JD02−34

Observations of southern pulsars at high radio frequencies

average profiles / polarization / multiple frequencies

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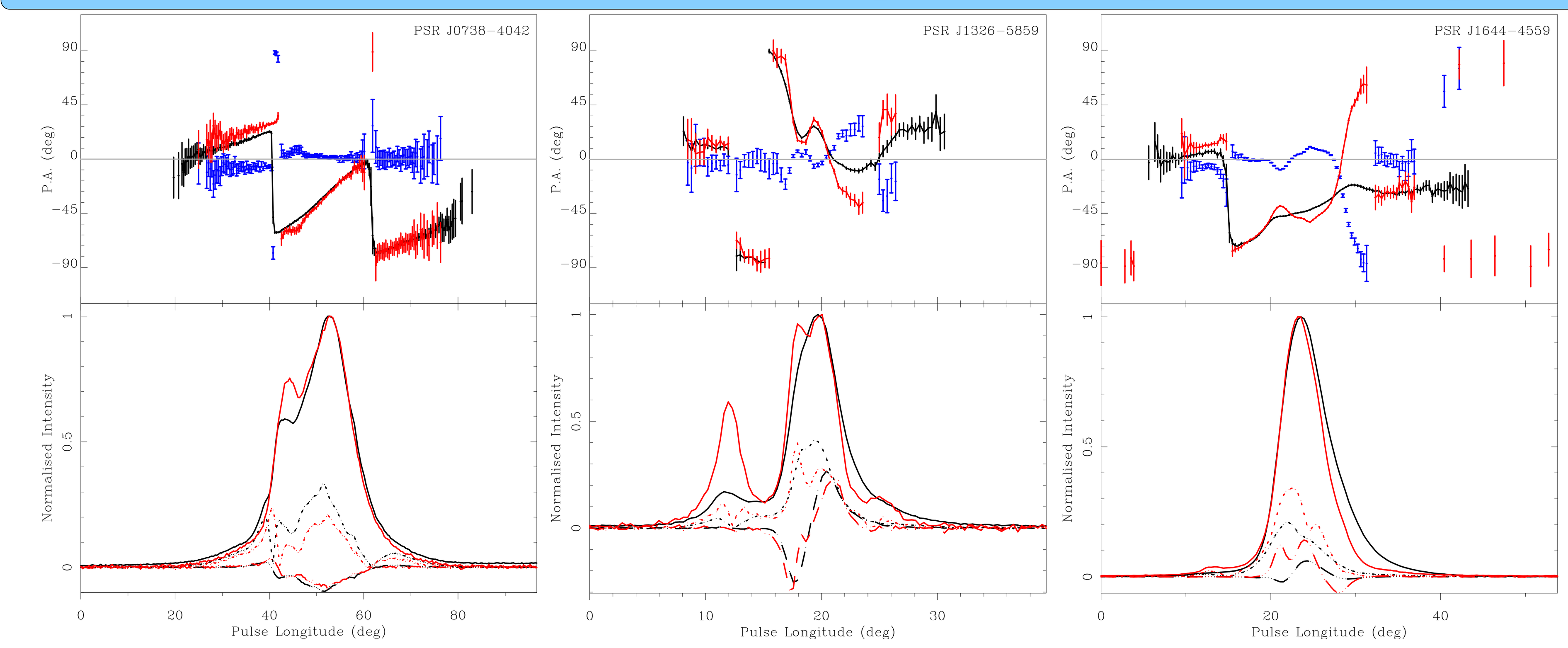
1.4 GHz

3.1 GHz

8.4 GHz

Absolute polarization position angle profiles at 1.4 and 3.1 GHz

Karastergiou & Johnston, 2006, MNRAS, 365



Overlaid polarization profiles at 1.375 (black) and 3.1 GHz(red). In the lower panel, the solid lines denote total power, the dotted lines linear polarization and the dash−dotted lines circular polarization. The upper panel shows the absolute position angles, following the same colour convention. The blue error bars denote the difference between the two PAs.

In the superposed polarimetric profiles of 17 pulsars at 1.375 and 3.1 GHz, (3 examples shown here), we find:

– the position angle (PA) profiles are similar at the two frequencies, despite a lack of resemblance to the rotating−vector−model S−shaped curve.

