RM-synthesis: 9 years later

Michiel Brentjens

Radio Observatory
ASTRON, Dwingeloo, The Netherlands

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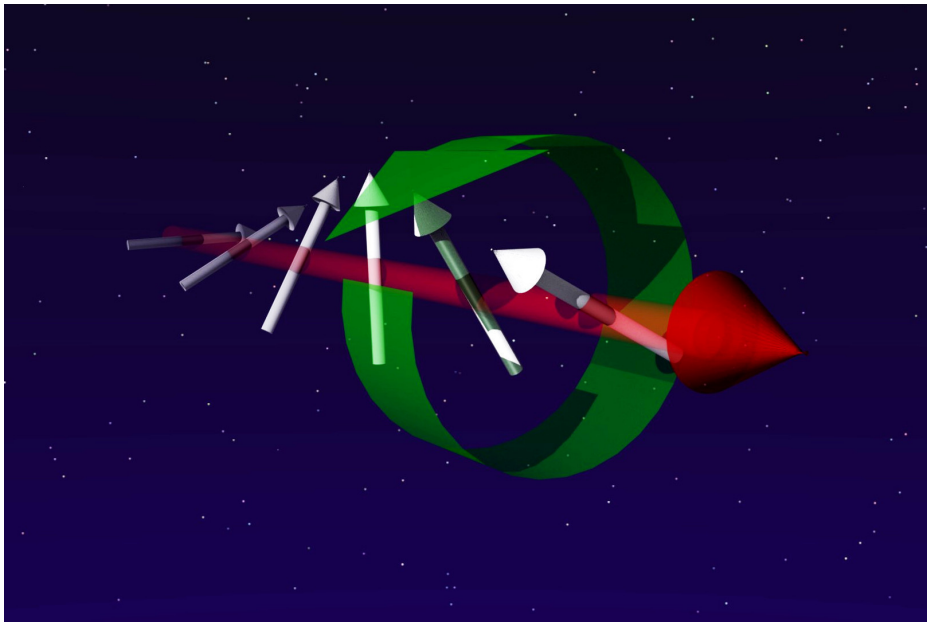
Faraday rotation

