Reconstructing Structure from Cosmic Magnetized Mediums

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Introduction

Cosmic magnetism is important in understanding many physical processes e.g star formation but difficult to observe. Nonetheless, it can be done using the Faraday effect (see Fig. 1).

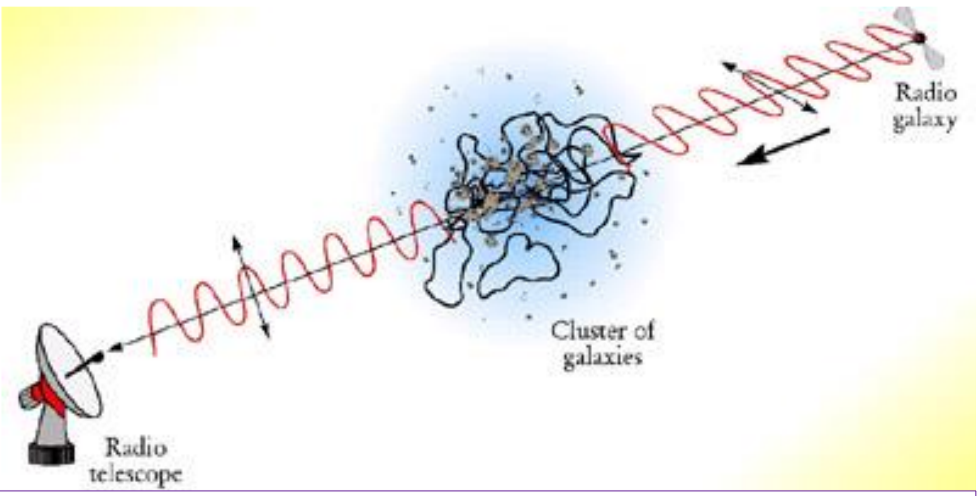

Fig.1: The plane of already polarized light is rotated in the presence of a magnetic field.

The Faraday effect can be described from birefringence of a magnetized medium where the polarization angle of linearly polarized radiation propagating through these mediums is rotated as a function of frequency. The Faraday rotation measure is defined as:

$$\mathrm{RM} \propto \int_{\mathrm{Source}}^{\mathrm{Telescope}} n_e(\vec{\ell})\vec{B}(\vec{\ell}) \cdot \mathrm{d}\vec{\ell}.$$

Eq.1: B is the magnetic field & n is electron density which is integrated along the line of sight.

$$\chi = \lambda^2 \mathrm{RM} + \chi_0$$

Eq.2: χ_0 is the linear polarization angle at λ=0, χ is the polarization angle

In this project, we are investigating how the different frequency coverage can impact the recovery of the RM structure.

Method

148 sources were cross matched & postage stamps were made by using both surveys. The noise level was estimated & we measured the spectrum for both QUOCKA (ATCA, 1-8 GHz) & POSSUM (ASKAP, 1.295 to 1.439 GHz). We ran 2 different RM synthesis algorithms to recover an estimated Faraday signal.

