Studying Radio Polarization of Galactic Supernova Remnants with ASKAP

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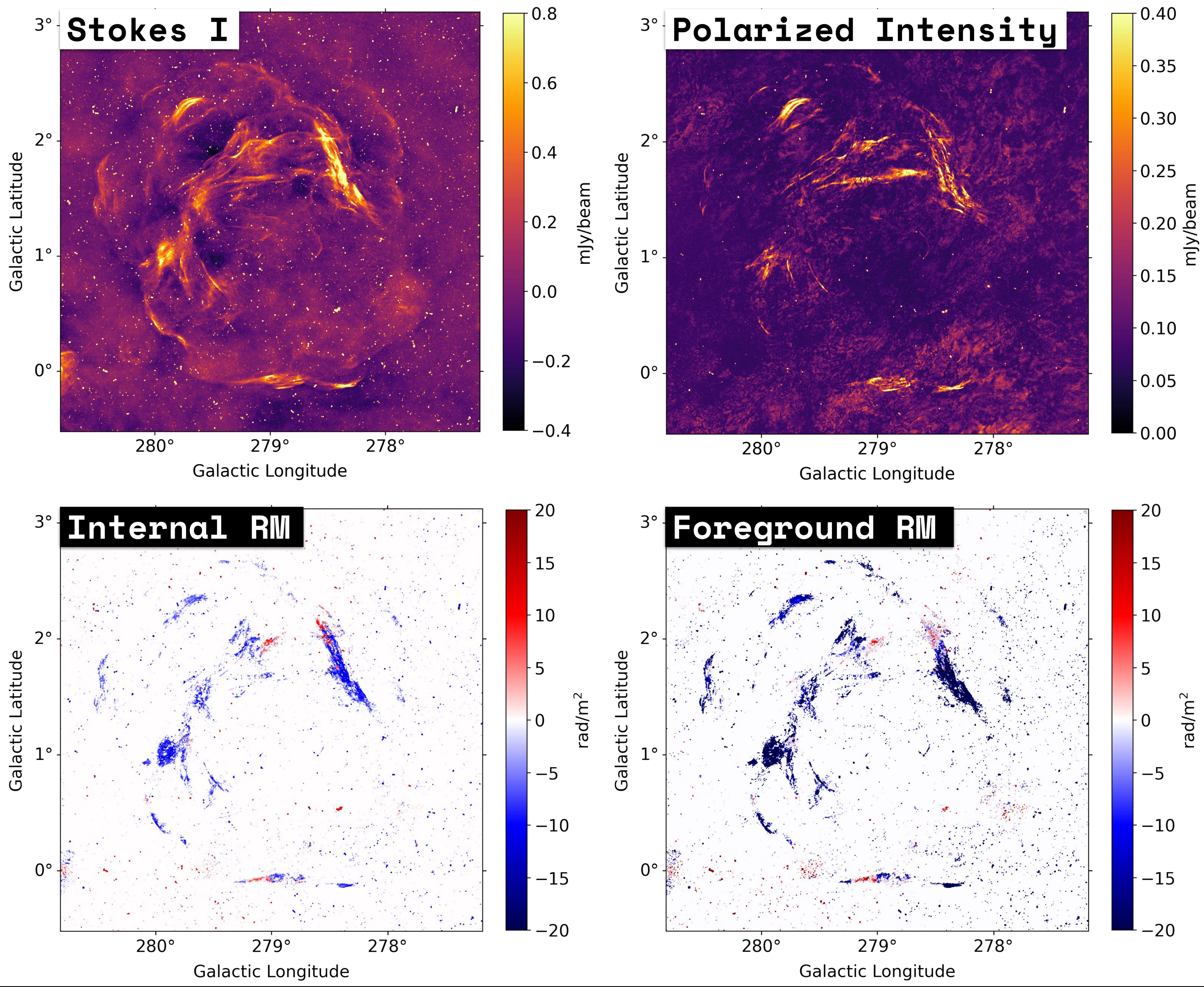
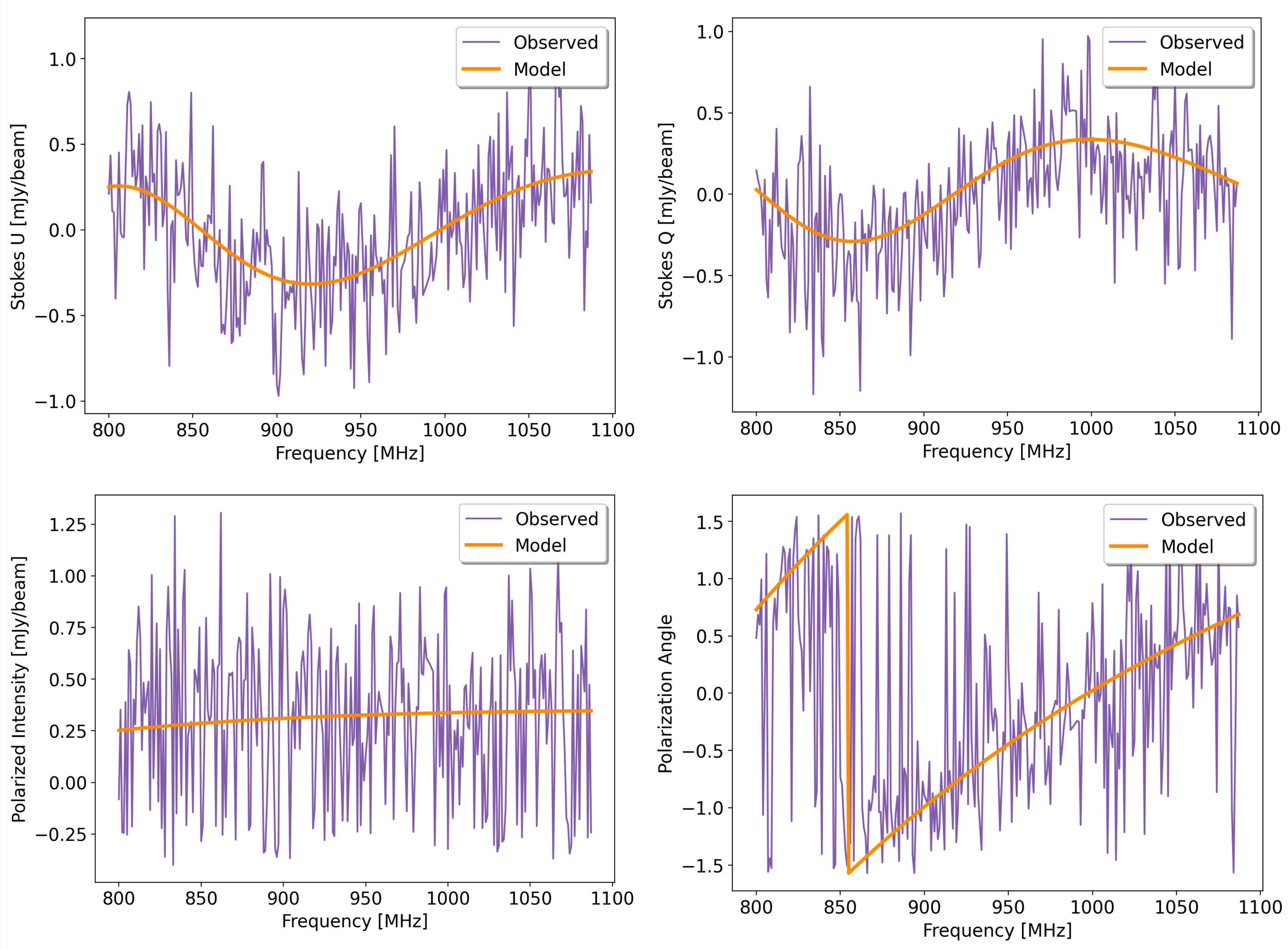
THE EMU & POSSUM SKY SURVEYS

