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Hollow Core?

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Abstract. We carried out the Gaussian fitting to the profile of PSR B1237+25 and found that six components rather than five are necessary to make a good fit. In the central part, we found that the core emission is not filled pencil beam but is a small hollow cone. This implies that the impact angle could be $\beta < 0.5°$. The "hollow core" is in agreement with Inverse Compton Scattering model of radio pulsars.

1. Introduction

The mean profiles are believed to be the cross-cut of the emission windows of pulsars. Early days, the conal double profiles helped to establish the hollow cone beam model. More components of accumulated profiles led D. Backer to suggest that pulsar emission beams are composed of a hollow cone and a central beam. Rankin(1983) further pointed out there exist two distinct types of emission components: one central (filled) core component and two conical components. Lyne & Manchester (1988) confirmed the existence of core and a hollow cone. To seperate emission components in mean pulse profiles, Wu et al. (1992) proposed to use Gaussian fitting to the mean profile. This approach was developed by many authors, e.g. Kramer et al. (1994). Here we discuss the Gaussian components of PSR B1237+25 and conclude that the core is not filled but is hollow.

2. PSR B1237+25

PSR B1237+25 was the prototype of five component pulsars (e.g. Rankin 1983). Yet at some frequencies observations apparently show six components. The Gaussian-fitting to the average profile gaves quantitatively the parameters of 6 individual emission components of PSR B1237+25. In our work, some profiles were taken from Phillips et al. (1992) and Bartel et al. (1982) (at frequencies 130MHz, 320MHz, 430MHz, 610MHz, 1418MHz,and 2380MHz) and some from Kuzimin et al. (1998) (at 100MHz, 200MHz, 400MHz, 600MHz, 1400MHz, and 4700MHz). We found that the all decomposed components are in a well-organized pattern, rather than randomly located. That implies that the decomposed six components are physically the same for all the frequencies. The most interesting is the two components at the central part, which demonstrates that the core is actually hollow beam.

In fact, this is not the unique case. Wu et al. (1998) decomposed PSR B2045+16 at some frequencies and also found that there are six components. Kramer et al. (1994) fitted 6 components to 1.42 GHz profile of PSR B1929+10. Kuzmin et al. found that PSR B0329+54 are best fitted by six components over a large frequency range.

Some theoretical models have been proposed to explain the core components, for example, the Inverse Compton Scattering (ICS) model. The model (see Qiao & Lin 1998 for details) can produce naturally the most complex beam of core plus two cones, it also explains the frequency behaviors of pulse profiles. When an observer's line of sight intersects the outer cone, the inner cone and the hollow core which all can be naturally given by the model, six components can be observed, almost exactly what we got for PSR B1237+25. Using the ICS model, we found that an impact angle greater than 0.4° can not be able to produce the phase seperation of the two core components $\Delta\phi$ at frequency 130 MHz and 320 MHz.

3. Conclusions and Discussions

Gaussian decompositions of PSR B1237+25 result in six individual components from the all profiles at six frequencies, and we found the core beam is actually hollow. This is exactly the case of small impact angle in the Inverse Compton Scattering model, $\beta < 0.5^\circ$. We noticed that Lyne & Manchester (1988) also got a similar impact angle through an independent way. According to the ICS model, the emission region of core is close to the surface of neutron stars, and the magnetic field there should be dipole. Multipole field is not necessary to be included to explain the hollow core emission.

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