Rotation Measure Synthesis of the Local Magnetized ISM:

The B-field of a Nearby HI Bubble

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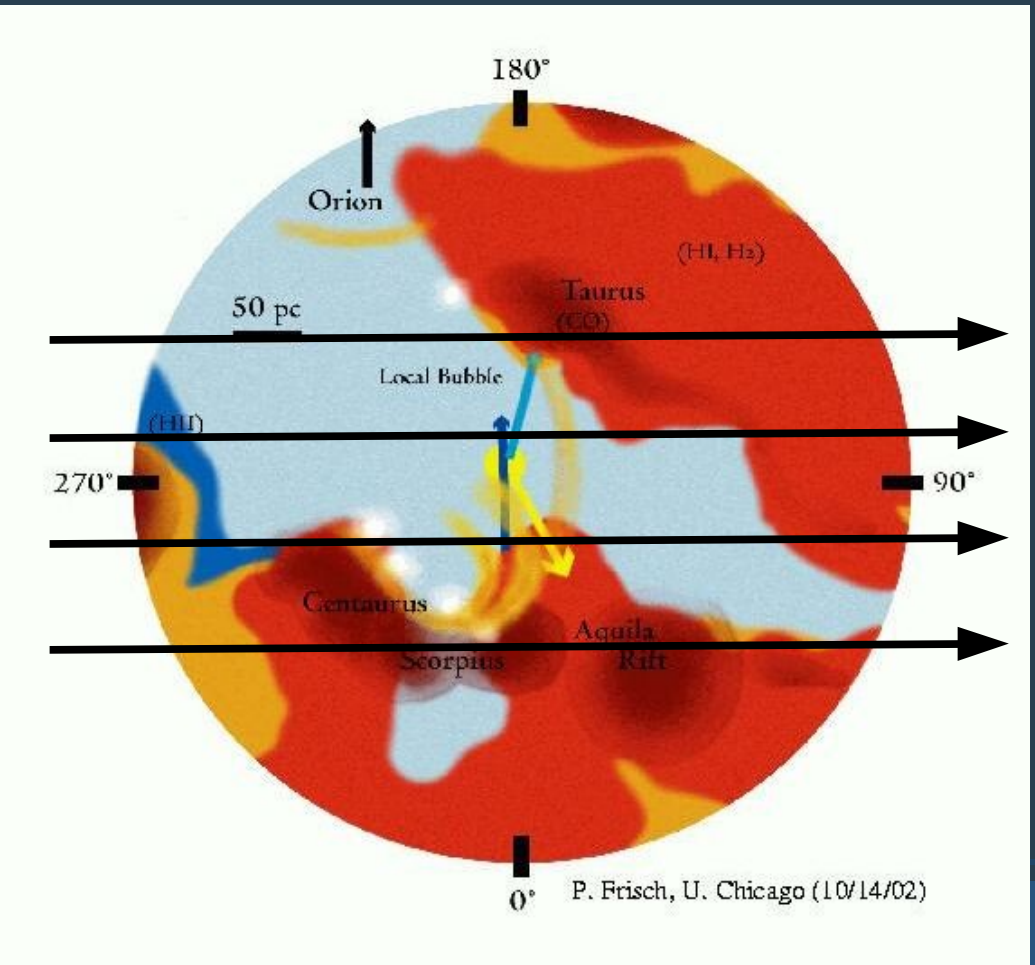
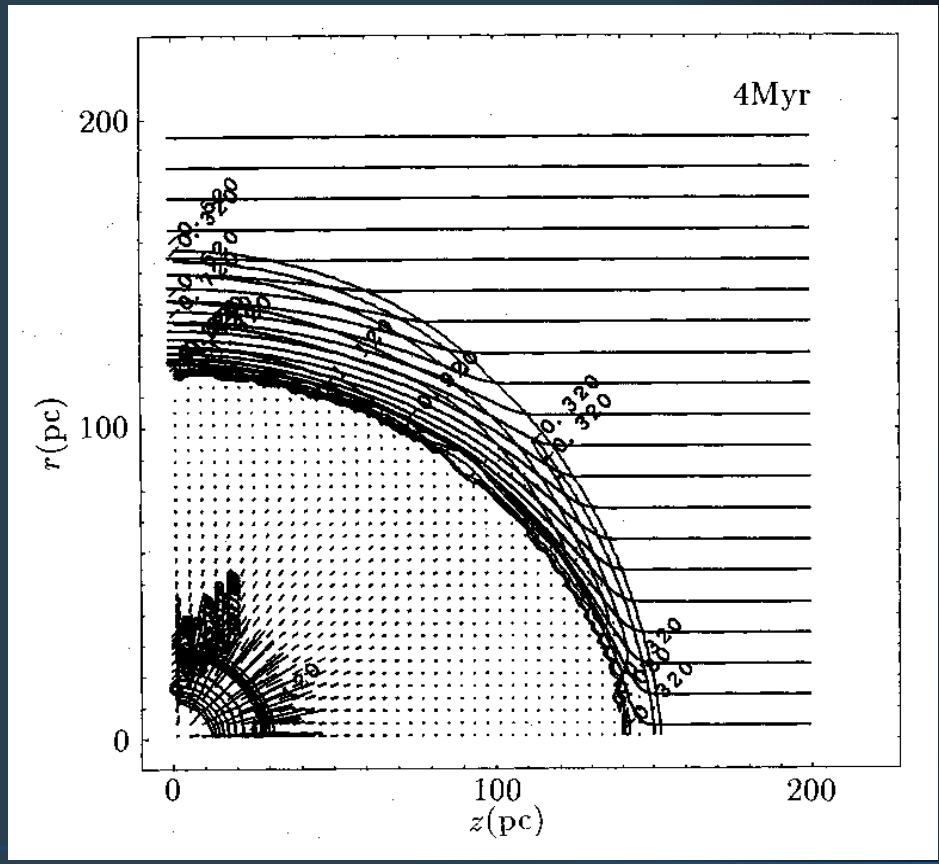
The Local ISM