EMU (Evolutionary Map of the Universe) and POSSUM (Polarization Sky Survey of the Universe's Magnetism) are ongoing radio sky surveys being conducted with the Australian Square Kilometre Array Pathfinder (ASKAP) that will cover most of the Southern sky. Early results from EMU and POSSUM have shown that they will be particularly useful for studying large, high-latitude Galactic supernova remnants, which are often not fully covered in surveys that are focused on the Galactic plane. These remnants are well-suited for studying the radio polarization of Galactic SNRs.

THE GALACTIC SNR "DIPROTODON"

The Galactic SNR G278.94+1.35 (nicknamed "Diprotodon") is one of the largest known SNRs in our Galaxy with an angular size of more than 3°. While this SNR was first identified by Woermann & Jonas (1988), recent ASKAP observations have revealed Diprotodon's angular extent to be much larger than previously measured. Diprotodon has also been detected in X-rays with eROSITA (Michailidis et al. 2024) and in gamma rays with Fermi-LAT (Araya 2020). Diprotodon's large angular size, high-latitude, and high degree of polarization make it particularly well-suited to polarization studies.

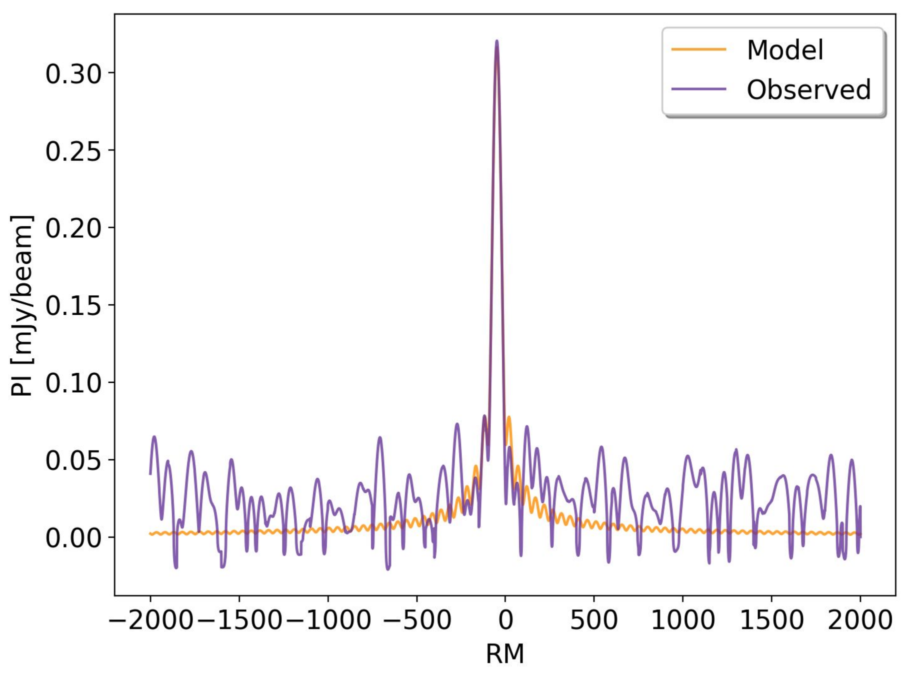




Comparing model and observed spectra for a sample pixel with:

- DP = 0.73
- Internal RM = -6.5 rad/m²
- Foreground RM = -41.6 rad/m²

The model produces results consistent with observations for U, Q, PI, and PA. We are also able to reproduce the Faraday depth spectrum.



POSSUM CATALOGUE of POLARIZED POINT SOURCES

We will use background polarized sources from the POSSUM polarization catalogue to probe the magnetic field configuration inside the SNR. The rotation measures of these point sources can be compared to Diprotodon's foreground RM and used to constrain estimates of its distance. Filipović et. al. (in prep.) estimate Diprotodon's distance to be ~1 kpc. We hope to confirm and perhaps further constrain this estimate by studying these polarized point sources.