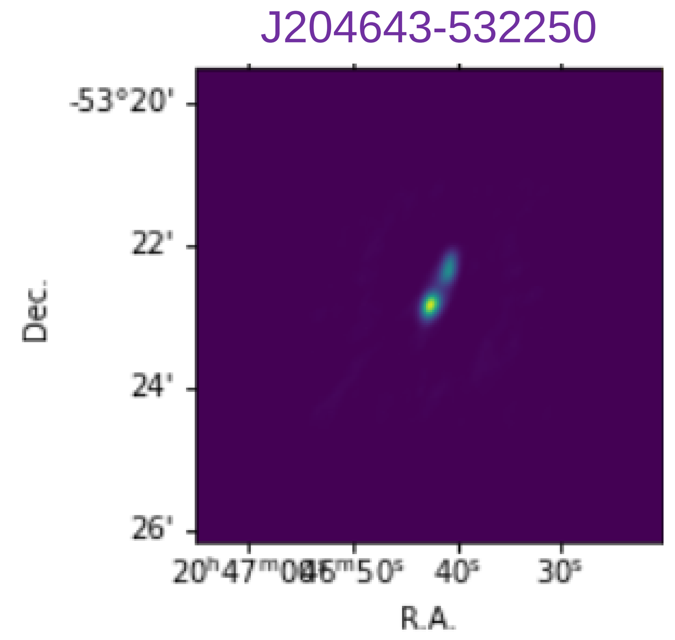

Fig.2 : QUOCKA Frequency Averaged Stokes I Image

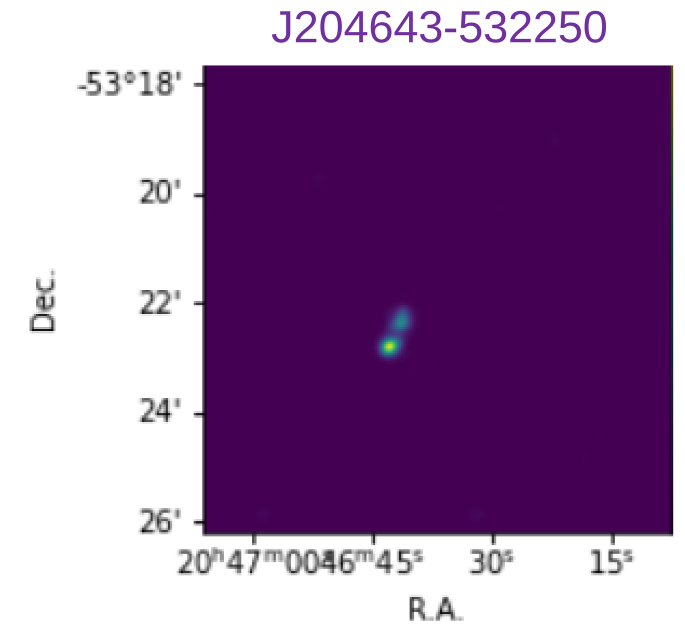

Fig.3: POSSUM Frequency Averaged Stokes I Image

Results

Figures 4 & 5 show the recovered Faraday spectrums of QUOCKA & POSSUM respectively, of a simple source (J204643-532250). Since this a real observation we do not know the ground truth Faraday spectrum, so it is hard to choose the parameters for the best result. For this source, non-parametric QU-Fitting produces similar results for both QUOCKA & POSSUM while RM Clean does not.