- Local Bubble, mean local B-field pointed towards l=90°
- Expanding shells sweep up and compress the ambient B-field
- Scorpius Centaurus association ~100pc away towards the Galactic centre

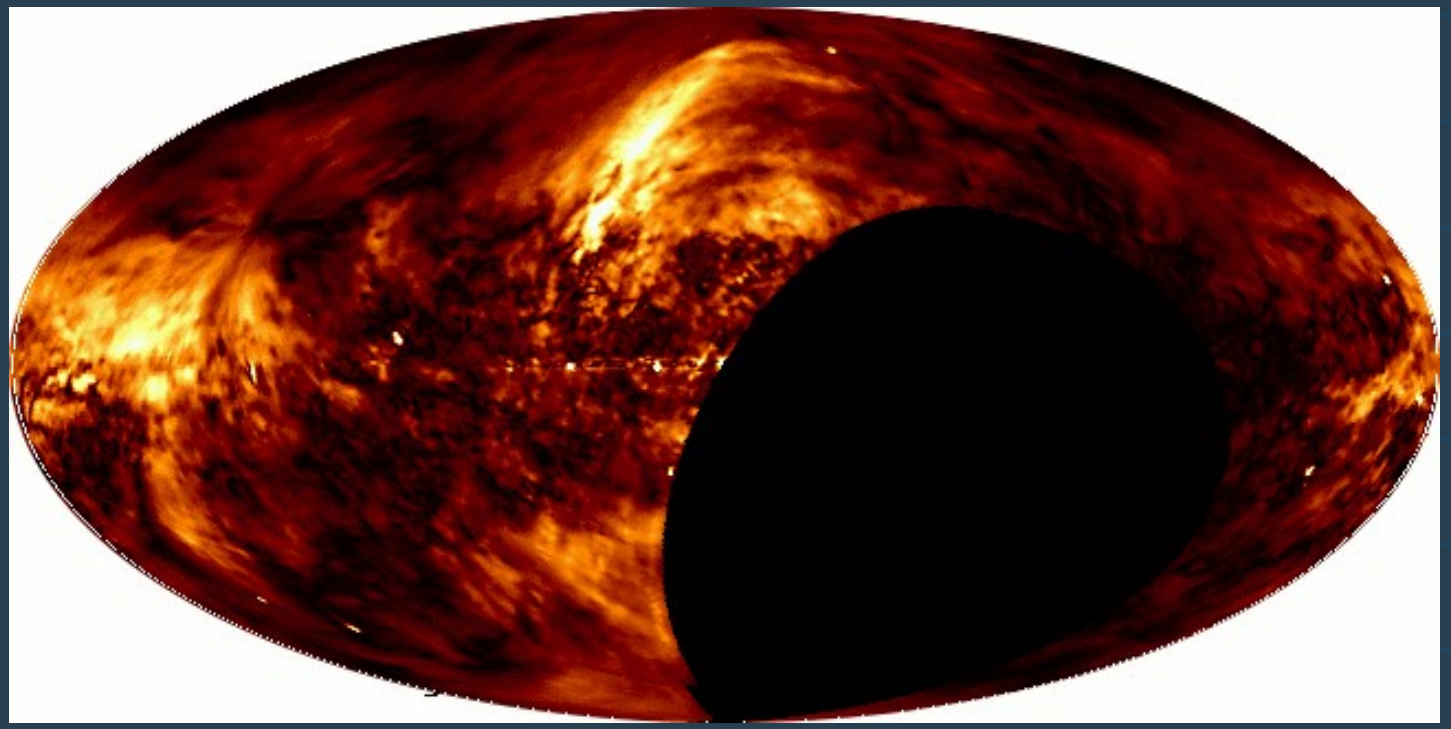




Tomisaka, 1992

Polarized Emission Surveys

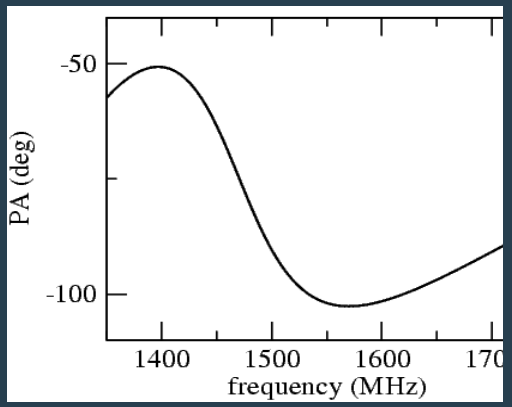
- Polarized Intensity at 1.4 GHz
- Single frequency surveys (CGPS, EMLS, DRAO, Testori et al.)
- Data suffer from depolarization due to differential Faraday rotation and beam depolarization
- Polarized filament of the North-Polar Spur (local)
- Rotation measures unknown from these observations