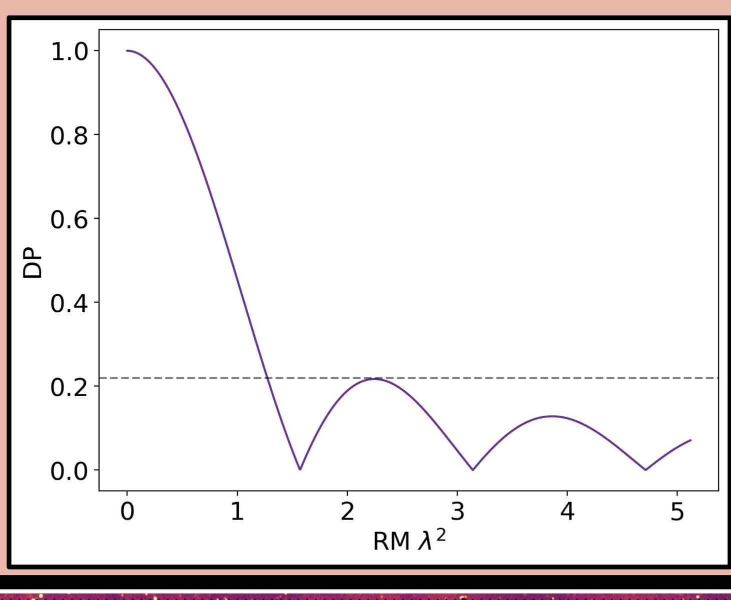
SEPARATING INTERNAL & FOREGROUND FARADAY ROTATION

We aim to separate the foreground Faraday rotation produced by the large-scale Galactic magnetic field from the internal Faraday rotation produced by the SNR shell. The internal rotation results in frequency dependent depolarization, as emission along the line of sight within the SNR shell undergoes different levels of Faraday rotation. The presence of random magnetic fields within the SNR shell can also result in depolarization that is frequency independent. We assume the foreground field to be relatively uniform and thus not a significant source of depolarization. This allows us to separate the internal and foreground components.

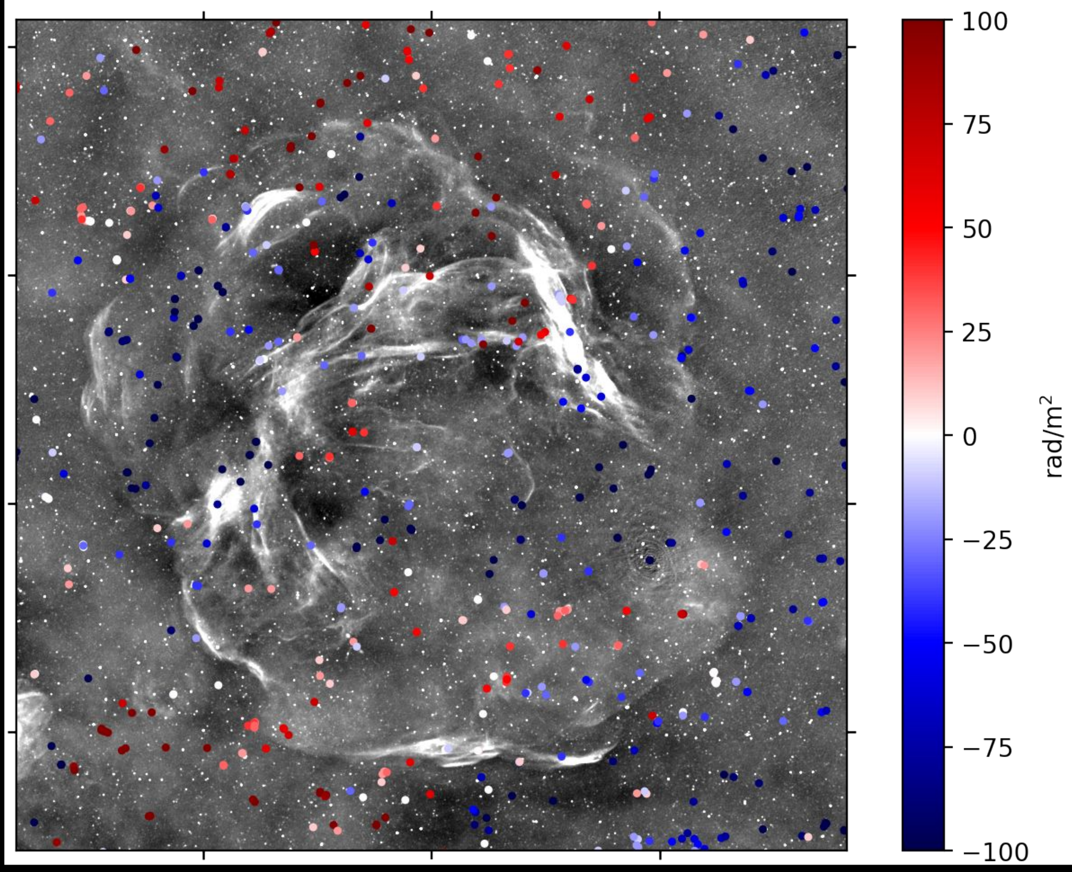
The degree of polarization (DP) refers to the ratio of the observed polarization to the expected intrinsic polarization. The expected intrinsic polarization can be derived from the spectral index. For Diprotodon, we assume a spectral index of -0.55 (Filipović et al., in prep.), which produces an expected intrinsic polarization of ~70%. This value can be compared to the observed polarization to find DP and determine the internal rotation measure (RM):

