Geometric Analysis of The Average Profiles for Pulsar PSR B1857-26

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Abstract Applying the method of Gaussian fit separation of the average profile (GFSAP), we studied the pulsar PSR B1857-26. It has been observed at 410, 610, 925, 1408 and 1642MHz, providing an excellent sample for a multi-frequency analysis. This method allows us to study the pulsar emitting geometry carefully.

Key words pulsar, average profiles, geometry

1 Introduction

In some way, the geometry of pulsar emission beams has provided important insight into pulsar radiation physics. Rankin's work (1983, 1986, 1990, 1993) established an empirical theory of pulsar emission and brought forward a comprehensive pulsar classification scheme. Wu et al (1992a,b; 1998) proposed the GFSAP method and analyzed the pulsar PSR B1451-68. The "core-double-cone" model requires a large population of five-component pulsars to support it. However the amount of such pulsars is small till now. The frequency range used in some analyses was not wide enough; and some results are still argumentative. Searching for more five-component pulsars still is a meaningful topic.

There is debate on the mechanisms of core and cone. Rankin pointed out that the spectrum of the core is steeper than that of cone, and she deems that they have different emission mechanisms. It is important to study the spectrum of each component in wider frequency range.

2 The Gaussian Fit Separation of Average Profile Method

The main idea of GFSAP is that the average profile is superposed by many independent emission components, each of which follows a Gaussian shape. Fitting the observed curve with multi-component model we get the position, intensity and width of each individual component.

The full profile is represented by $f(\phi)$, as a sum of individual Gaussian components:

$$f(\phi) = \sum_{j=1}^{M} g_j = \sum_{j=1}^{M} h_j e^{-4ln2(\phi - p_j)^2/w_j^2} , \tag{1}$$

where w_i is the half-power width of component i, p_i is the peak position, and h_i the amplitude.

The method of GFSAP follows the usual fitting procedure, i.e. the sum of the squared residuals between the observed profile and equation (1) is minimized by searching parameter space for that set of parameters which best represents the observational curve.

3 Analysis of Fitting Results

3.1 The Emission Region Geometry

Assuming a dipolar magnetic field configuration and taking the emission region to be roughly circularly symmetric about the magnetic axis, the problem of determining the conal radius ρ reduces to a relation of spherical geometry (Gil 1981):

$$\rho = cos^{-1}[cos\beta - 2sin\alpha sin\zeta sin^2(\Delta\phi/4)] \tag{2}$$

where α is the angle between the magnetic axis and the spin axis, β is the impact angle, and ζ is the impact angle of the line of sight with respect to the rotation axis and $\Delta\phi$ is the half power width of the conal component pairs.

Assuming that the pulsar has a dipolar magnetic field and the core component comes from the surface of the pulsar, the emission altitude of cone component is:

$$r(km) = 6.66\rho^2 P\,. \tag{3}$$

The results are listed in Table.1.

Table 1 The Parameters of Emission Geometry

Parameter	408 MHz	610 MHz	925 MHz	1408 MHz	1642 MHz
$\rho_{core}(deg)$	2.6	2.6	2.8	3.1	3.0
$\rho_{inner}(deg)$	5.8	5.6	5.3	5.6	5.1
$\rho_{core}(deg)$	8.6	8.3	7.9	7.7	7.6
$r_{inner}(km)$	205.9	190.7	169.3	189.2	159.3
$r_{outer}(km)$	451.4	424.7	385.4	366.9	358.6

3.2 Spectrum Property

Another important thing is the spectra behavior of difference parts of emission region. We can study the spectrum difference by taking reference to the results of flux density measurement. Here reference is given to Lorimer et al 1995, and the results are listed in Table.2. We can see clearly that the core spectrum is steeper than the inner and outer cone. The results are consistent with the results of Wu et al. (1998) and the conclusion of Rankin, and reveal different emission mechanism of the emission region.

Table 2 The flux density of different parts

Parameter	408 MHz	610 MHz	925 MHz	1408 MHz	1642 MHz	
Flux	408 MHz	610 MHz	925 MHz	1408 MHz	1642 MHz	Spectra Index
Mean(mJy)	130	73	29.3	2.5	9.3	-1.94 ± 0.07
$F_{core}(mJy)$	51.5	17.8	7.3	3.5	2.3	-2.31 ± 0.14
$F_{inner}(mJy)$	34.3	32.0	10.5	4.6	4.9	-1.69 ± 0.23
$F_{outer}(mJy)$	44.1	23.1	11.3	4.3	1.9	$-1.90 \pm 0,08$

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