Studying the Ionized and Magnetic ISM with LOFAR

Hands-on project 3

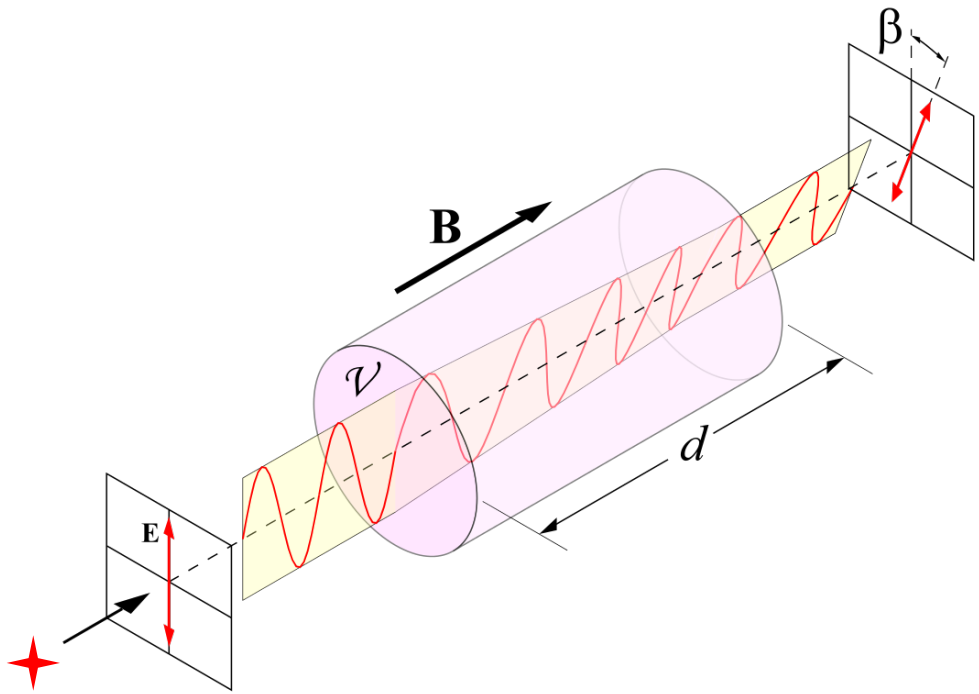
Advisor: Andrea Bracco

2021.07.23

Participants

Dazhi, Meriem, Parul, Rohit, Vijayatha

Faraday rotation



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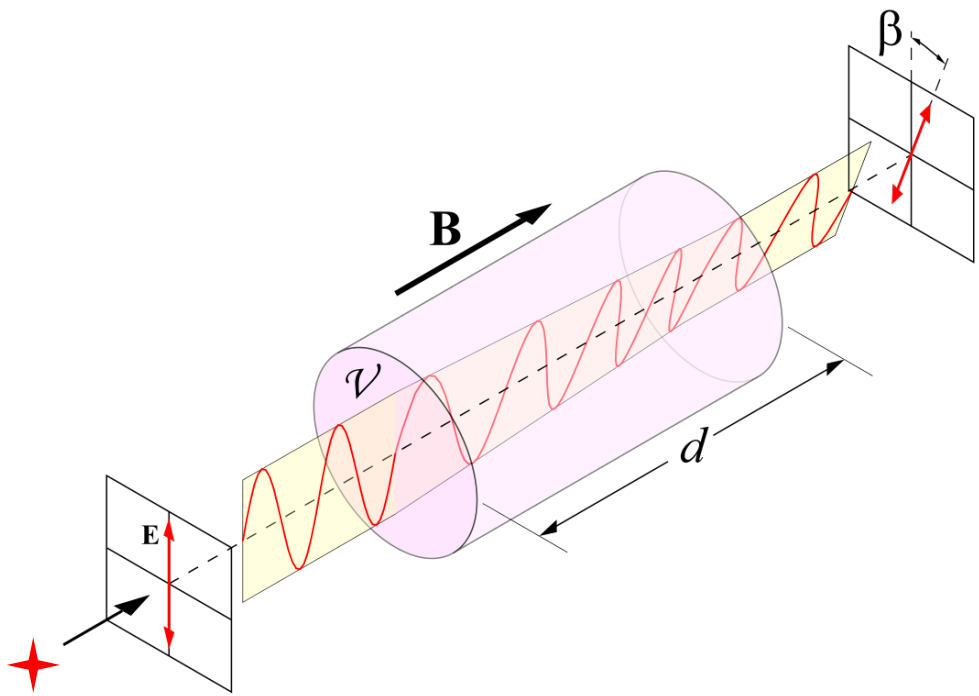
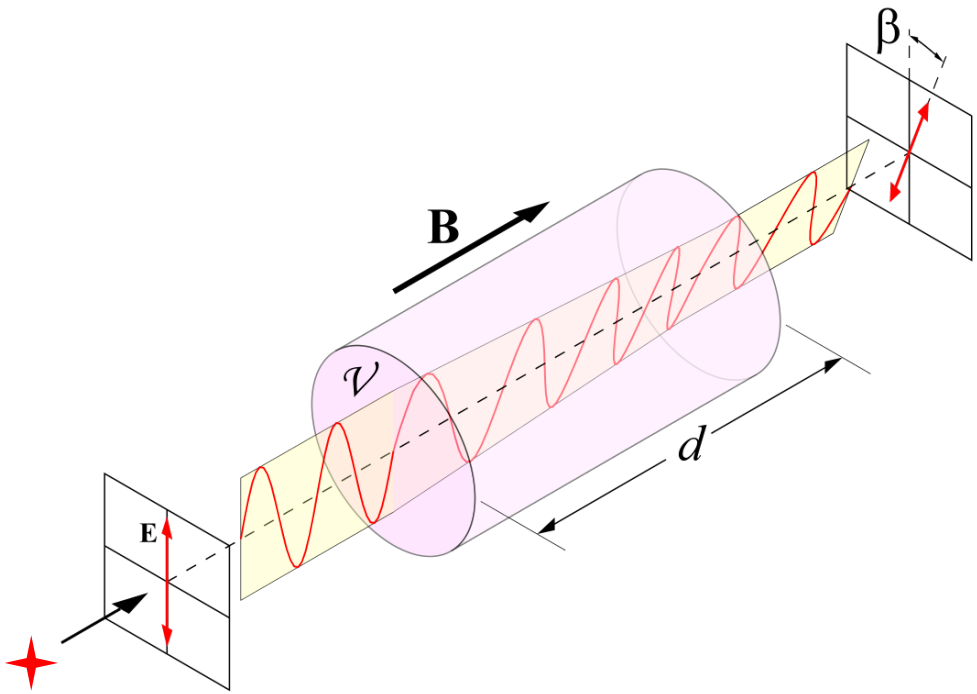