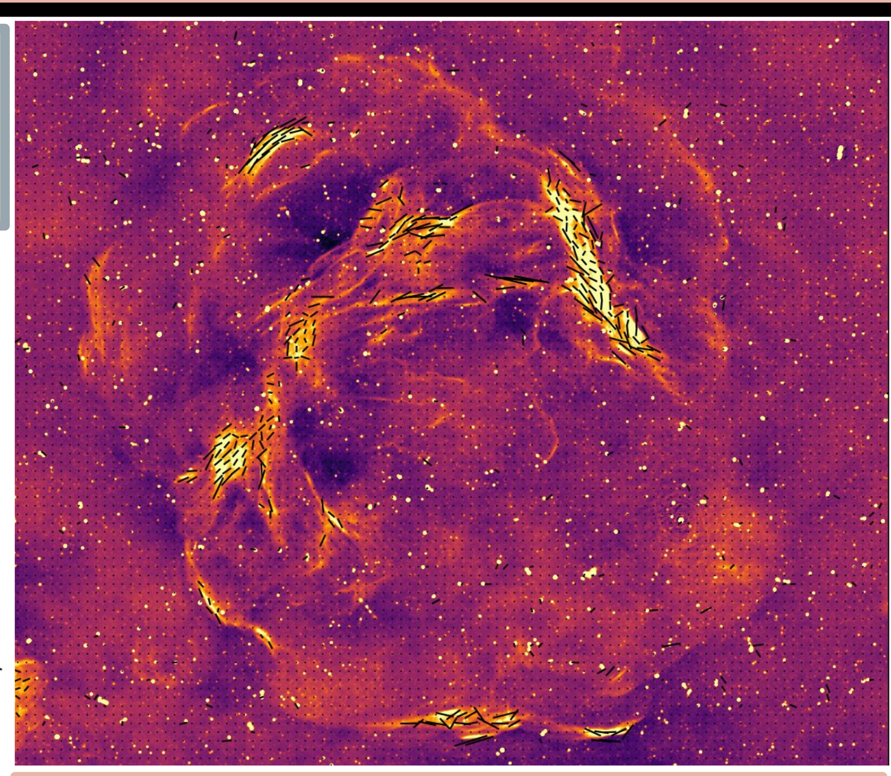
$$\mathrm{DP} = \frac{\sin(2|\mathrm{RM}|\lambda^2)}{\sin(2|\mathrm{RM}|\lambda_0^2)} \times \frac{\lambda_0^2}{\lambda^2}$$

This allows us to separate the internal and foreground effects. However, this method can only be applied reliably if DP>0.22. Below this value, there is no longer a unique solution (see figure). At our central frequency of 943MHz, this corresponds to an internal RM of <12 rad/m². Thus, this method can only be applied to sources with a high degree of polarization and low internal RM.



Polarized point sources from the POSSUM catalogue overlaid on the total power image of Diprotodon. The RMs of these point sources can be compared to the foreground RM to estimate the SNR's distance.





Magnetic field vectors overlaid on the total power image of Diprotodon. In the bright filaments, we see the vectors are remarkably well-aligned and indicate a tangential magnetic field, consistent with expectations for an SNR.

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