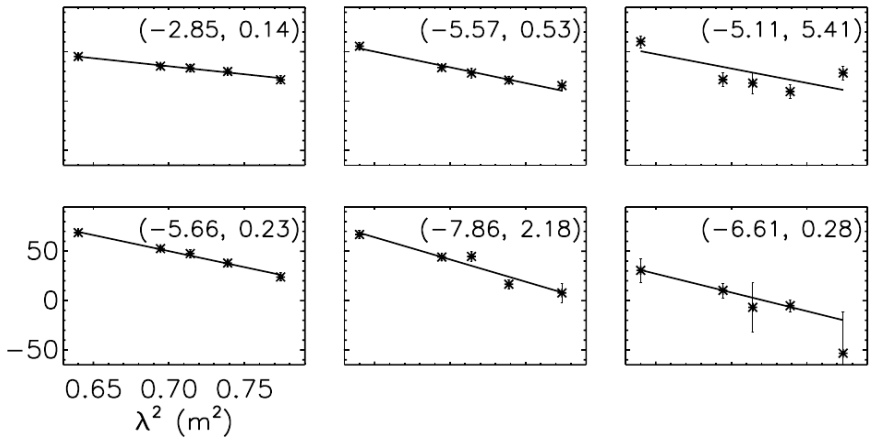


Process

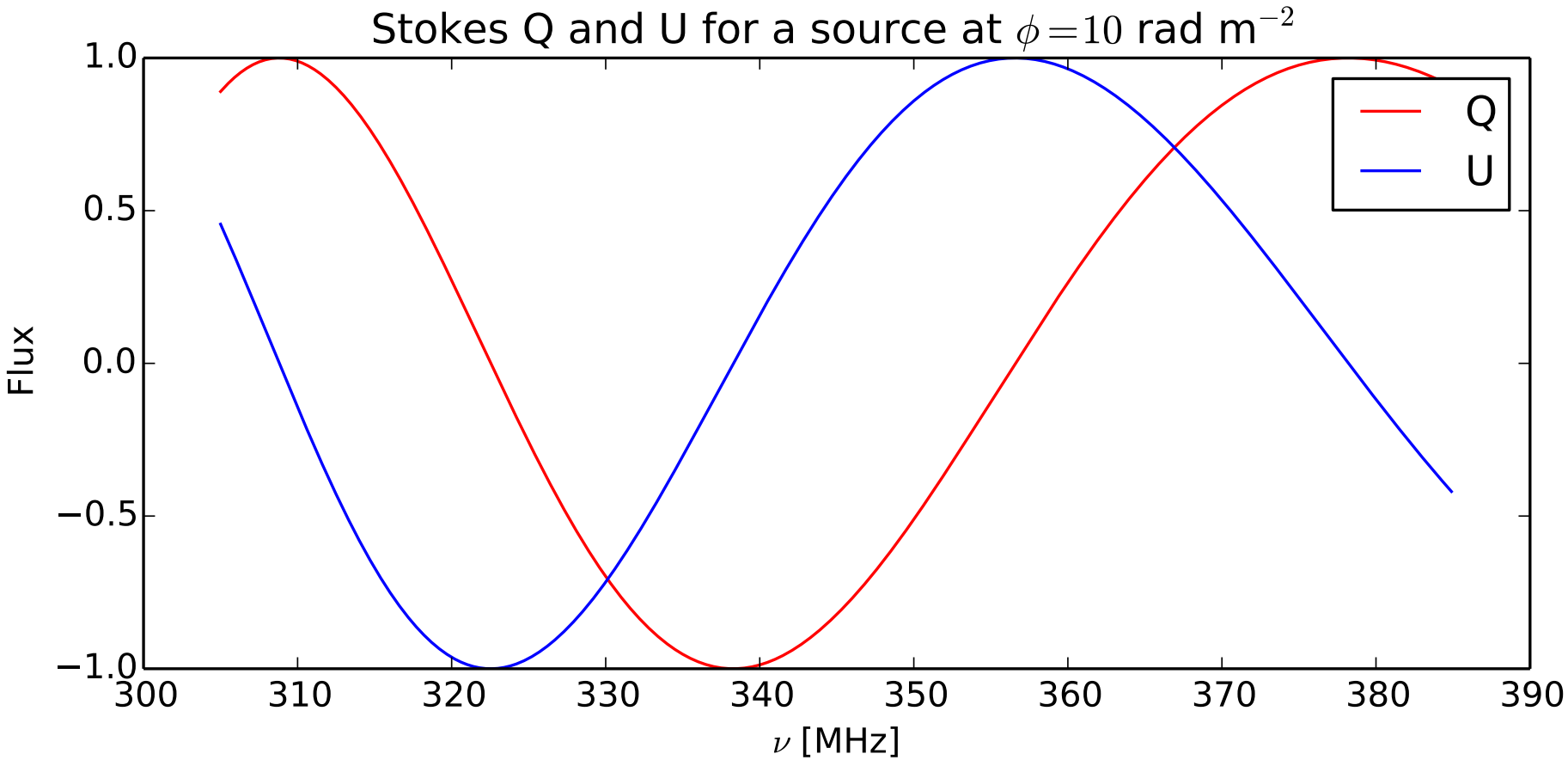
- Modifies polarization state
- Delay between LCP and RCP
- Rotates linear pol angle
- $\Delta\chi = \chi_0 + \phi\lambda^2$

$$\begin{aligned} \phi &= 0.812 \int_{\text{there}}^{\text{here}} n_e \mathbf{B} \cdot \mathrm{d}\mathbf{l} \\ P &= Q + \mathrm{i}U \\ P(\lambda^2) &= P_0 \mathrm{e}^{2\mathrm{i}\phi\lambda^2} \end{aligned}$$