$\beta = RM\ \lambda^2$

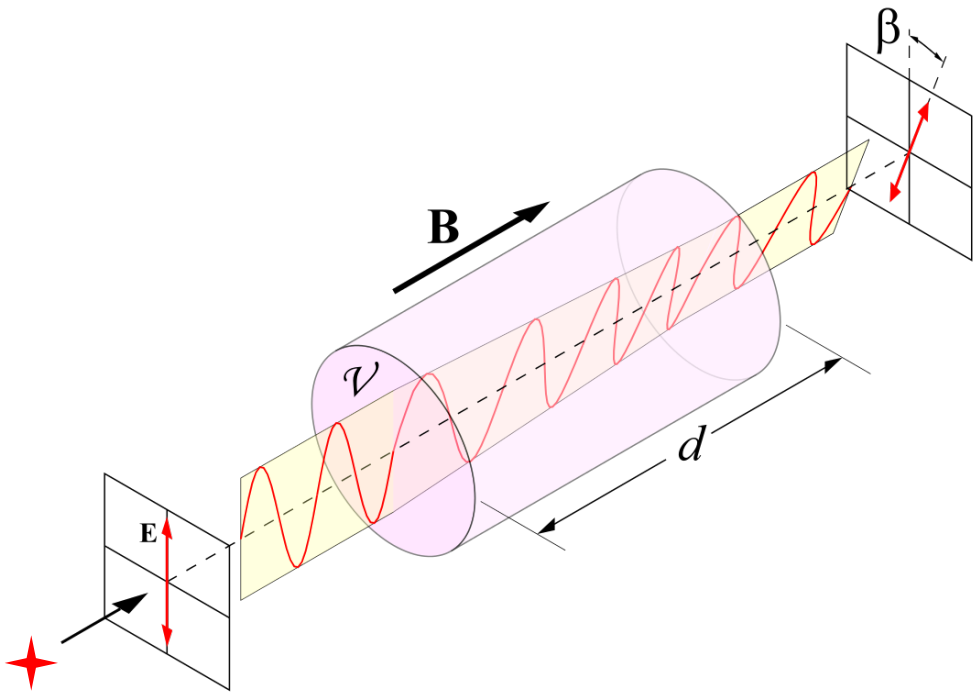
Faraday rotation



$\beta = RM\ \lambda^2$

$$\frac{\mathrm{RM}}{\mathrm{rad\ m^{-2}}} = 0.81 \int \frac{n_e(L)}{\mathrm{cm^{-3}}} \frac{B_{\parallel}(L)}{\mu\mathrm{G}} \frac{dL}{\mathrm{pc}}$$

Faraday rotation



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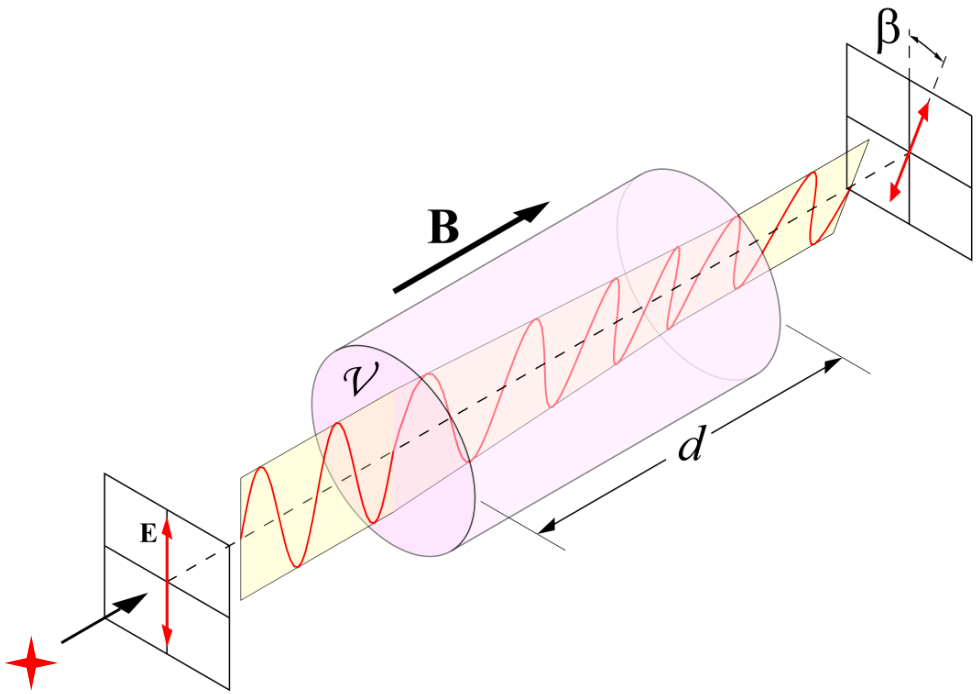

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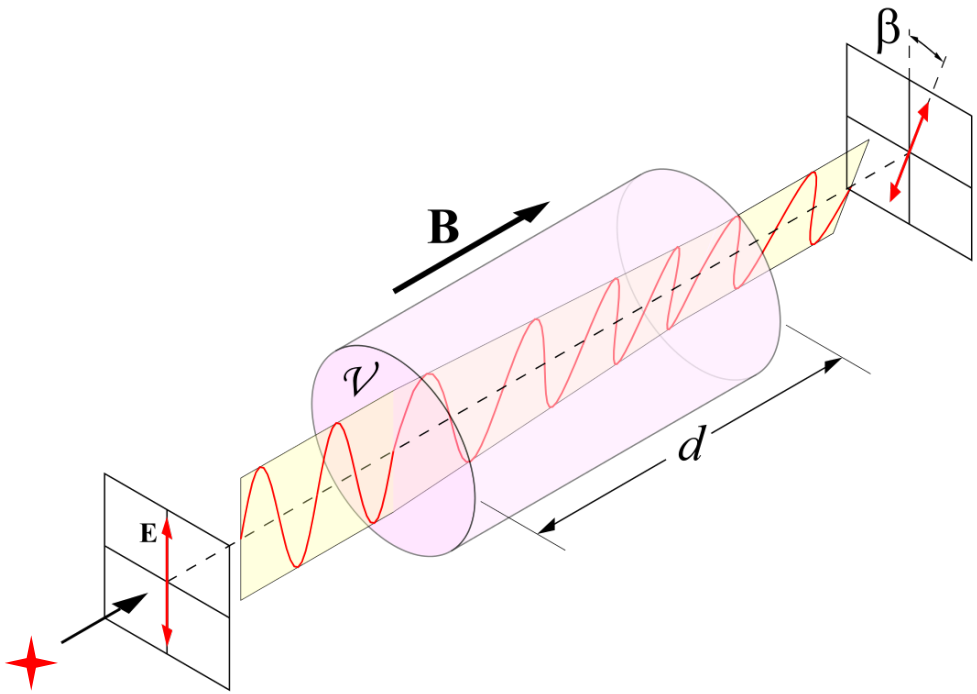