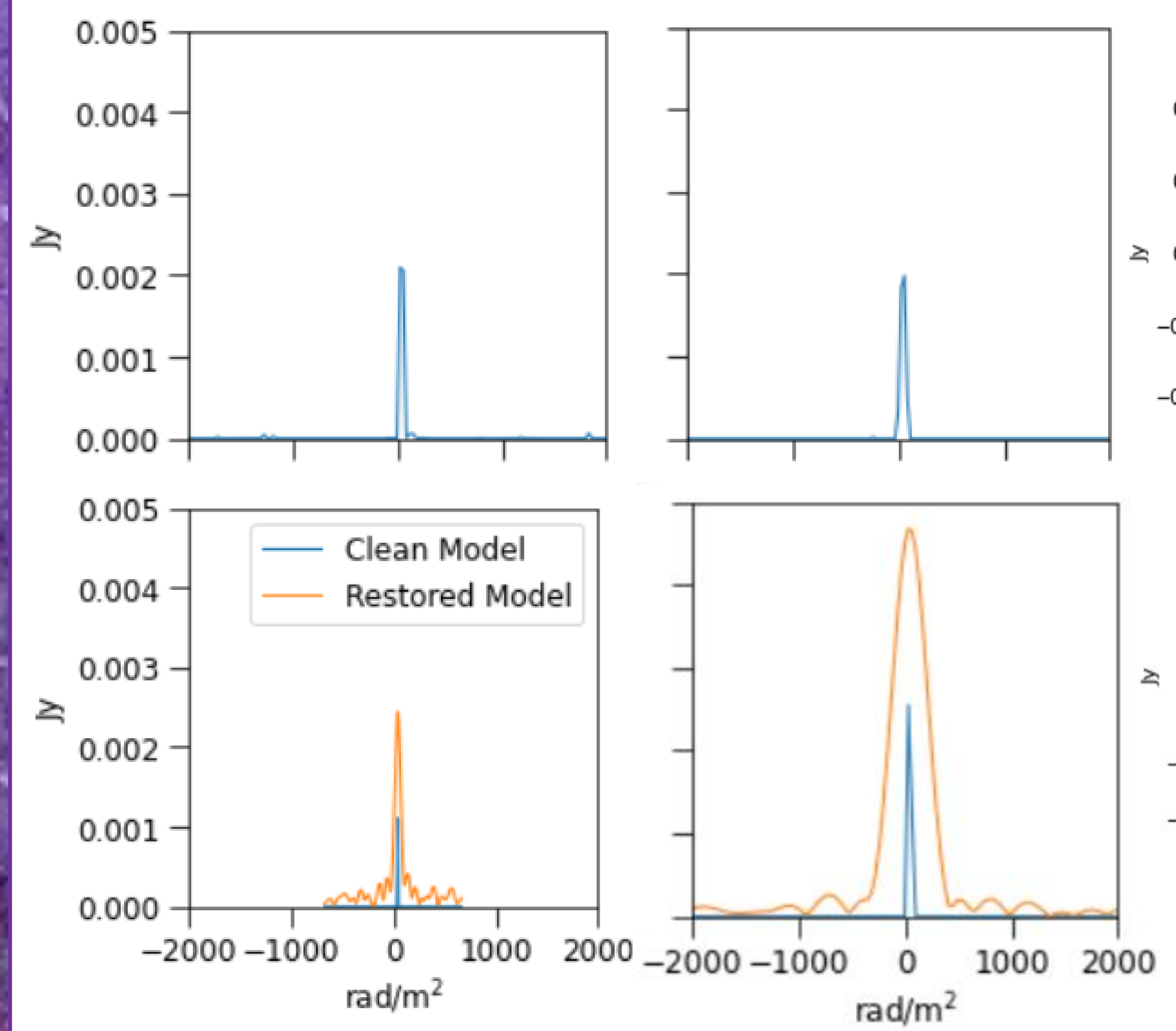

Fig.4: Faraday Depth Spectrum (amplitude) of
Top Left: QUOCKA non-parametric QU-Fitting
Top Right: POSSUM non-parametric QU-Fitting
Bottom Left: QUOCKA Clean & Restored Model
Bottom Right: POSSUM Clean & Restored Model

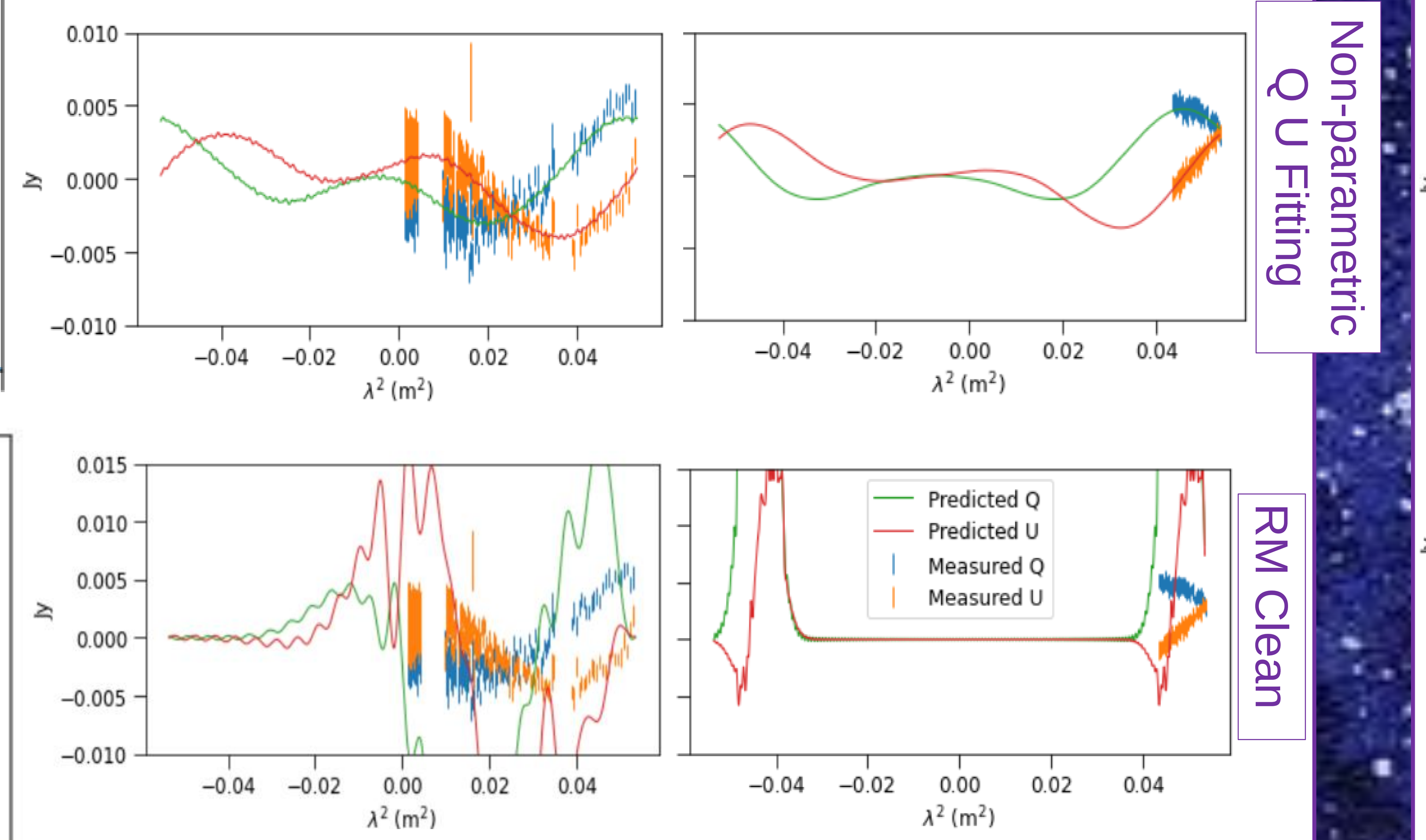

Fig.5: Predicted vs. Measured Stokes Q & U of
Top Left: QUOCKA non-parametric QU-Fitting
Top Right: POSSUM non-parametric QU-Fitting
Bottom Left: QUOCKA RM Clean algorithm
Bottom Right: POSSUM RM Clean algorithm