λ^2 law *Haverkorn et al. (2001)*



Polarization at low frequencies: 10 rad m^{-2}



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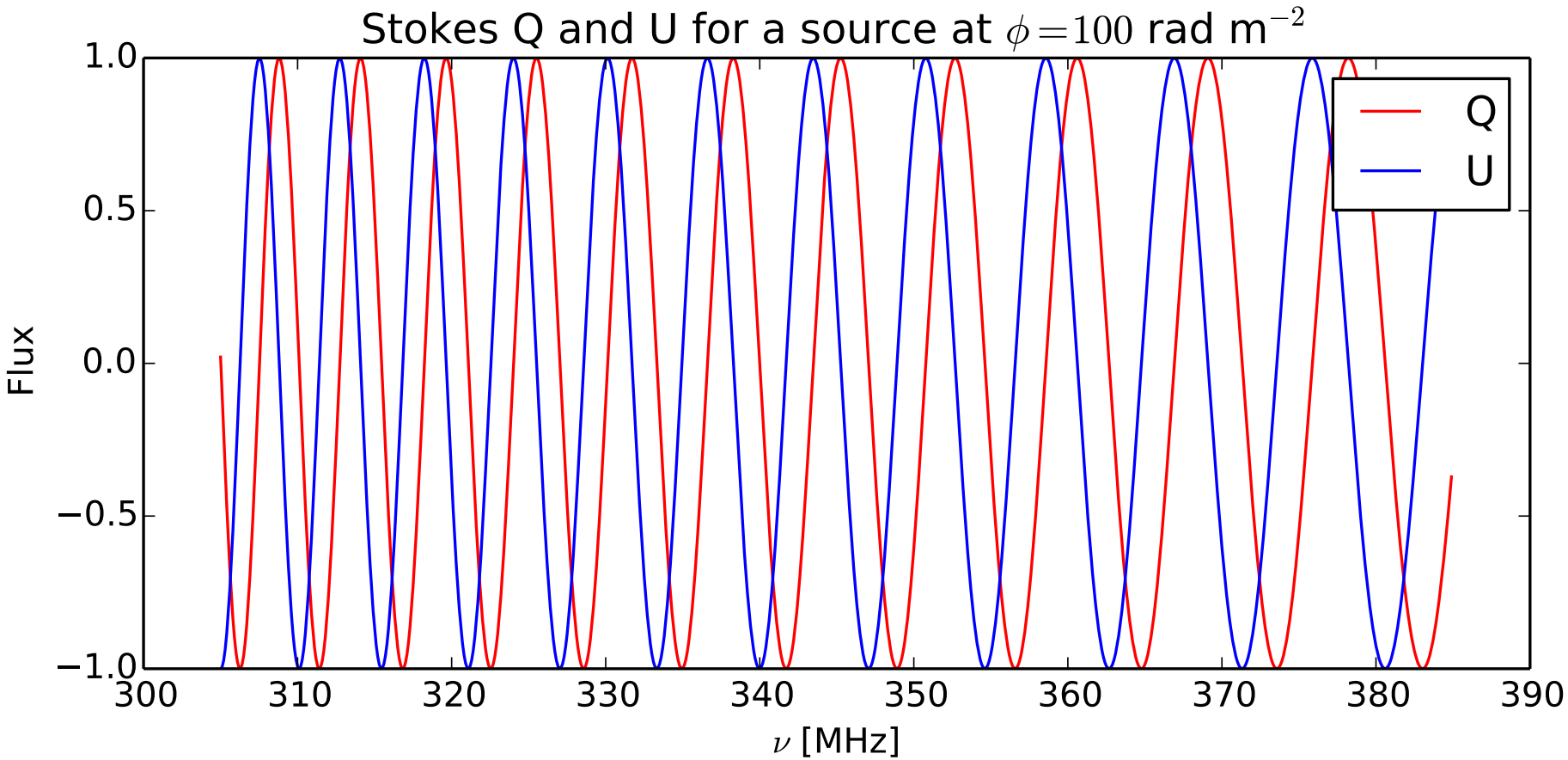


NETHERLANDS FOUNDATION FOR RESEARCH IN ASTRONOMY

NOTE 655

RM-synthesis via wide-band low-frequency polarimetry

MAART 1996

BY A.G. de Bruyn

Future applications

We expect the new tool to be particularly powerful in the study of weakly polarized extended sources, such as giant radio galaxies where the RM's are known to be small. Small changes in the RM across the surface of extended sources should be easily traceable, especially if these RMs are showing some spatial coherence.

The wideband spectrometer (the DZB) currently being built for the WSRT makes it possible to search for and study weakly polarized structure over a much wider range of RM. The side-lobe levels in the RMTF that occur with an 8-channel system will be much reduced when 128 frequency channels can be used to cover a wide (80 MHz) low frequency band.

Very small variations in RM can be expected to occur close to the core of AGN when polarized structure moves relative to a foreground Faraday screen. With a sensitivity of 0.1 rad/m^2 extremely sensitive measurements of the ionized gas around polarized radio sources can be made. If several sources with a well-determined RM are found wihin the synthesized field of view the fundamental limit imposed by the uncertainty of the ionospheric RM can be avoided by the study of *differential* RM variations. The diffuse galactic background emission, which is highly polarized at low frequencies, and has a typical RM of $\approx$ 5–10 rad/m^2, may well be useful as a non-variable RM reference.

The range in RM where the RM-synthesis technique will be a useful tool depends on frequency. At 1400 MHz, and a bandwidth of 160 MHz, this range begins at a few hundred rad/m^2. A practical limit, in real radio sources, will occur when depolarization due to fine-scale structure in RM within the beam, i.e. beam-depolarization, begins to dominate over bandwidth-depolarization.

A final intriguing possibility opened up by low frequency wide-band polarimetry is the study of the Faraday rotating material *within* radio sources. The Fourier-relationship between the complex polarization and the 'Faraday depth' suggests that observations over a large range in frequency may be used to derive information about the spatial disposition of the emitting and depolarizing material.