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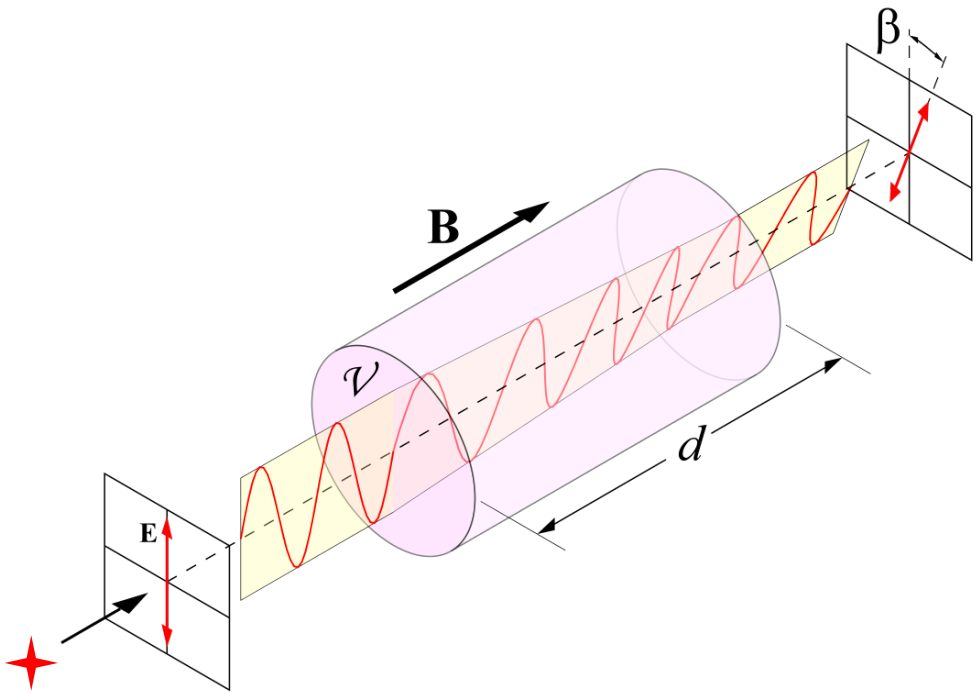
But it can be complex and emitting polarized emission itself!

Faraday rotation



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The ISM is a Faraday rotating medium

But it can be complex and emitting polarized emission itself!

How to disentangle all the different emissions then?

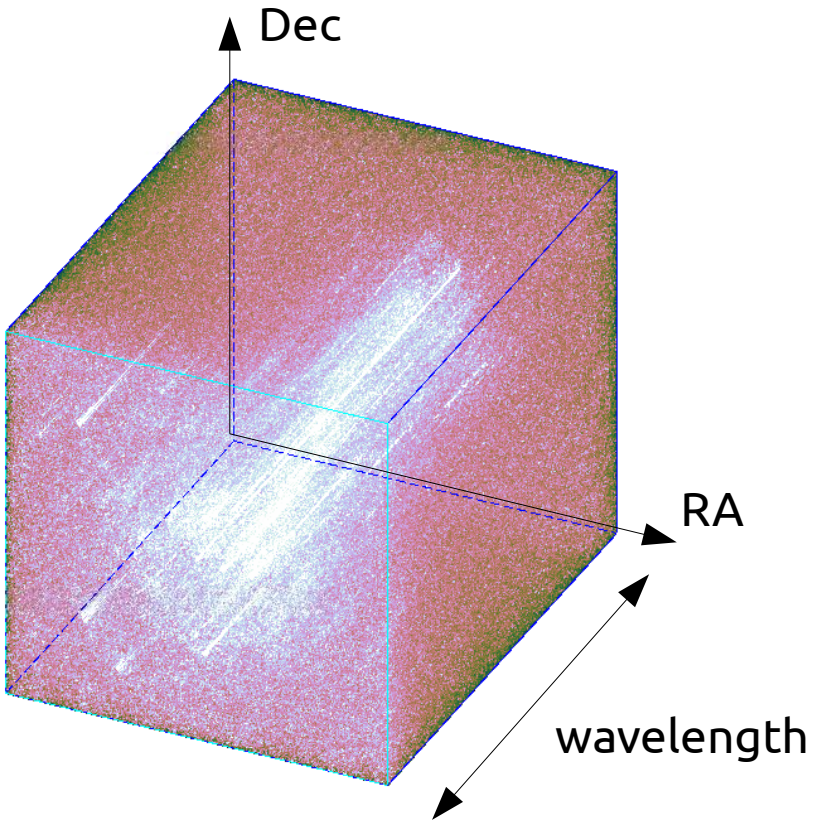
Faraday Tomography

Perform rotation measure (RM) synthesis

Generalize the RM to Faraday depth

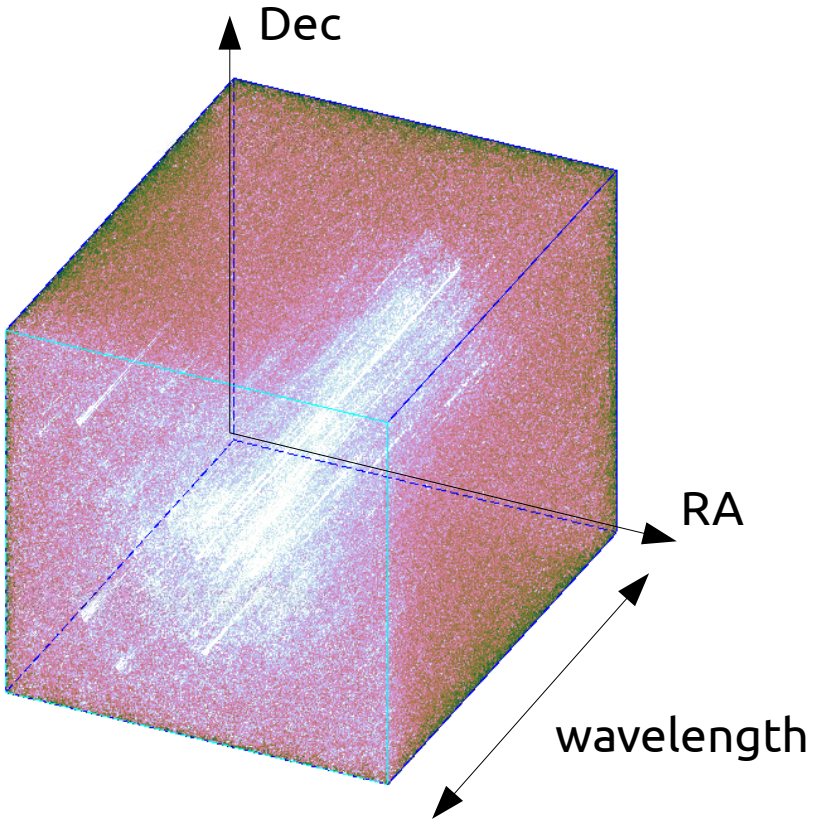
Go from wavelength space to Faraday-depth space (Fourier transform)

