

A Summary of Pulsar Circular Polarization

Xiao-peng You ^{*} and Jin-lin Han

National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China

Abstract We update the systematic studies of circular polarization in integrated pulse profiles of Han et al. Sense reversal can occur in either core or cone components, or near the intersection between the components. The correlation between the sense of circular polarization and the sense of position angle variation for conal double pulsars is confirmed with a much larger database. Some pulsars show clear changes of circular polarization with frequency. Circular polarization is marginally different between millisecond and normal pulsars.

Key words: polarization — pulsars: general

1 INTRODUCTION

The polarization properties of pulsars are very important for the understanding of the geometry and emission mechanism of pulsars. Han et al. (1998) collected the published polarization profiles and reviewed the characteristics of circular polarization in pulsar integrated profiles, and they discovered the correlation between the sense of circular polarization and the sense of position angle (PA) variation for conal double pulsars, and they refuted the correlation between the sense reversal of circular polarization near the core components and the sense of PA.

A large sample of normal pulsars and millisecond pulsars has been observed for polarization (Gould & Lyne 1998; Stairs et al. 1999; Weisberg et al. 1999; Weisberg et al. 2004; Han et al. 2006), especially at multiple frequencies. The data have increased by a factor of about three to that in Han et al. (1998). So, it is good time to update the database of pulsar circular polarization and re-check the conclusions of that paper.

2 MAIN PROPERTIES

Polarization profiles of pulsars are collected from published papers if the circular polarization has a good signal-to-noise ratio. The main properties of circular polarization are summarised.

2.1 Sense Reversals of Circular Polarization

2.1.1 Sense reversals associated with core components

Using data of a sample of 25 pulsars, Radhakrishnan & Rankin (1990) found that the change of circular polarization from left hand to right hand is associated with decreasing PA, and that from right hand to left hand is associated with increasing PA. Gould (1994) and Han et al. (1998) found many contrary examples, which led Han et al. (1998) to conclude that no such correlation exists.

Here we use a very large sample of pulsar data and confirm the conclusion of no correlation. In our dataset, 19 pulsars support the correlation, but 20 pulsars do not.

2.1.2 Sense reversals outside core

Many sense reversals of circular polarization are detected outside of the central region of the profile, being associated not with core components but with cone components or near the conjunction of components. In our selected data, sense reversals of 33 pulsars occur outside the core.

^{*} E-mail: xpyou@bao.ac.cn

2.1.3 Sense reversals associated with orthogonal polarization modes

We checked for possible association of the sense reversal of circular polarization with the orthogonal polarization modes of polarization angle. Among 81 pulsars with sense reversals in V and with clear PA variation curves, about 31 of them show such an association. A few pulsars show two sense changes across the profile.

2.2 Circular Polarization of Conal-double Pulsars

Using the polarization data of a sample of 20 conal-double pulsars available at that time, Han et al. (1998) found a strong correlation between the sense of PA sweep and the sense of circular polarization for conal double pulsars. A decrease of PA accompanies left-hand (positive) circular polarization of conal components, and an increase of PA accompanies the right-hand. Occasionally, sense reversal is observed in one cone component.

Now, using a larger sample of 36 pulsars available, the correlation is solidly confirmed. Table 1 lists all conal double pulsars with good measurements of circular polarization and PA.

Table 1 Conal-double Pulsars with Significant Circular Polarization

PSR Name	PA	Sign of V	
		Comp 1	Comp 2
J0151-0635	inc	-	-
J0528+2200	inc	-	-
J0653+8051	inc	+/-	-
J0754+3231	inc	-	-
J0820-1350	inc	-	-
J0837+0610	inc	-	-
		+/-	-
J0959-4809	inc	-	-
J1015-5719	inc	-	-
J1110-5637	inc	.	-
J1136+1551	inc	-	-
J1137-6700	inc	-	-
J1159-7910?	inc	.	-
J1420-6048	inc	-	-
J1906+0641	inc	-	.
J1915+1606	inc	-/+	-
J1921+2153	inc	-/+	-
J1954+2923	inc	-	-
J2022+2854	inc	-	-
J2046+1540	inc	-	-
J2053-7200	inc	+/-	-
		-/+	-
J2124+1407	inc	-	-
J0055+5117	dec	+	+
J0304+1932	dec	+	+
J0631+1036	dec	+	+
J1041-1942	dec	-/+	+
J1123-4844	dec	+	+
J1302-6350	dec	+	.
J1345-6115	dec	+	.
J1527-3931	dec	+	+
J1731-4744	dec	+	.
J1751-4657	dec	-/+	+
J1803-2137	dec	+	+
J1826-1344	dec	+	+
J2055+2209	dec	+	+
J2324-6054	dec	+	.
J2346-0609	dec	.	+

Note: ? Not so sure for conal-double pulsars.

2.3 Circular Polarization with Frequency

For some pulsars the circular polarization clearly changes with frequency. von Hoensbroech & Lesch (1999) showed three pulsars with a trend of increasing circular polarization with frequency and interpreted that in terms of propagating natural wave modes in the magnetosphere.

The variation of degree of circular polarization with frequency is very different from pulsar to pulsar. We noticed that four pulsars in our dataset show their circular polarization increases with frequency, but four other pulsars show a decrease.

Some pulsars show that the sign of sense reversal changes with frequency. PSR J2053–7200 which shows a sense reversal near the intersection of two components has a clear frequency dependence. The sense reversal is from left-hand to right-hand at low frequencies (Qiao et al. 1995; Manchester et al. 1998; van Ommen et al. 1997), and from right-hand to left-hand at high frequencies (Qiao et al. 1995; Han et al. 2006).

2.4 Circular Polarization in Normal Pulsars and Millisecond Pulsars

Compared to normal pulsars, millisecond pulsars have weaker surface magnetic fields, wider profiles, and a different profile dependence on frequency. Though their PA variations are often complex, most of them appear to follow the rotating vector model. The basic radio emission mechanism is similar for millisecond pulsars and normal pulsars based on these similarities.

Here we compiled a sample of millisecond pulsars observed near 1400 MHz and compared their circular polarization with that of normal pulsars. The distributions of degree of circular polarization is marginally different for millisecond and normal pulsars. The Kolmogorov-Smirnov test indicates 16.49% probability for the two population to come from the same distribution.

3 CONCLUSIONS

Circular polarization in pulsars shows a variety of patterns. Though a sense reversal of circular polarization often occur in core components, it can also happen in cone components and near the intersection between components. We confirm the correlation between the sense of circular polarization and the sense of position angle sweep for conal-double pulsars.

More polarization observations of millisecond pulsars can determine whether circular polarization in normal pulsars is different from that in millisecond pulsars. Both increasing and decreasing frequency dependence of circular polarization are observed.

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