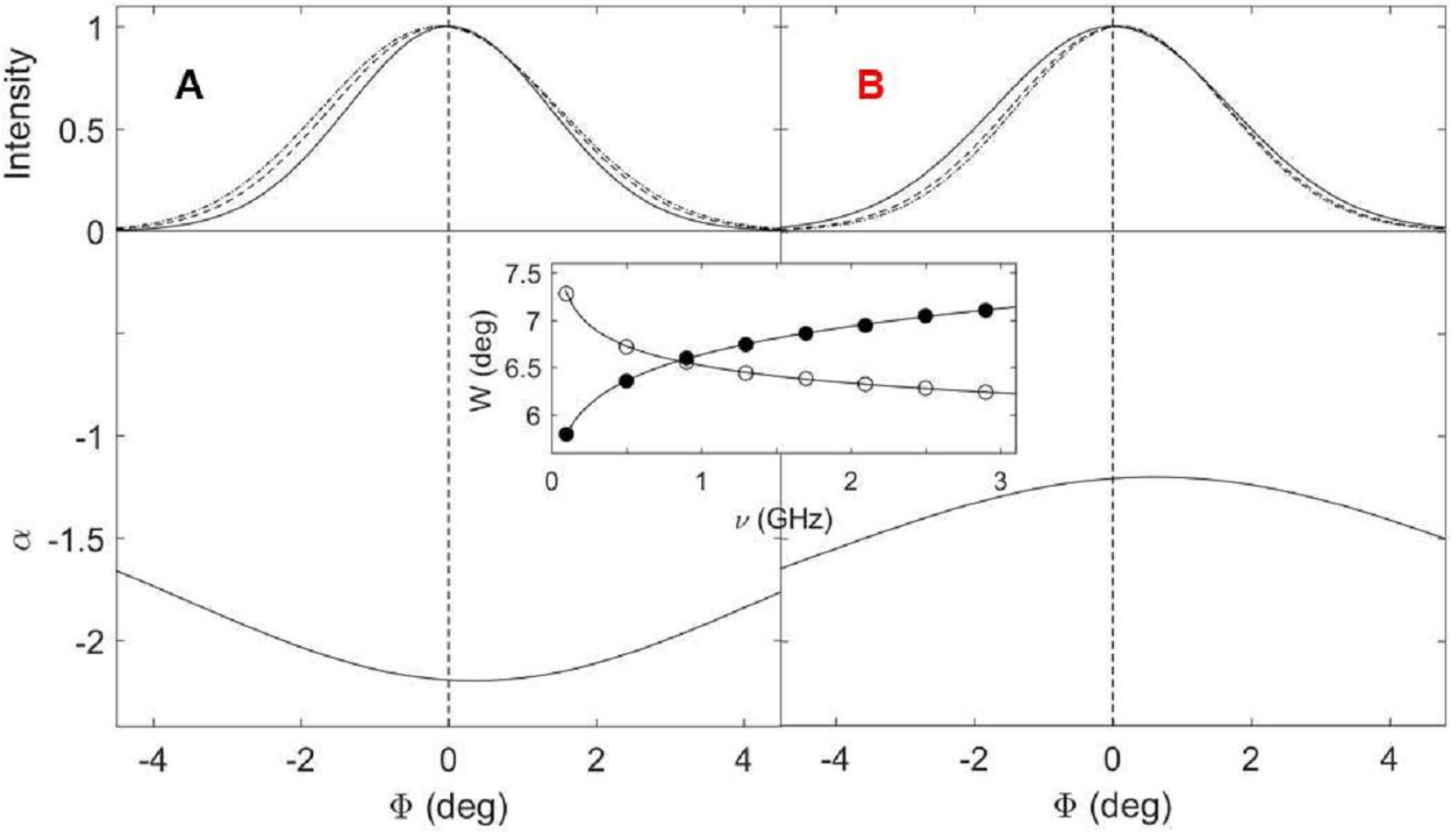
2. Our work

- 辐射区域
- 辐射区高度变化：-70 ± 40 km、-110 ± 70 km、-270 ± 150 km
- 辐射区经度变化：



2. Our work

- Implication to spectral properties of the emission beams.



3. Summary

- Mode dependent spectra
- Mode dependent Thorsett relationships
- Frequency independent phase offset
- Mode dependent phase-flux correlations
- 磁场位形在模式变换时基本不变
- SGP点偏移方向和辐射窗口中心偏移方向相同

- 辐射区高度：A < B
- 辐射区经度：A < B
- Different spectral distributions

- Phase-resolved spectra

4. References

- [1] **张颜荣**,陈建玲,王洪光,黄秀健, 2019. 模式变换脉冲星PSR J0614+2229的多波段辐射区的研究[J]. 天文研究与技术 .
- [2] **张颜荣**,王洪光,黄秀健,陈建玲, 2019. Multifrequency Study on The Mode Switching of PSR J0614+2229[J]. ApJ.（Under review）
- [3] **张颜荣**. 脉冲星模式变换的分类研究[D]. 广州大学, 2019.

Thanks for Your Attention!