Faraday Tomography



Quasar 3C196

Faraday Tomography

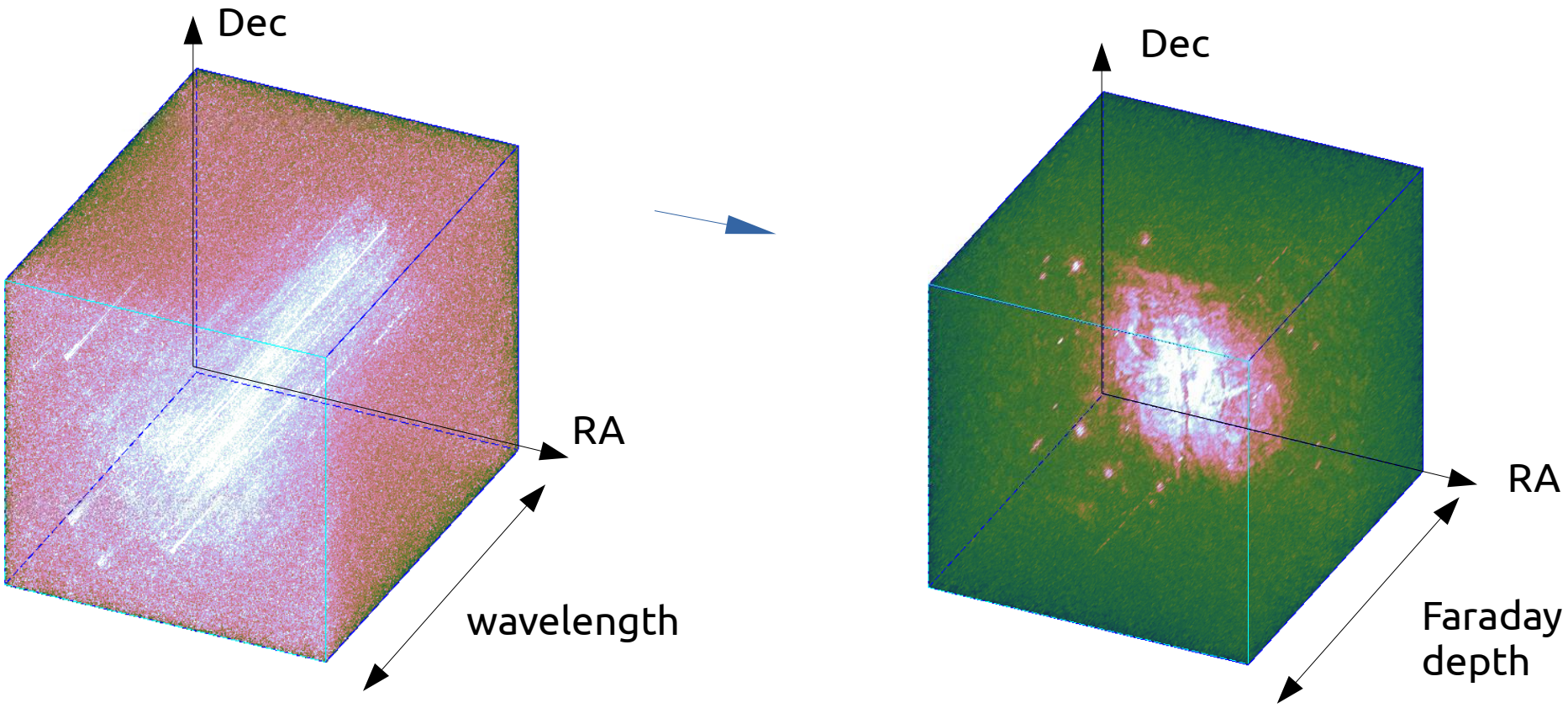


Quasar 3C196:

Observed with LOFAR
from 115 to 175 MHz

Faraday Tomography

Go from wavelength space to Faraday-depth space (Fourier transform)



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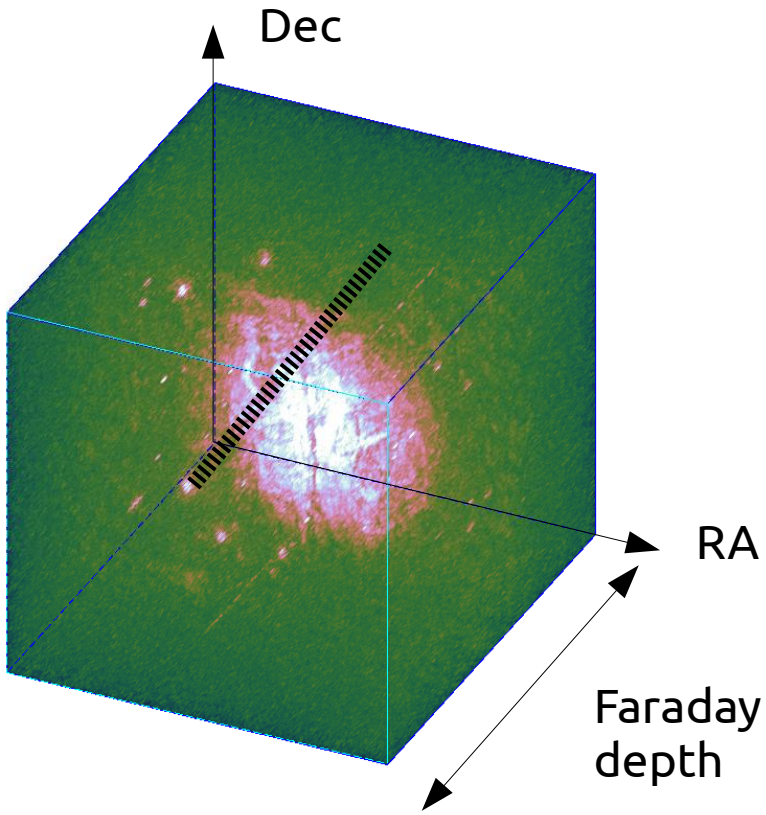