SINGS survey NGC 6946 *Heald et al. 2009*

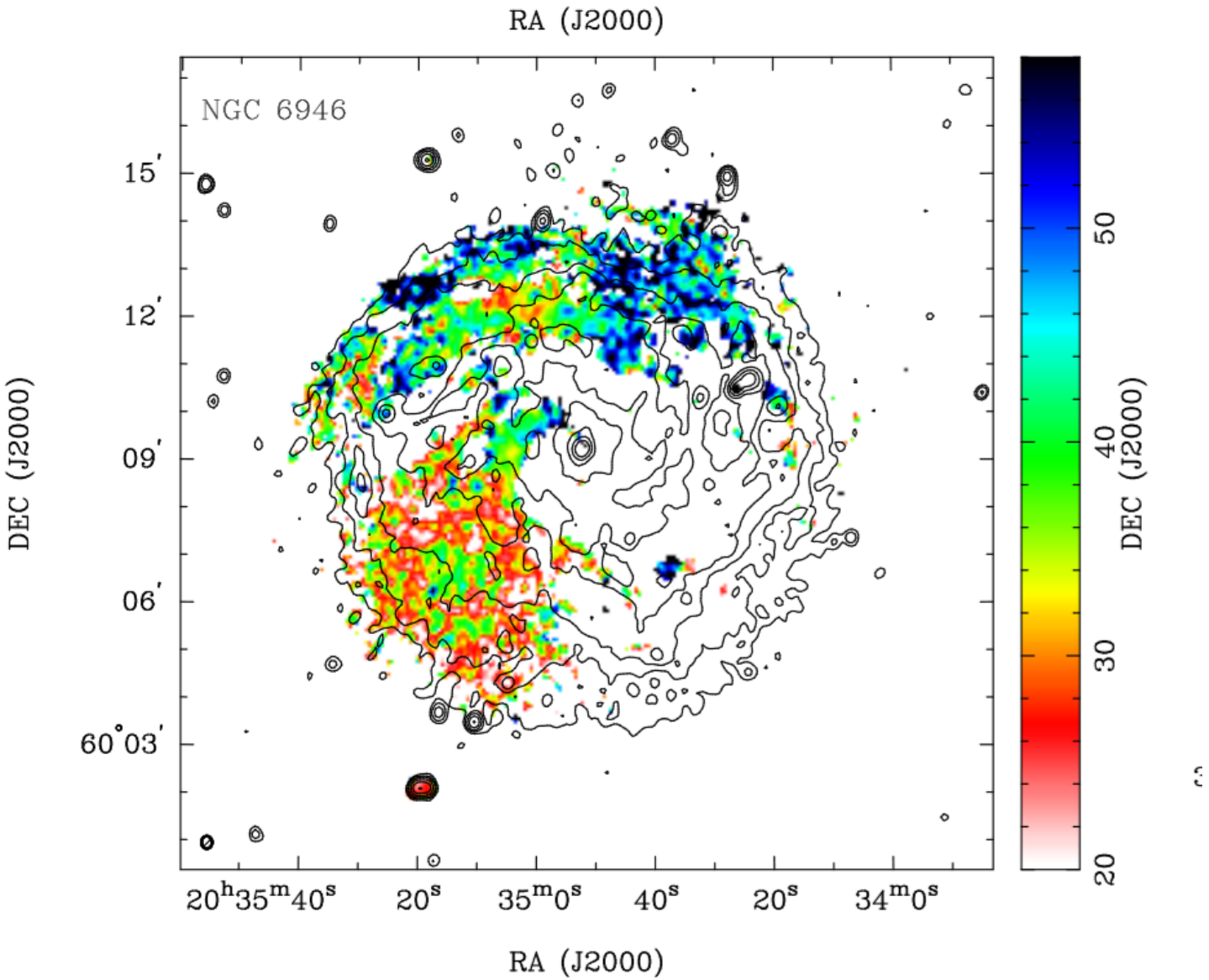


Fig. 6. (continued) Images of peak ϕ in some of the survey galaxies.

