The Magnetised Environments of Radiative-mode and Jet-mode AGN


Abstract:
We present results from a broadband (1 to 10 GHz) radio polarisation analysis of 102 radio-loud AGN. We investigate the most likely mechanisms causing the observed differences in the integrated 1.4 GHz polarisation properties of radiative-mode and jet-mode AGN, as found in O'Sullivan et al. (2015). Our analysis shows that jet-mode sources with high integrated polarisation at 1.4 GHz have low RM dispersion, are dominated by a single polarised component, and have a steep spectral index. We find that while, on average, the radiative-mode AGN are in slightly more turbulent magnetised environments than the jet-mode AGN, it is mainly the intrinsically disordered magnetic field structures of the radiative-mode AGN that leads to the lower integrated polarisation seen at 1.4 GHz (O'Sullivan et al. 2016, in prep).

Polarisation model-fitting approach:
To accurately describe the broadband polarisation and Faraday rotation measure (RM) behaviour of our sources, we use the QU-fitting and model selection technique described in O'Sullivan et al. (2012). To capture a broad range of possible Faraday rotation behaviour, we use a model for the complex polarisation (P) which describes the effects of both random and uniform magnetic fields in the environment of the source (e.g. Sokoloff et al. 1998).

\[ P = P_1 \exp(i\phi) \exp(i\Delta \lambda/\lambda^2) \]  

\[ \Delta \lambda = (\Delta \lambda_1 + \Delta \lambda_2) \exp(i\phi_1) \exp(i\phi_2) \]

\[ \Delta \lambda_1 = \Delta \lambda_2 = 32 \text{ rad m}^{-2} \]

\[ \phi_1 = \phi_2 = 5 \text{ rad} \]

\[ \Delta \lambda_{\text{tot}} = \Delta \lambda_1 + \Delta \lambda_2 \exp(i\phi_1) \exp(i\phi_2) \]

\[ \phi_{\text{tot}} = \phi_1 + \phi_2 + \ldots \]

Results:
There are ~40% of sources that have one dominant RM component, ~50% with two RM components and ~10% with three RM components. Therefore, in order to investigate the magnetised environments of all sources in a consistent manner, we calculate the polarisation-weighted RM dispersion, \( \sigma_{\text{RM,wtd}} \), for sources with low RM dispersions that also have low degrees of polarisation at 1.4 GHz. This provides a characterisation of the general amount of depolarisation in the local environment of each source.

Example sources:
Here we show examples of the total intensity morphology and broadband polarisation behaviour of three of our sources. Importantly, we find the polarisation model-fitting results consistent with the high resolution images.

Summary & Future work:
- Our study emphasises the necessity for broadband polarization observations to accurately determine the Faraday rotation measure properties of the integrated emission from radio-loud AGN.
- The results show how we can distinguish between the intrinsic magnetic field properties of sources and the external magnetised environment that causes depolarisation, using our polarisation model-fitting approach.
- We find that the radiative-mode AGN are in more turbulent magnetised environments and have more intrinsically disordered magnetic field structures than the jet-mode AGN, on average.
- Future all-sky radio polarization surveys, with telescopes such as the Australian SKA Pathfinder (ASKAP) and the VLA, will provide much greater statistical power to investigate the detailed magnetic field properties of different classes of radio-loud AGN in different types of environments.