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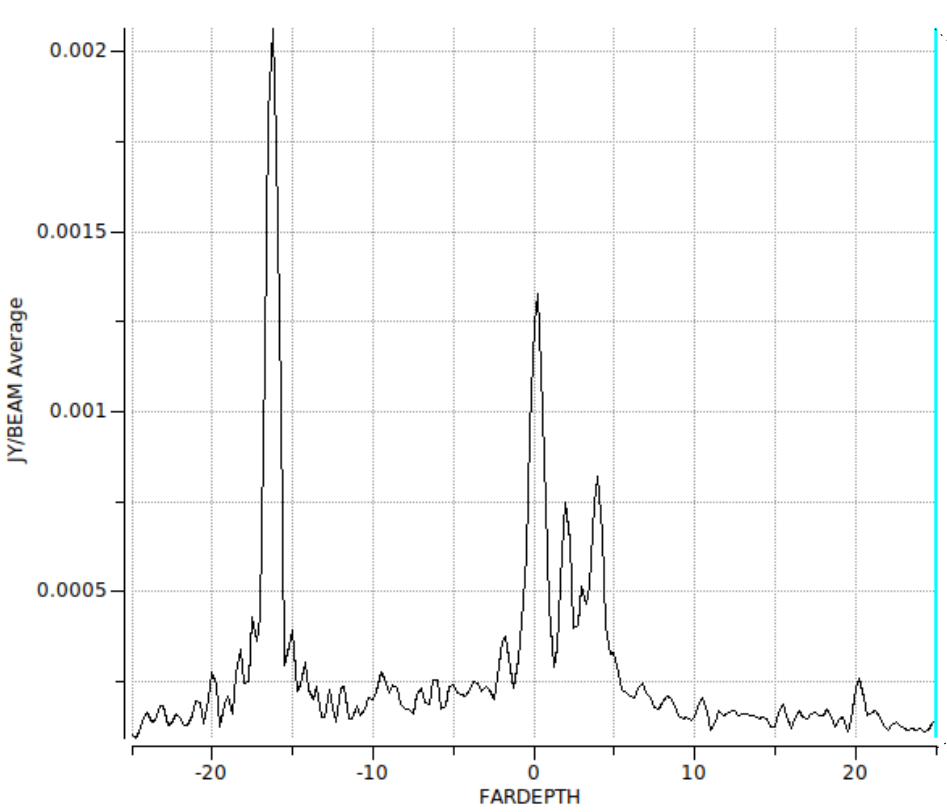
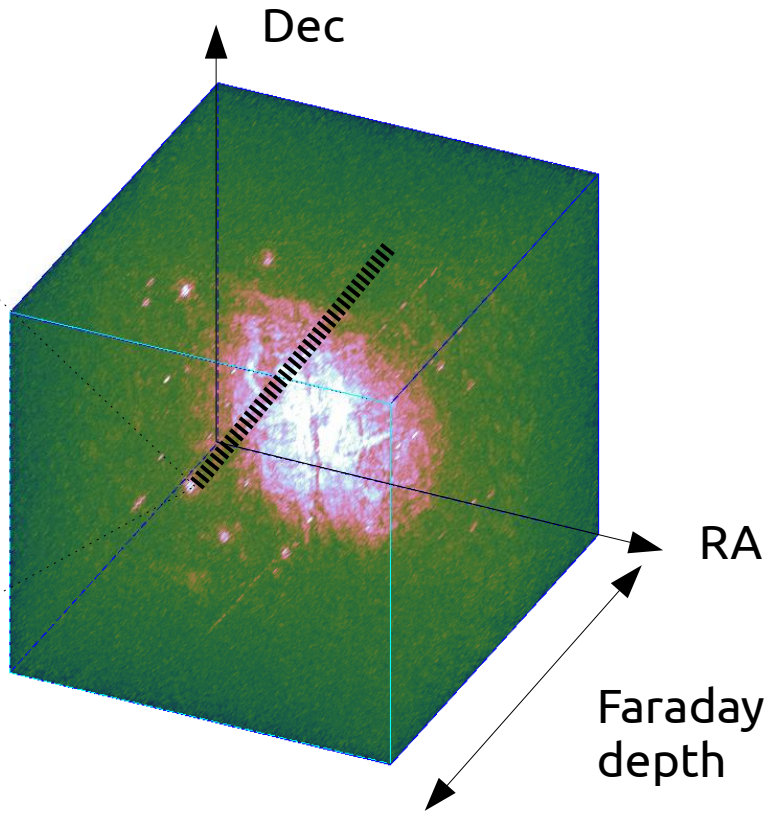
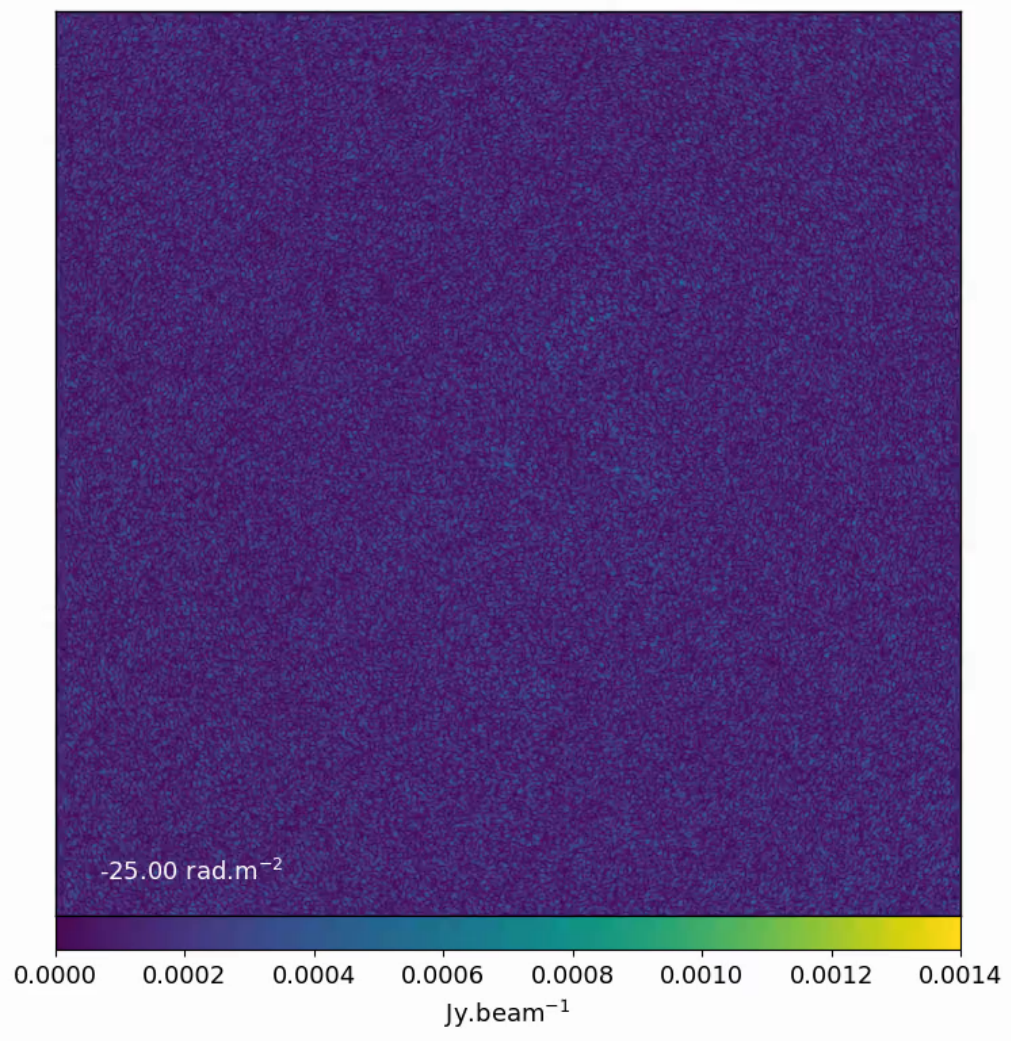