SINGS survey Faraday spectra

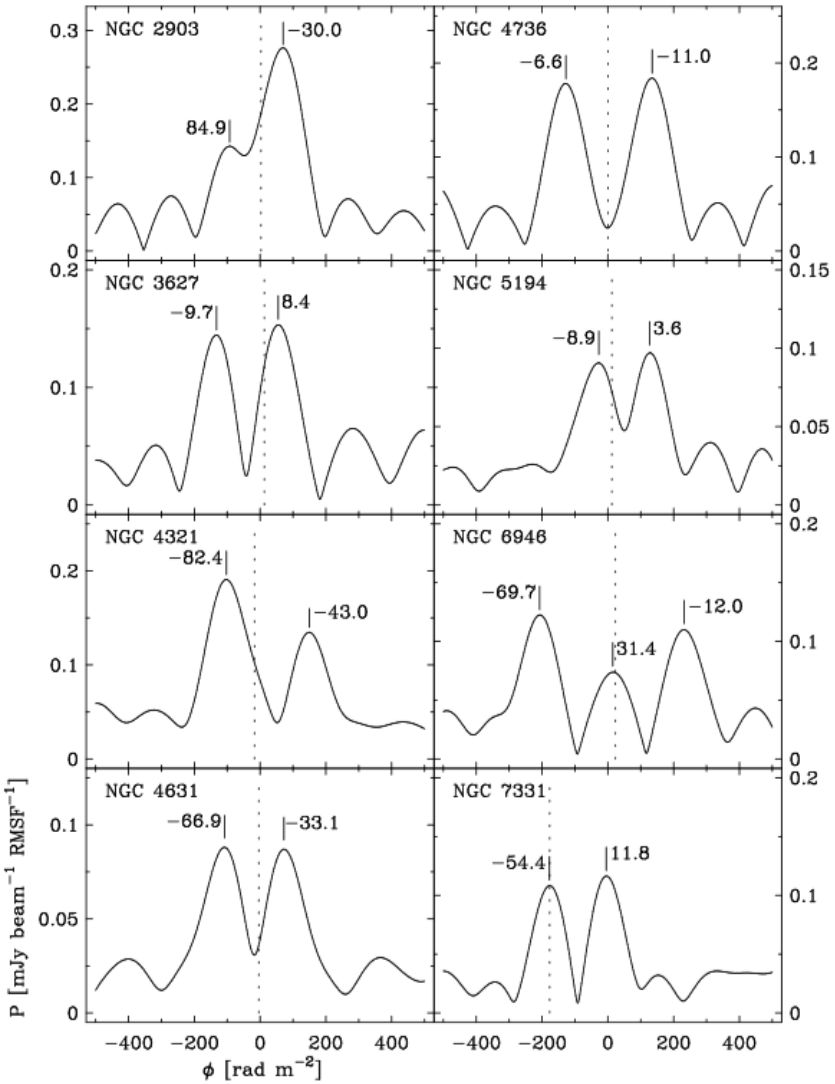
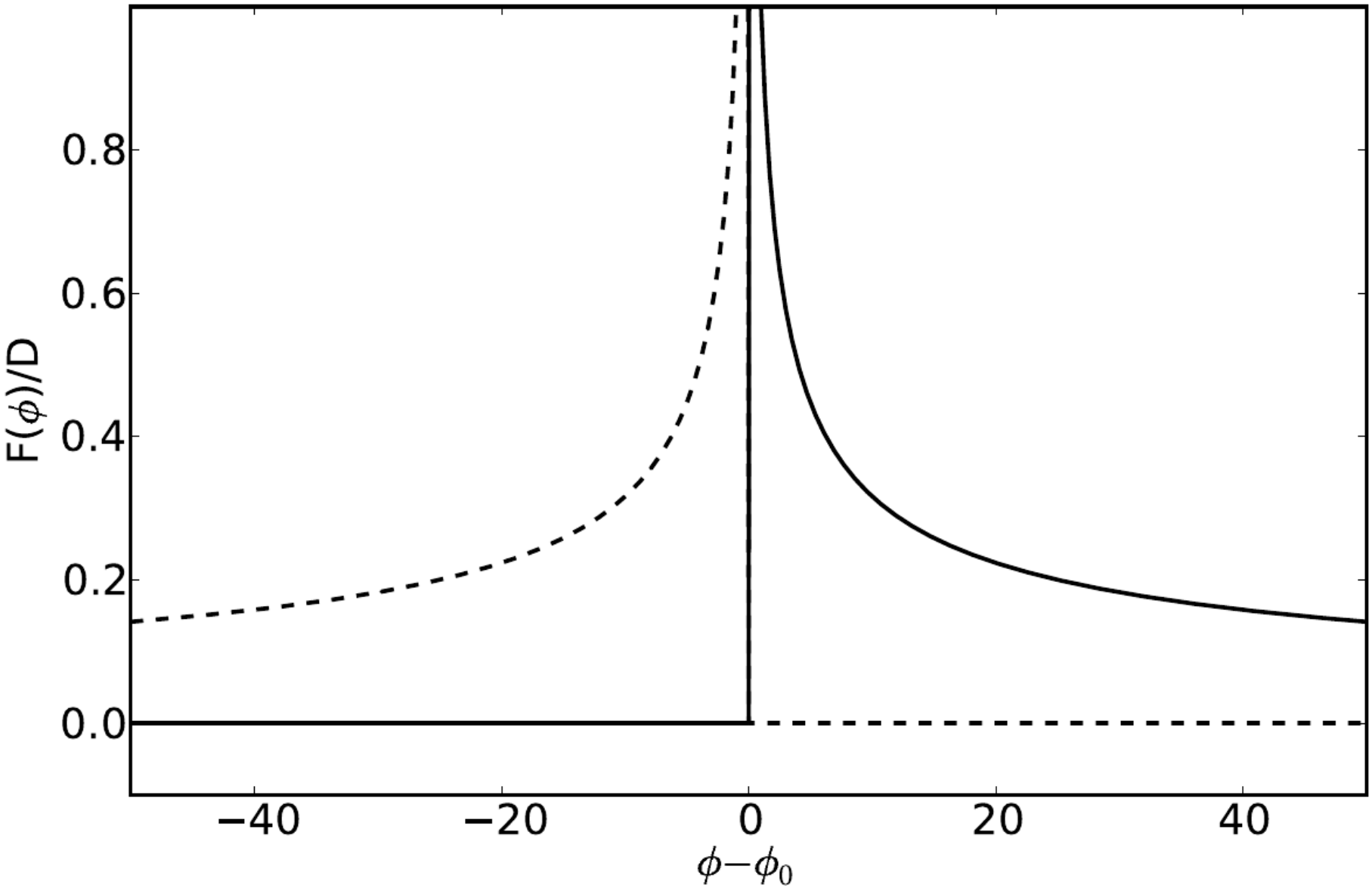


Fig. 7. RM spectra extracted from the central regions of the indicated galaxies (coordinates are listed in Table 3). Features with tabulated characteristics are indicated with solid lines; the polarization angle at that value of RM is indicated. The Galactic foreground contribution (from Table 1) is indicated with dotted lines.