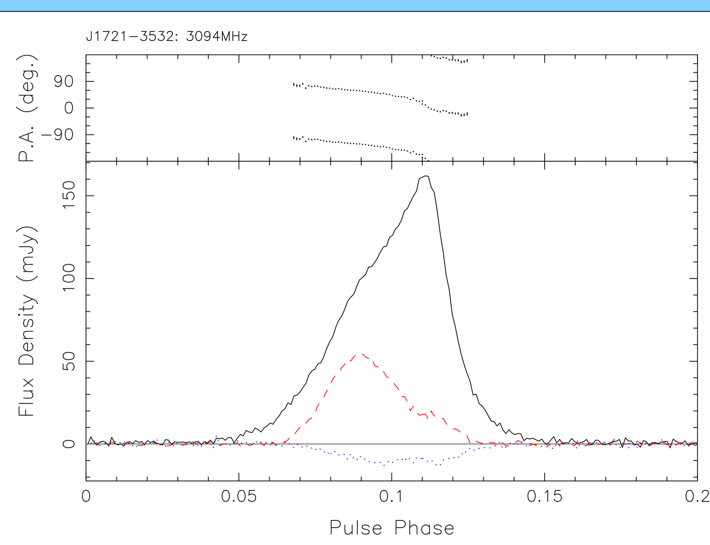
– we identify a tentative association between the change in the PA between the two frequencies and the change in relative amplitude of overlapping total−power components; this suggests that the polarization at each pulse longitude is constrained by the pulse component in which it belongs and is not determined purely by geometry.

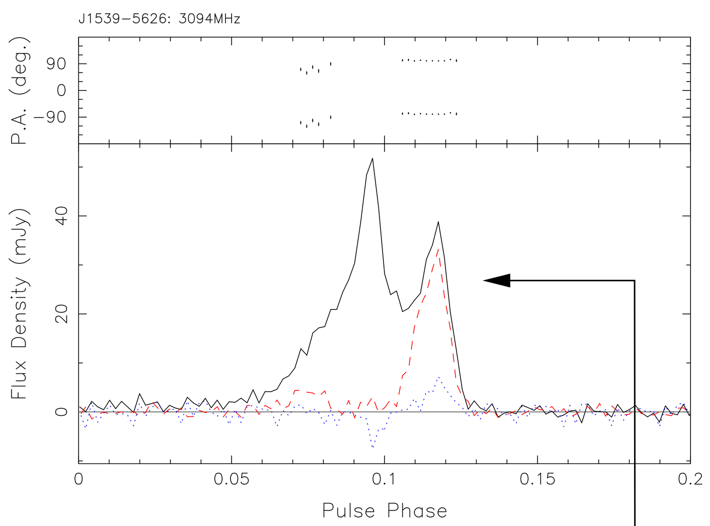
– the similarity of the PA profiles permits an alignment method based on the PA, which allows us to calculate very accurate rotation measures.

– in most pulsars. the differences in PA between the two frequencies vary on short scales of pulse longitude; in some cases, like PSR J0738−4042 (shown here at the far left), we find a constant offset in PA across extended parts of the profile, as yet unexplained.

Polarization of individual components of 3.1 GHz profiles

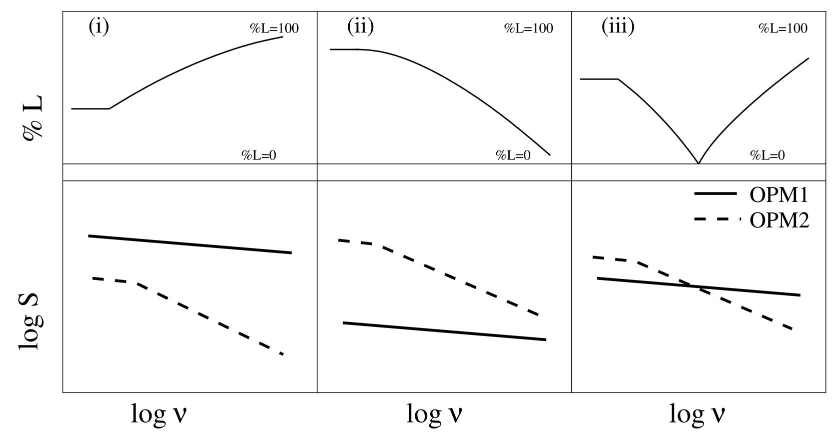
Karastergiou, Johnston & Manchester, 2005, MNRAS 359





We studied the average polarization profiles of 48 southern pulsars with the 10−cm receiver at the Parkes telescope. Although, as expected, a number of profiles are less linearly polarized at this frequency than at lower frequencies, we identify some pulsars where individual components show an increase in linear polarization (see two examples on the left) compared to previous, lower frequency observations.