Faraday Tomography: video

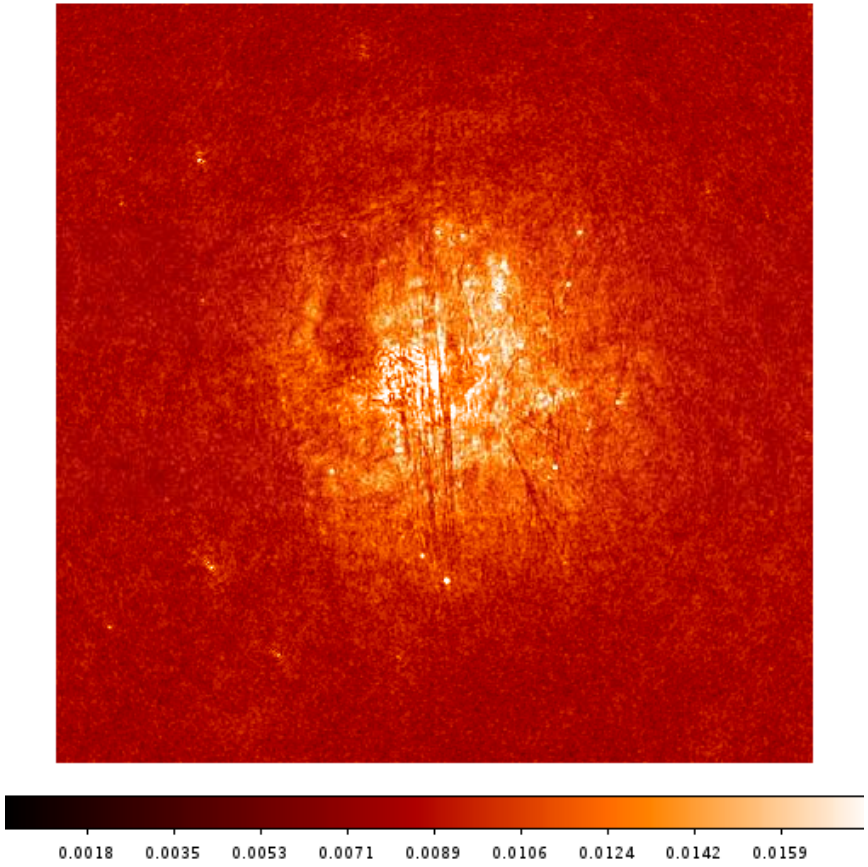


Moment maps

Moments: a 2D way to understand the 3D cubes

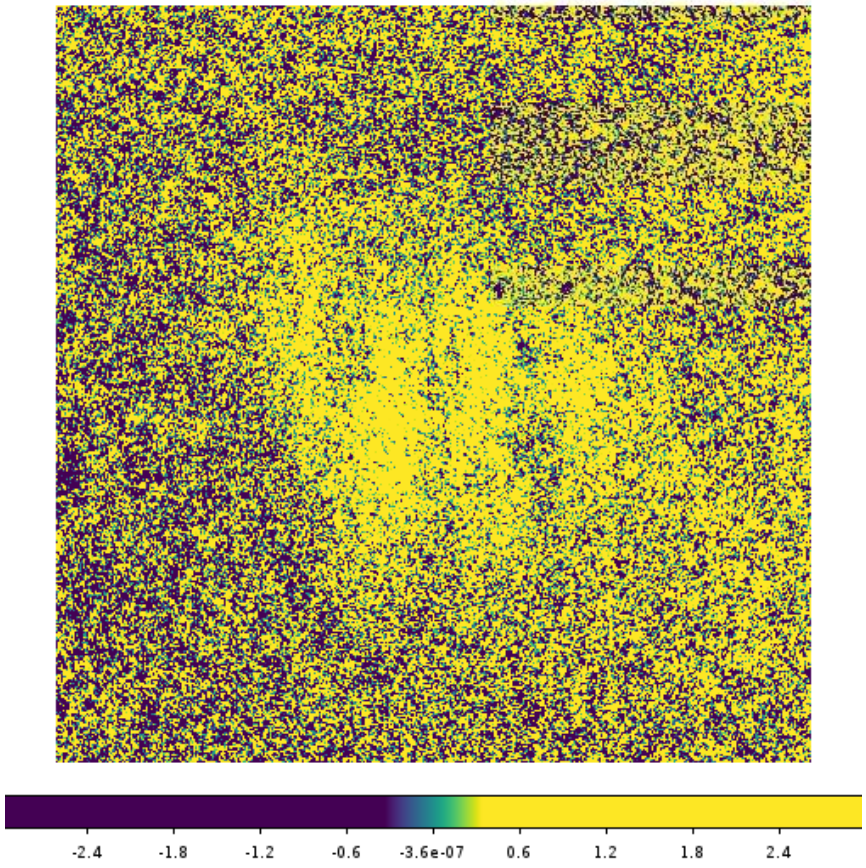
Moment maps

Moment 0: total linearly polarized intensity (Jy/beam * rad/m/m)



Moment maps

Moment 1: Faraday depth average weighted by polarized intensity (rad/m/m)



