THE RADIO INTERPULSE FROM PSR 0950+08

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Two hypotheses exist to explain the radio interpulse of PSR 0950+08 within the context of polar cap emission models:
1) The emission originates at a single magnetic pole as for other two-component pulsars, except that the component spacing is much wider.
2) The interpulse emission originates at the opposite magnetic pole.
We discuss here some new observations and their implications for the single and double pole hypotheses.

The strongest evidence for a single pole model is the 180° monotonic sweep of linear polarization position angle from the interpulse, across the emission "bridge", and across the main pulse. This behavior is similar to that of other pulsars with two closely spaced components, and provides primary support for polar cap emission models. The emission "bridge" is similar to that in the Crab and Vela optical and gamma ray profiles where their component separation is frequency dependent and symmetrical about the midpoint between the components. In general, the point of symmetry for intensity and polarization profiles is thought to be the point where the line of sight comes nearest to the magnetic polar axis. A histogram of component separations (Manchester, 1978) shows their distribution to be nearly uniform above 30°, implying that a single mechanism may account for all separations, including the 155° separation we found for 0950+08, shown in the figure.

Several observations are difficult to explain with a single pole model. The component widths and separations for virtually all pulsars are frequency dependent in some range. We have found that below 400 MHz the main and interpulse halfpower widths scale with frequency as $\nu^{-0.5\pm0.1}$ and that the main pulse itself is bifurcated with a component separation dependence of $\nu^{-0.7}$. However, the main to interpulse separation is frequency independent from 40 to 5000 MHz, which is very difficult to explain with a conventional hollow cone beam model with well-established (Cordes, 1978) radius to frequency mapping and consequent average profile frequency dependence. Furthermore, if the emission is from only a single pole then the amplitude difference of the main and interpulse must be explained as well as the lack of bifurcation of the interpulse.

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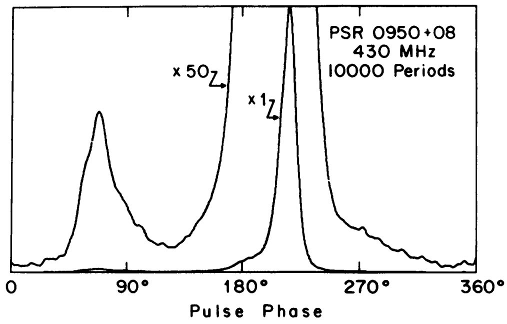

Figure 1: The average profile of PSR 0950+08

The main to interpulse separation frequency independence coupled with the frequency dependence of all other average profile features strongly supports a double pole model. Furthermore, microstructure time scales (Hankins and Boriakoff, 1978, 1980) show that the emission mechanisms in both regions must be similar, whereas single pole models require a different mechanism for the main and interpulse emission, and the polar cap models predict emission from both polar regions.

For a two pole model, however, the two components should be 180° apart, rather than 155° as we observed unless the emission originates very near the surface where the magnetic field could depart from a strict dipolar configuration. The monotonic position angle rotation is also difficult to explain in a two pole model, since the position angle should either sweep through the same values across each component in the same or mirror image sense, depending upon the exact alignment of the spin and magnetic axes and the line of sight.

We have found a correlation of pulse intensities between the main-pulse and the interpulse which follows it, 205° of pulse phase later. This implies a communication mechanism between the components. If the observed correlation is interpreted as a subpulse drift due to a sparking region circulating around the polar cap in a single pole model, then we are only surprised to find no evidence of drift in the bridge region. On the other hand, in a two pole model rapid communication from one pole to the other is required to trigger the interpulse.

In conclusion, we find observations which both support and contradict the single and two pole models for PSR 0950+08, and both require ad hoc additions to explain all the observations.

REFERENCES

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DISCUSSION

F.G. SMITH: Does the histogram of pulse intensities for the interpulses differ from that of the main pulses?

HANKINS: No. They are both approximately exponential, so that the weaker main and interpulses make a much larger contribution to the average profile than the less frequent stronger ones. The peak in the main-interpulse energy crosscorrelation function is therefore also not strongly influenced by the occasional strong pulses.

KUNDT: Why do you take pulse-interpulse correlations as evidence against the two-pole model? If there is communication at the speed of light, then everything that happens way inside the speed-of-light-cylinder happens effectively simultaneously.

HANKINS: If the communication is strictly along field lines the problem persists, since the polar field lines in the emission region are open in the upward direction, and may be very contorted inside the neutron star.

KIRK: Does emission over 360° occur over all frequencies, or can a cut-off frequency for this "bridge" emission be seen?

HANKINS: The "bridge" of emission between the interpulse and main pulse has about the same spectral index as the main pulse. The low level "shoulder" after the main pulse can be seen at 430 and 1400 MHz, but at 2380 MHz the signal to noise ratio was insufficient.

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