A simple model



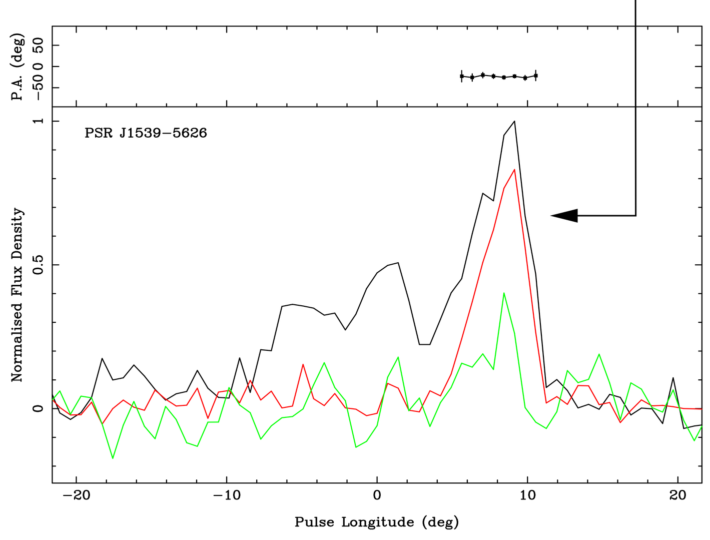
Emission occurs in two, superposed orthogonal modes of polarization. The relative strength of the modes determines the degree of linear polarization: if one mode is much stronger than the other the polarization is high, whereas two equal modes result in no observable polarization. If we assume that one mode has a relatively flat spectrum and the other a relatively steep spectrum, the frequency dependence of the polarization observed is related to the crossover frequency of the two spectra. The figure on the right schematically describes this model. The bottom plot shows the spectra of the two modes versus frequency, and the top plot shows the resulting degree of linear polarization. Most components of most pulsars arguably fall under the second of the three possibilities shown, where the degree of linear polarization is determined by the mode with the steep spectrum and decreases with frequency.

Our model implies that the degree of linear polarization and the total power are tied at a given frequency. For pulsars with components that fall under the first category shown, the dominant polarization mode has a flatter spectrum, which results in two things: 1) the degree of linear polarization increases initially and remains high at high frequencies and 2) the spectrum of the total power is also flatter than for components of the second category. This picture is similar to what is seen in some high spin−down, young pulsars.

Polarization profiles at 3.1 GHz. The solid line is the mean total power, the dashed line is the average linearly polarized power and the dotted line is the mean circular polarization. On the top part of each plot is the position angle (PA) profile, with an arbitrary zero offset. The PA is plotted twice, modulo 180 deg.

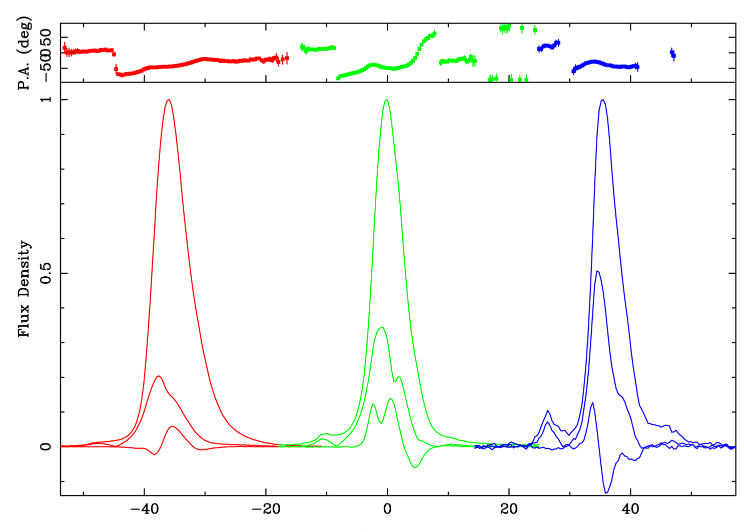
Average pulsar polarization profiles at 8.4 GHz

Johnston, Karastergiou & Willett, 2006, MNRAS 369



We observed 32 pulsars at 8.4 GHz with the Parkes telescope. Only the young, energetic pulsars continue to show polarization fractions in excess of 60 per cent. All pulsars show evidence of conal emission, while only one third also show core emission. Many profiles are asymetric, with either the leading or trailing part of the cone not detectable.

In young pulsars, the emission height is large even at high frequencies (Johnston & Weisberg 2006). and the emission remains polarized. Core emission in older pulsars arises from low in the magnetosphere and quickly becomes less polarized with frequency. Pulsars that show clear conal rings also appear to have low emission heights and are also observed to show little or no polarization at high frequencies. We therefore surmise that the fractional polarization is related to the emission height.



The figure above shows the profile of J1539−5626 at 8.4 GHz. Note how the trailing component is highly polarized. A comparison to the 3.1 GHz profile of this pulsar, shown above, reveals that the trailing component not only retains its high degree of linear polarization, but also has a flatter spectral index in total power than the rest of the pulse. This highly polarized component may originate from higher in the magnetosphere than the other components.

In the sample observed, the asymetric profiles at 8.4 GHz tend to be more polarized than the symmetrical ones. Also, little or no pulse narrowing is seen between 1.4 and 8.4 GHz.

1.4 GHz   3.1 GHz   8.4 GHz

Polarization profiles of PSR J1644−4559,showing a peculiar evolution of linear and circular polarization with frequency

Points to remember:

1. The polarization position angle may change with frequency as the relative strength of overlapping components changes.

2. A simple model where two orthogonal modes with competing spectral indices can account for many observational properties of the linear polarization and total power of individual components.

3. Young energetic pulsars remain highly polarized at high frequencies.

4. Highly polarized components may originate from higher in the pulsar magnetosphere than unpolarized components.