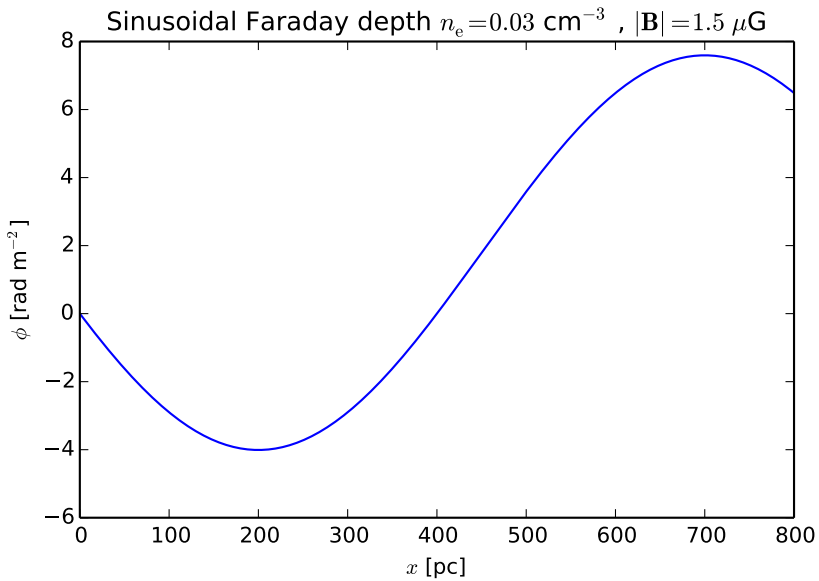
Challenges

- Accurate reconstruction of Faraday spectra
- . . . *quickly*. . .
- Inference of physical properties still at cartoon / sketch level.
- Important progress in Bell, Junklewitz & Enßlin (2011).