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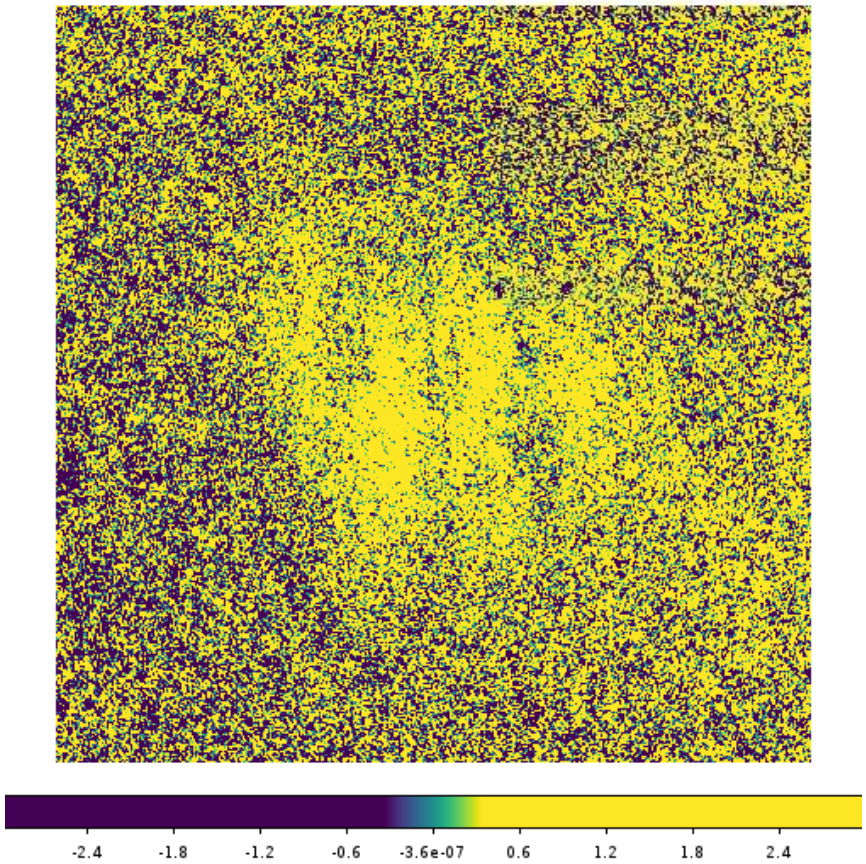
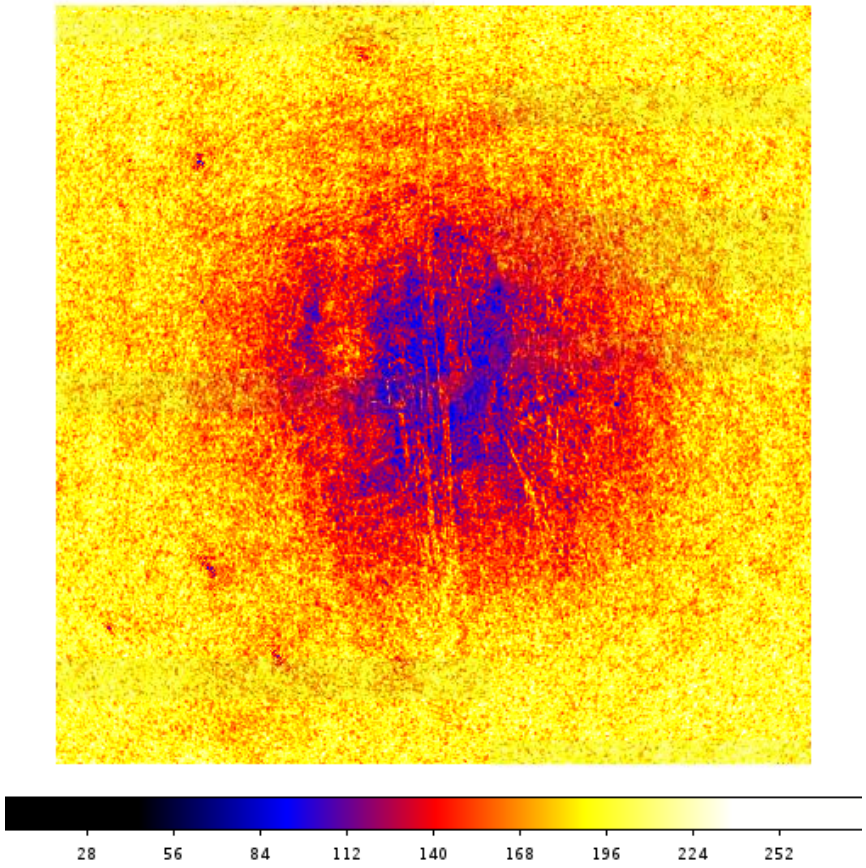


B-field direction: away from us towards us

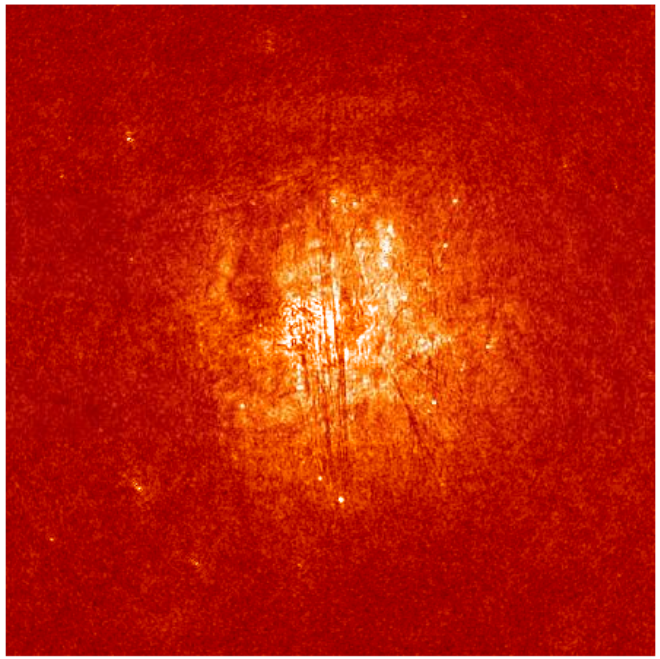
Moment maps

Moment 2: variance of the polarized intensity



Moment maps

Moment 0



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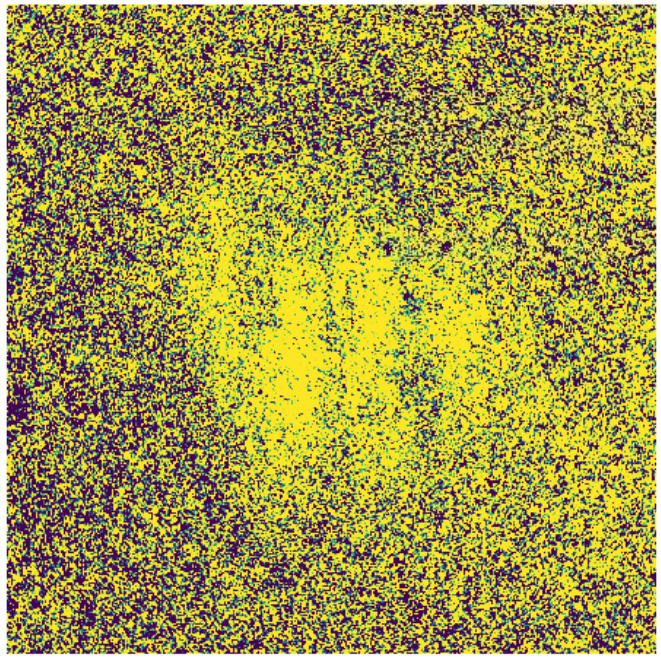
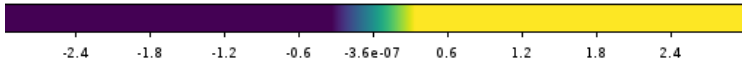
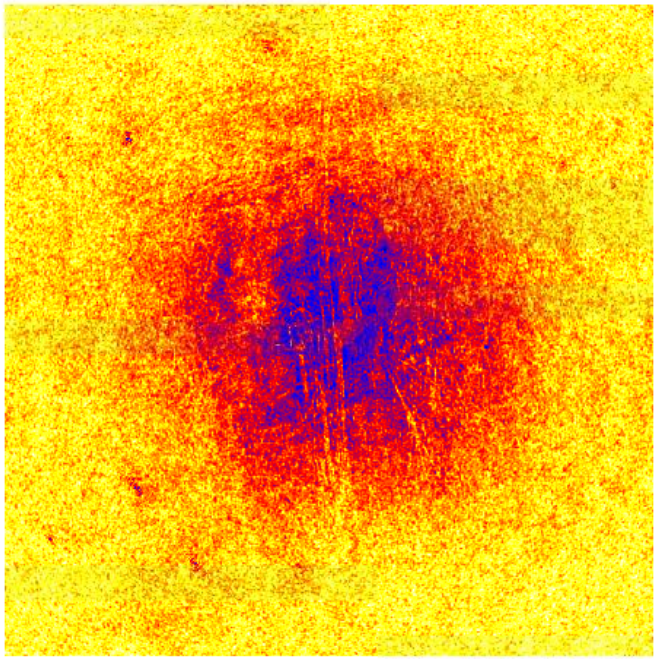
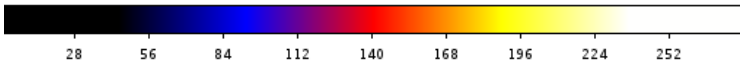