Conclusions

We investigated how predictive the POSSUM dataset can be for the wider bandwidth QUOCKA dataset & that the new algorithms worked well for simple sources. However, looking at the more complicated ones show that the POSSUM dataset is not enough to predict QUOCKA e.g., source J205837-575636 (see Fig. 6).

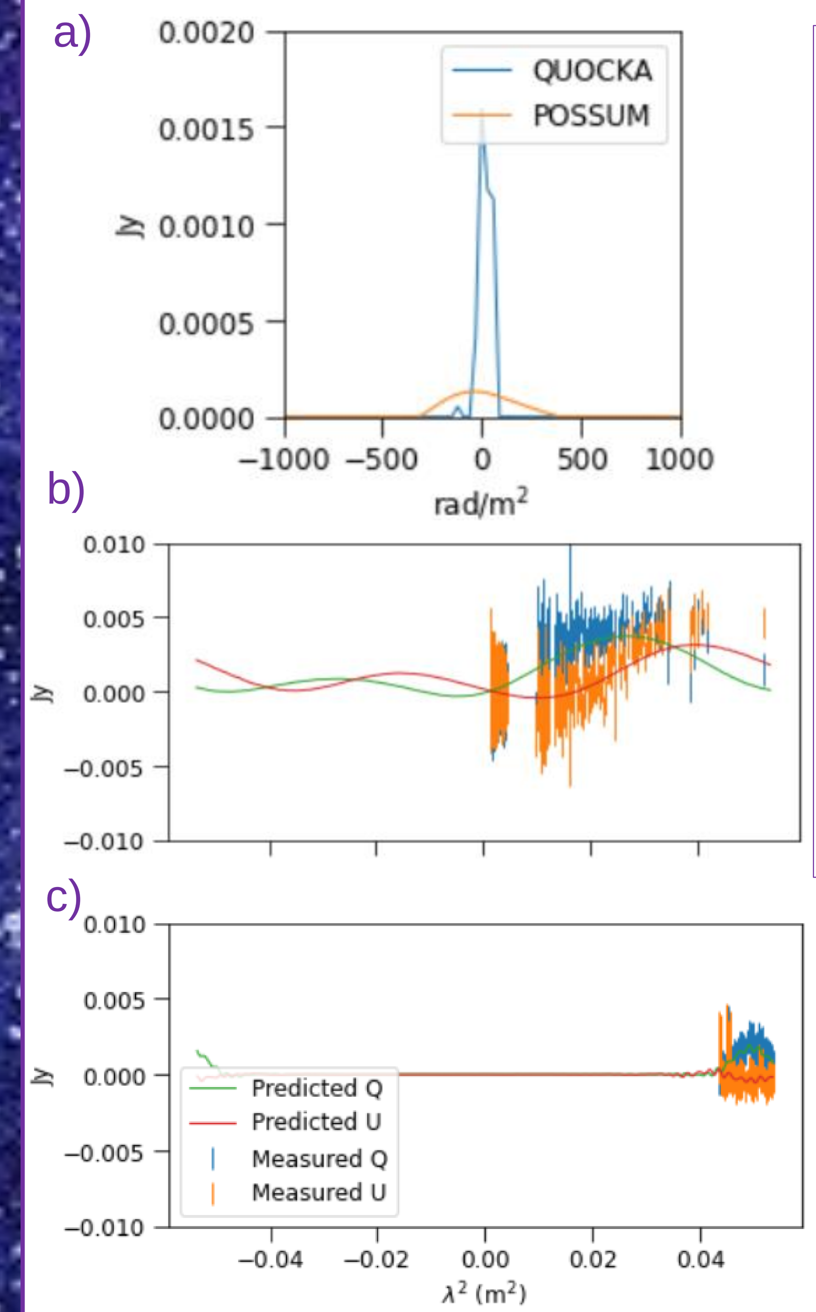

Fig.6: Non-parametric QU-Fitting of a Complicated Source
a) Faraday Spectrum
b) QUOCKA predicted vs. measured Stokes Q & U
c) POSSUM predicted vs. measured Stokes Q & U

Next Steps...

Explore more techniques e.g., parametric QU-Fitting, to model the Faraday spectra. Eventually, we could find a quantitative way to understand how predictive each method is.