Faraday Caustics *Bell, Junklewitz, Enßlin (2011)*

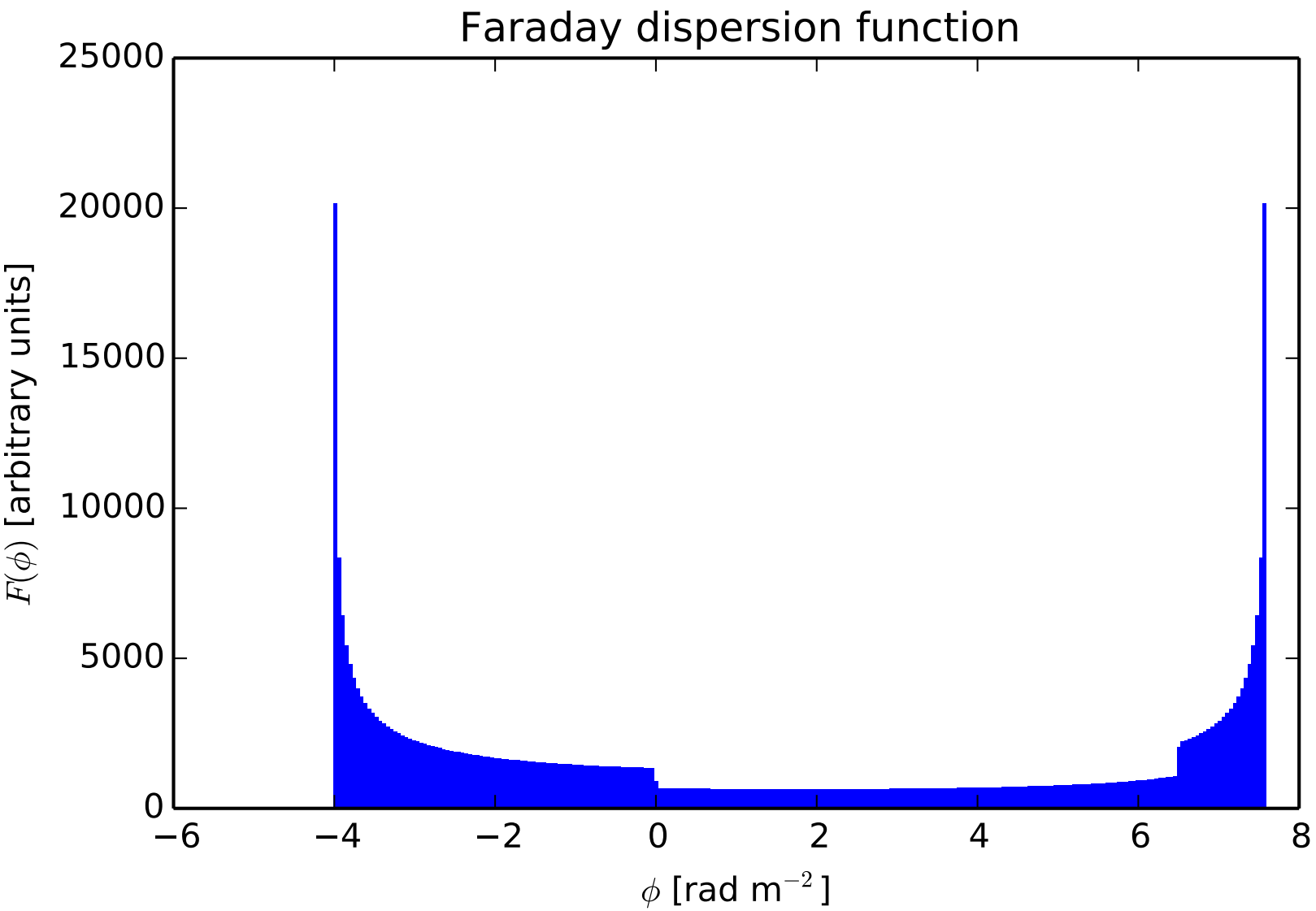


A simplistic model to understand caustics

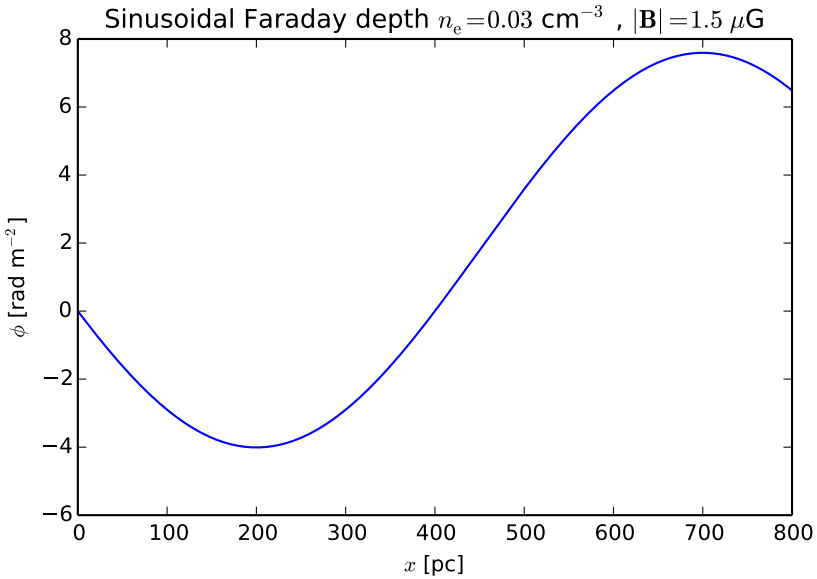


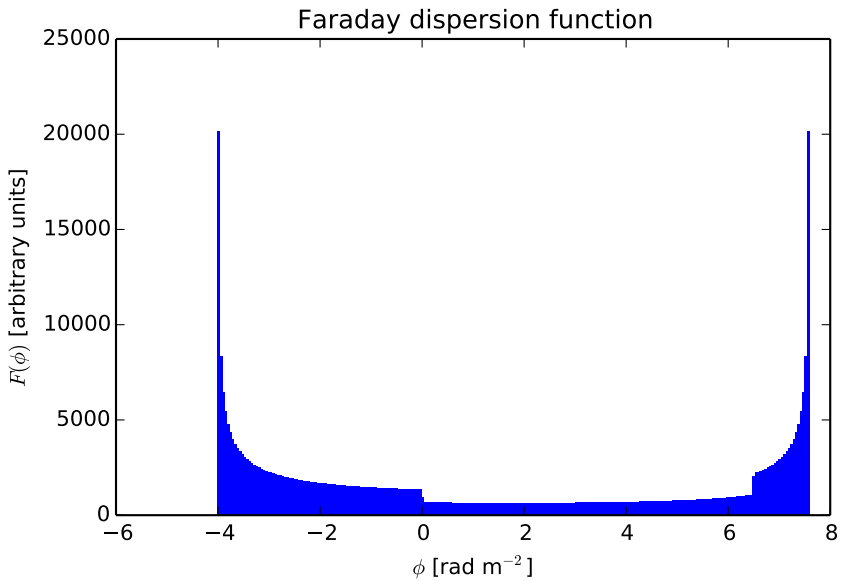
- $n_e = 0.03$ cm^{-3}
- $\|\mathbf{B}\| = 1.5$ μG
- Line of sight in Galactic plane
- **B** is in Galactic plane
- **B** rotates around vertical pivot
- angle $\propto x$, period 1 kpc
- Synchroton emissivity uniform