Moment 2



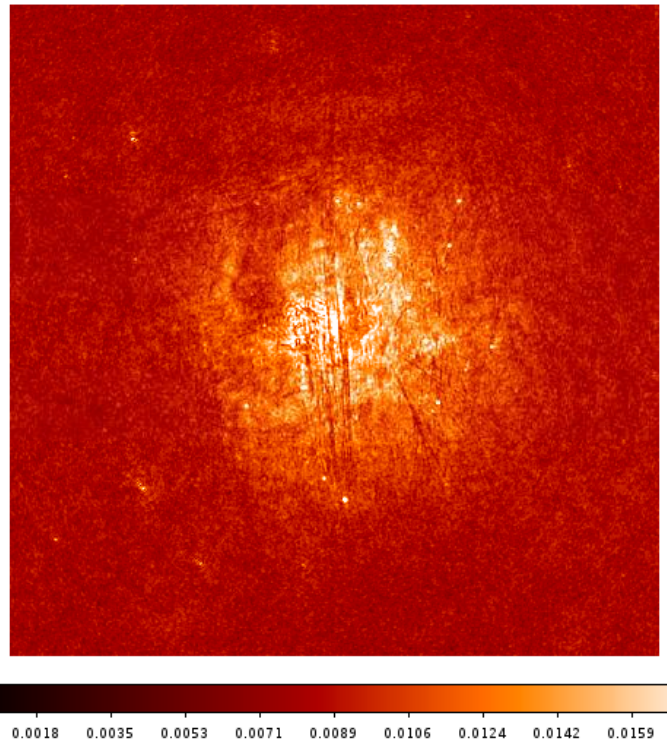


Moment maps

What are the linear features?

‘Faraday ghosts’ or ‘depolarization canals’ (for ex. see Shukurov & Berkhuijsen 2003)

Moment 0



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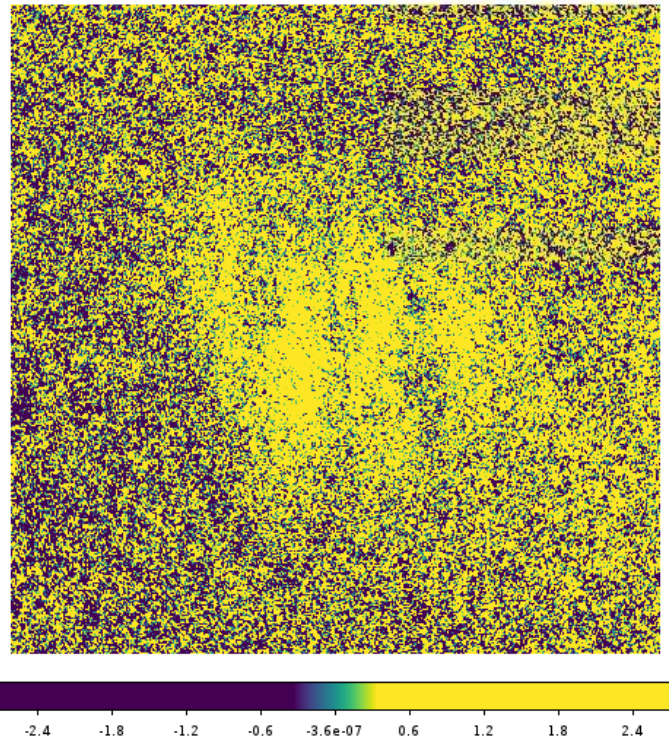
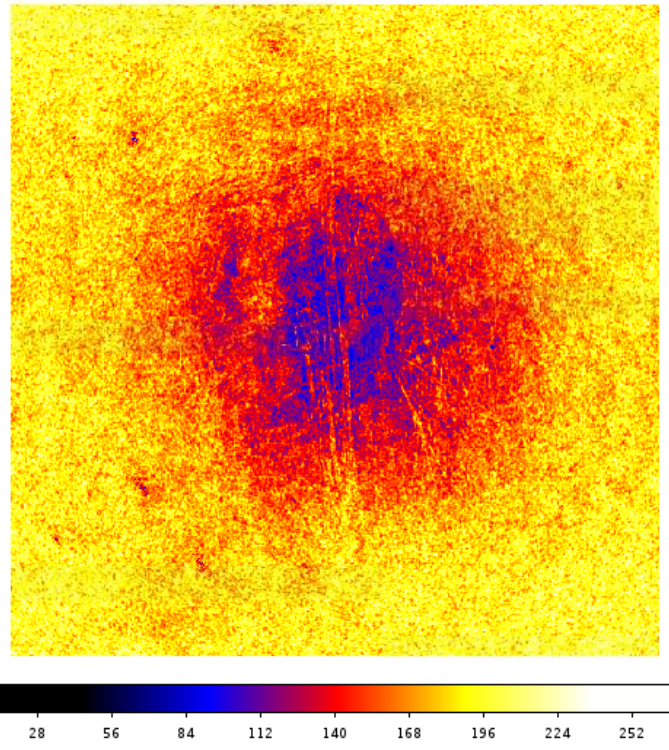


Moment 2



Takeaways

For polarization studies:

- Galactic foreground emission is important at low radio frequencies
- Use RM synthesis to disentangle the line-of-sight emissions

Thank you! Questions?