PSR 0031-07: THE HARMONIC PULSAR

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PSR 0031-07 has a period of 0.94 seconds and the relatively old timing age of 37 million years. Its properties were first established by Huguenin et al. (1970), based on observations at 145 and 400 MHz.

In common with other older pulsars, the emission consists of long null stretches, occasionally interrupted by bursts of drifting subpulses. The drifting subpulses always assume one of three approximately harmonically-related drift-rates. Their corresponding P_3's are 12.5 P_1 ("A-drifts"), 6.8 P_1 ("B-drifts") and 4.5 P_1 ("C-drifts"). An emission burst is always constituted in one of three ways: (1) a series of A-drifts followed by B-drifts, (2) B-drifts alone, (3) B-drifts followed by C-drifts.

Intrigued by these unusual properties, we have recently observed this pulsar with the 100-m telescope at Effelsberg at 1620 MHz. Our analysis is not yet complete, but we can summarise our results so far as:

1) Drift-bands occur with the same organisation (AB, B, BC) found at lower frequencies, with the same three discrete values of P_3.
2) Our observations are consistent with the hypothesis that both nulling and drift-change occur simultaneously at all frequencies.
3) The A-, B- and C-drifts integrate separately to three different profiles. The A-profile is narrower than the B-profile, which is in turn narrower than the C-profile.

This last result has particularly interested us and we have been able to show two further properties of the drift-profiles: Firstly, the shape of the A-profile, if expanded by a constant time-scaling factor (1.61), fits exactly the shape of the B-profile. Second, the common A-B profile formed in this way can be fitted to a good approximation by a Lorentzian curve. It follows that the A-, B- and probably C-profiles are all near-Lorentzians, differing only in their scaling constant.

We have tried to understand this result in terms of the polar cap model (Ruderman and Sutherland, 1975). According to this model, our line-of-sight moves across the polar cap on a straight line, so the

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question arises: what intensity-distribution on the cap can be intersected so as to yield a Lorentzian profile?

It can be shown that a Lorentzian will be generated if the intensity distribution is proportional to $1/(R^2-R_o^2)$, where R is the radius on the polar cap measured from the magnetic pole. The distribution is symmetric about the magnetic axis and implies an asymptotic "resonance" at an inner radius R_o. The width of the generated Lorentzian depends on the closeness of the line-of-sight trajectory to the resonant radius, a narrow profile indicating a close passage. From the progressive expansion of the profiles A→B→C, we can deduce that the resonant radii (R_A, R_B, R_C) for each drift mode satisfy

$$R_A > R_B > R_C$$

Thus an interpretation of our observations in terms of a polar-cap model requires a multiple-ring structure. The observed transitions A→B and B→C (and never the reverse) suggest that the emission peak on the cap switches from an outer to an inner radius, thereby increasing its angular velocity about the pole.

A "resonant radius" may be interpreted in terms of the polar cap model as the radius where the plasma frequency and curvature radiation frequency are equal, thus maximising the coherent boosting of the curvature radiation. The intensity distribution which we have derived to fit the observed profiles is reminiscent of the "coherence function" obtained theoretically by Buschauer and Benford (1980).

Acknowledgements

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References

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Huguenin, G.R., Taylor, J.H. and Troland, T.H.: 1970, Astrophys. J. 162, p. 727.

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DISCUSSION

F.G. SMITH: Are the P_3-values of the A-, B-, and C-drift actually harmonically related?

WRIGHT: Possibly, but not certainly.

ARONS: Can you put a quantitative limit on how simultaneously the switching between different drift modes is?

WRIGHT: The nulls and A-, B-, and C-drift modes appear with the same occurrence rate found at lower frequencies.