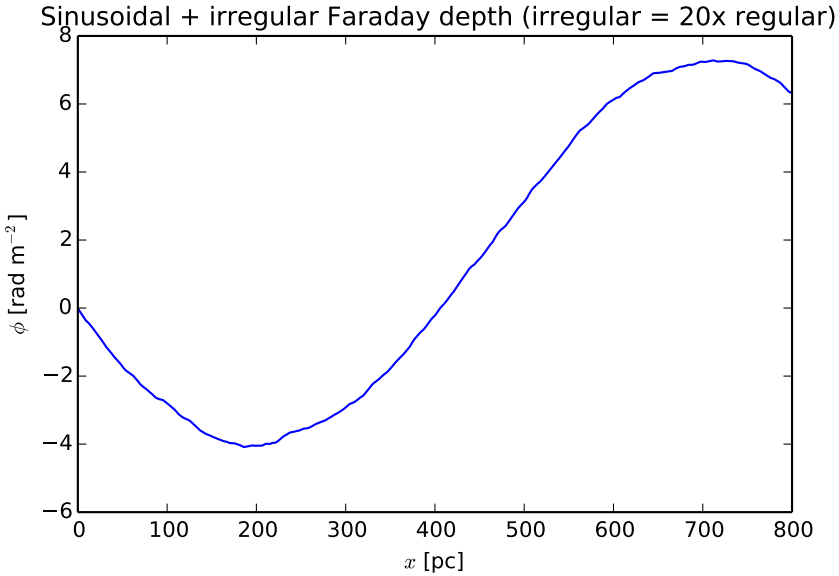
Faraday dispersion function

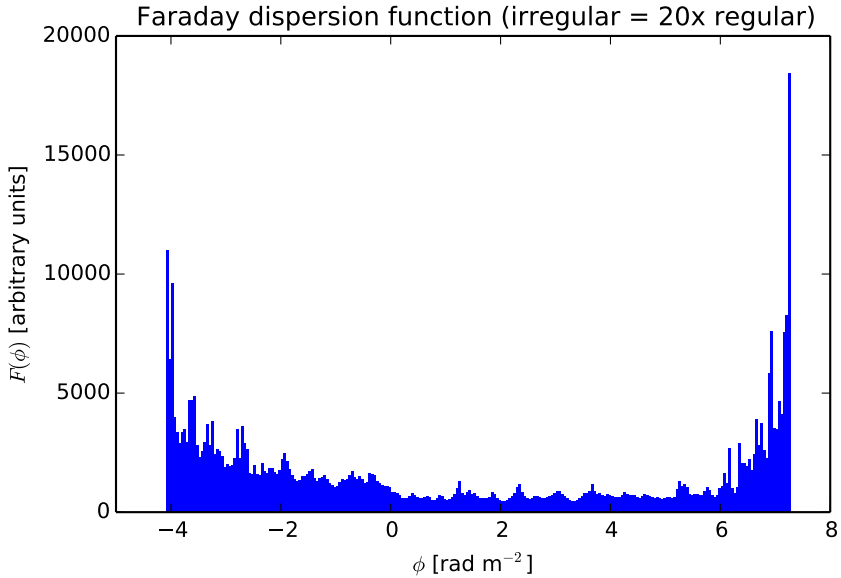


Faraday dispersion function

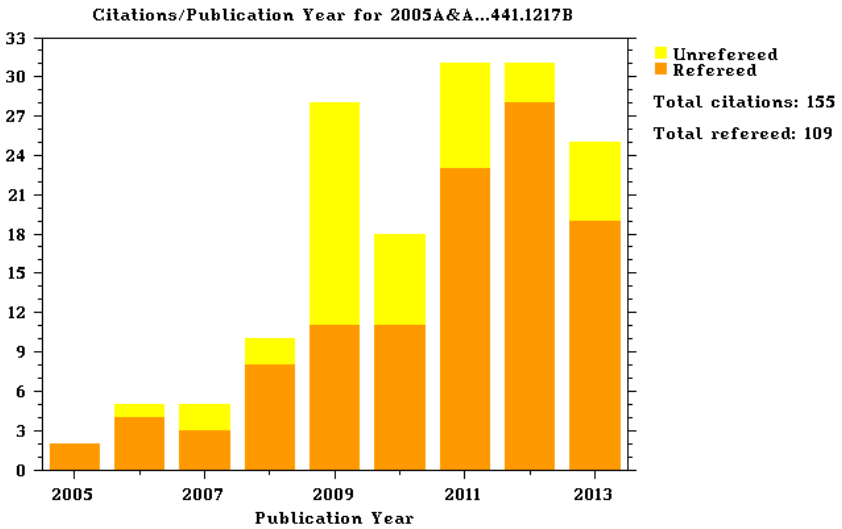








Finally



- Brentjens & de Bruyn (2005) RM-synthesis paper is doing well.
- RM-synthesis is a great detection technique.
- Interpretation of $F(\phi)$ still "sketchy".
- Bell et al. (2011) may hold key to fixing this.