Pulsar Astrophysics the Next Fifty Years
Proceedings IAU Symposium No. 337, 2017
P. Weltevrede, B.B.P. Perera, L.L. Preston
& S. Sanidas, eds.

doi:10.1017/S1743921317010316

On sub-pulse drift related profile mode-changes studied with a new technique

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Abstract. Sub-pulse drift related profile mode-changes provide a useful probe of pulsar radio emission. Measurements on modal profiles of PSRs B0031−07, J1822−2256 and B2319+60 are presented for different drift modes in this communication. The width of profile increases with the drift rate, while no such trend is seen for the pulsed flux density for all these pulsars. A brief discussion of implications for models is presented.

Keywords. pulsars: general, pulsars: individual : PSR B0031−07 : PSR J1822−2256 : PSR B2319+60, radiation mechanisms: general

1. Introduction

Pulses associated with distinct drift rates have been reported to average to distinct average profiles in PSRs B0031−07 (Vivekanand & Joshi 1997; Joshi 2013), B2319+60 (Wright & Fowler 1981), B1918+19 (Rankin *et al.* 2013) and B1706−16 (see contribution by Naidu *et al.*, this volume). These changes are similar to pulsars with profile mode changes (Lyne 1971) and suggest fundamental reorganization of the pulsar beam. These may be due to changes in the magnetospheric configuration, originally proposed to explain changes in spin-down rates of intermittent pulsars (Timokhin 2010). Thus, measurements on modal profiles, particularly at multiple frequencies, coupled with measurements of drift properties, can be useful for unraveling geometry from emission dynamics. Here, such measurements for PSRs B0031−07, J1822−2256 and B2319+60, analyzed with a new technique to separate drift modes, are presented in this context.

Observations for PSRs B0031−07 and B2319+60 were made using the legacy Giant Meterwave Radio Telescope (GMRT) at 313 MHz and the Westerbok Synthesis Radio Telescope at 1380 MHz respectively in 2011 (See Gajjar *et al.* 2014 for details). PSR J1822−2256 was observed recently with the new upgraded GMRT between 300−500 MHz in July 2017 (Also see contribution by Joshi *et al.*, this volume). Two different techniques were used to separate drift modes. While a sliding window for computing short time Fourier Transform shows changes in drift rates (Naidu *et al.* 2017), it misses shorter drift modes and contaminates drift modes due to the use of a fixed length window. A good alternative is a wavelet based method (Joshi and Padlekar 2018), where a trade-off between time and frequency resolution allows better localization of drift modes at the expense of slightly coarse estimate of P_3. Here, this new wavelet based method is used to separate drift modes.

2. Results and Discussions

The drift mode separated profiles for PSRs B0031−07, J1822−2256 and B2319+60, obtained using our new technique, are shown in Fig. 1, where the drift rate increases from

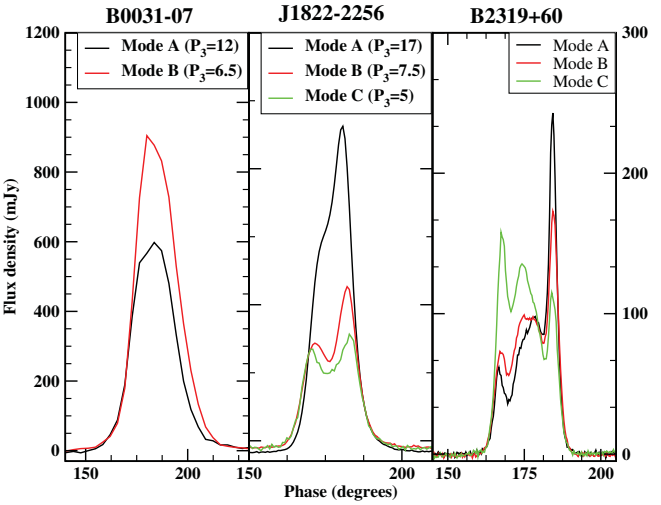

Figure 1. Average drift mode profiles of PSRs B0031−07, J1822−2256 and B2319+60 (left to right panel) for different drift modes. In each case, the drift rate increases from Mode A to C.

Mode A to Mode C. Clearly, different drift modes add up to different profiles as reported earlier. We also confirm the previously reported profile width increase with modal drift rate in PSR B0031−07 (Vivekanand & Joshi 1997). Note that previous observations were single polarization as opposed to dual polar observations presented here. PSR B0031−07 is brighter in Mode B than in Mode A. Similar changes in profiles are seen in PSR J1822−2256 and B2319+60. In the former pulsar, Mode A is brighter than Mode B (or Mode C), whereas the profile width increases from Mode A to Mode C. In PSR B2319+60, the ratio of amplitudes of the trailing component (C2) and the leading component (C1) as well as the separation between these components reduces with increasing drift rate.

In the "switched magnetosphere" model proposed by Timokhin (2010), the emission beam, geometry and heights are expected to change for different modes. The increase in profile widths with increasing "apparent" drift rate may be a consequence of this. Recently, Rankin *et al.* (2013) explained the different apparent periodicity, P_3, for PSR B1918+19 by assuming that the total "number of sparks", drifting with a constant circulation speed, reduce by 1 for drift modes with increasing apparent drift rate. In their model, sub-pulse separation, P_2, and hence profile widths, should increase with drift rate, similar to our results. Our "three musketeers" range from single to multiple component profiles potentially providing alternative constraints on these models with their changing beam geometry. Work is in progress to check quantitatively implications of these for both these model.

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https://doi.org/10.1017/S1743921317010316 Published online by Cambridge University Press