Research Summary: Reconstructing Structures from Cosmic Magnetized Mediums

Cosmic magnetism is important in understanding a lot of physical processes i.e., star formation, but it has been hard to observe them. One of the ways it could be studied is using Faraday rotation which is the effect that takes place when an incoming polarized light shifts its propagation by a certain angle as it passes through magnetized mediums. This effect occurs when polarized beams pass through a magnetic field, the left and the right circular polarized waves propagate at different speeds which is called circular birefringence. To recover emission at multiple Faraday depths along a particular line of sight, rotation measure synthesis is used which utilizes mathematical properties of polarization and Faraday rotation.

To achieve excellent resolution in Faraday depth, we require a wide coverage in wavelength squared (λ^2). However, there is limited coverage, so the two telescopes used in this project measure different frequency bands, but some bandwidth is lost due to radio frequency interference. Subsequently, we used a new algorithm to fit the Faraday depth structure and investigated how different frequency coverage can impact the recovery of the rotation measure structure. 148 sources were cross matched and postage stamps were made using both surveys. The noise level was estimated, and we measured the spectrum for both surveys; QUOCKA of ATCA that covers broadband bandwidth of 1 to 8 GHz and POSSUM of ASKAP that uses bandwidth of 1.295 to 1.439 GHz.

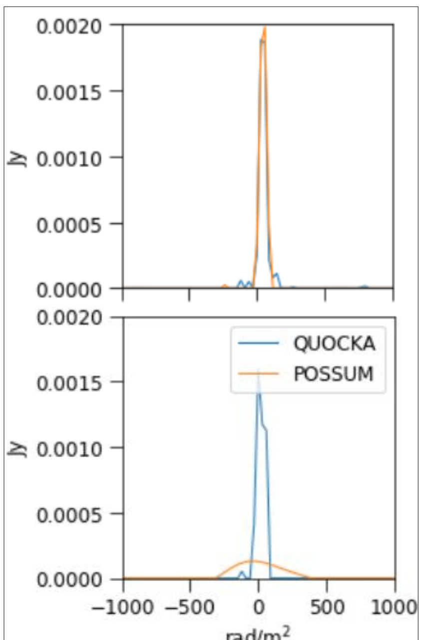

Fig. 1: Examples of Faraday Spectrum using Nonparametric QU-Fitting: top is a simple source (J204643-532250) & bottom is a complicated source (J205837-575636).

We ran 2 different rotation measure synthesis algorithms, the non-parametric QU-fitting, and the standard algorithm, RM clean to recover an estimated Faraday signal and compared the two algorithms for each source. Observed signals were different from what we expect since we did not know the ground truth Faraday spectrum and can be hard to choose the parameters for the best result. In figure 1 for the simple source, non-parametric QU-fitting produced similar results for both QUOCKA and POSSUM while for the complicated one, POSSUM in yellow did not recover a similar Faraday spectrum as the QUOCKA one in blue. The RM Clean algorithm did not recover similar spectrums for either type of source. In conclusion, the non-parametric QU-fitting worked well with simpler sources, but the more complicated ones show that the POSSSUM dataset is not enough to predict QUOCKA ones. In future, we can run more algorithms like parametric QU-fitting to explore quantitatively how predictive each method is.