MODE-CHANGING, DRIFTING SUBPULSES, AND INTERPULSE EMISSION IN PSR 1822-09

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PSR 1822-09 is a nearby galactic disk pulsar with a typical .769 s period. Its large period derivative indicates a young timing age of 250,000 yrs and a strong estimated surface magnetic field of 6.4×10^{12} G. We have observed this pulsar at frequencies around 1700 MHz and 2650 MHz. The mean pulse profile at these frequencies consists of a double peaked main pulse with two dissimilar components and a weak interpulse 185° of pulse longitude after the main pulse second component. The interpulse is detected in both frequency ranges, and the main pulse - interpulse separation does not change between these frequencies and the low frequencies around 327 MHz where the interpulse was discovered by Cady and Ritchings (1977).

We have observed mode-changing behaviour in both the 1620 MHz and the 2650 MHz data. During the quiescent (Q-) mode, the main pulse first component is extremely weak, faintly visible at 3% of the second component peak. Every 5 minutes or so, the burst (B-) mode appears suddenly for about a minute. The first component rises sharply to about half of the second component value, which is itself about 50% stronger. The Q- and B-mode average mean pulse profiles are shown in Fig. 1. The two modes are also distinguished by different subpulse drifting behaviour. The second component shows clear drifting during the Q-mode (the interband spacing, $P_3 \sim 40\ P_1$) and only occasional distinct drifting during the B-mode with a much shorter interband spacing ($P_3 \sim 11\ P_1$). The drift direction is leading-to-trailing edge in both cases.

We also have evidence that the interpulse is stronger in the radio emission during the Q-mode. Full period 250 pulse integrated profiles at 1620 MHz show a strong anti-correlation between the presence of component 1 (and therefore the amount of B-mode emission during the average) and the height of the interpulse (Fowler and Wright, 1980a). Furthermore, the interpulse is present in average profiles built from strings of full period Q-mode single pulses at 2695 MHz, but is weaker in similar averages built from the interspersed strings of B-mode single pulses. These observations will be reported upon more fully in Fowler and Wright (1980b).

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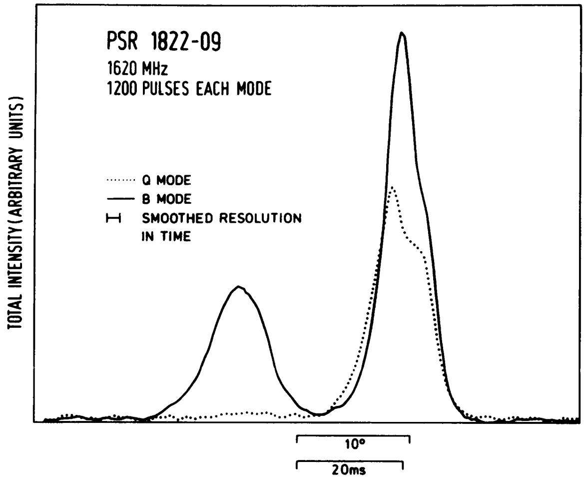

Figure 1

Our observations have bearing upon the question of the nature of interpulses. A geometrical model having pulse and interpulse emission coming from opposite magnetic poles is attractive in view of the nearly 180° separation, and the frequency independent nature of the separation. However, this model would require that information about the mode-change must be propagated from one pole to the other.

The communication problem is alleviated if the pulse and interpulse come from the same pole and result from the observer's line of sight making a cut across a wide angle emission cone as suggested by Manchester and Lyne (1977). However, the pulse - interpulse separation is not frequency dependent as would be expected in this model. The difficulties of understanding interpulse observations in terms of either of these two models is reflected in the discussion of Hankins and Cordes (1981).

The characteristics of interpulses should receive more theoretical attention, since they may be able to resolve the question of the location of pulsar emission, at least in some specific cases. We suggest here a possible construct that might satisfy the observations. The mode-change might reflect a change in the magnetospheric particle types or equilibrium producing a corresponding change in the spark drift rate. The interpulse could then be a hot spot at the light cylinder where particles from the leading edge of the main pulse are forced to leave the field lines as first suggested by Kahn (in Smith, 1973). The field line link makes possible the observed anti-correlation between the first component and interpulse.

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