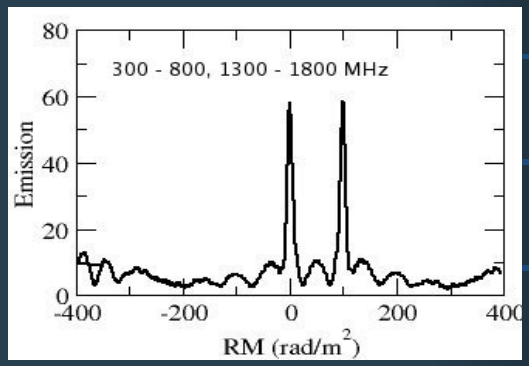
Wolleben et al. 2006

Rotation Measure Synthesis

- Usually polarization angle does not depend linearly on λ^2
- RM-Synthesis is a Fourier Transformation of Stokes U & Q
- Derotation of Faraday-rotated emission using a set of assumed RM values
- Resolution in RM-space (Faraday depth φ) depends on λ^2 coverage



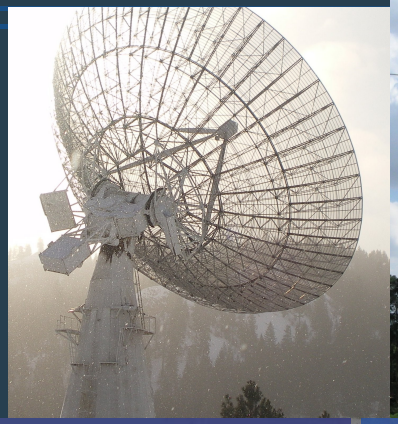
RMS

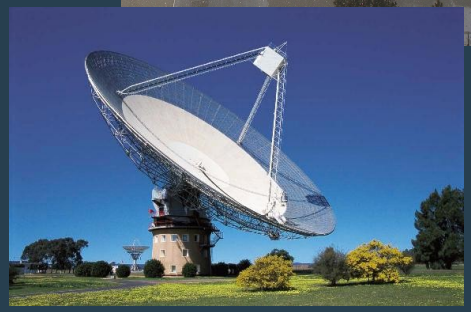


Polarization angle for a simulated line-of-sight

the RM-Spectrum for this line-of-sight

GMIMS: The Global Magneto Ionic Medium Survey



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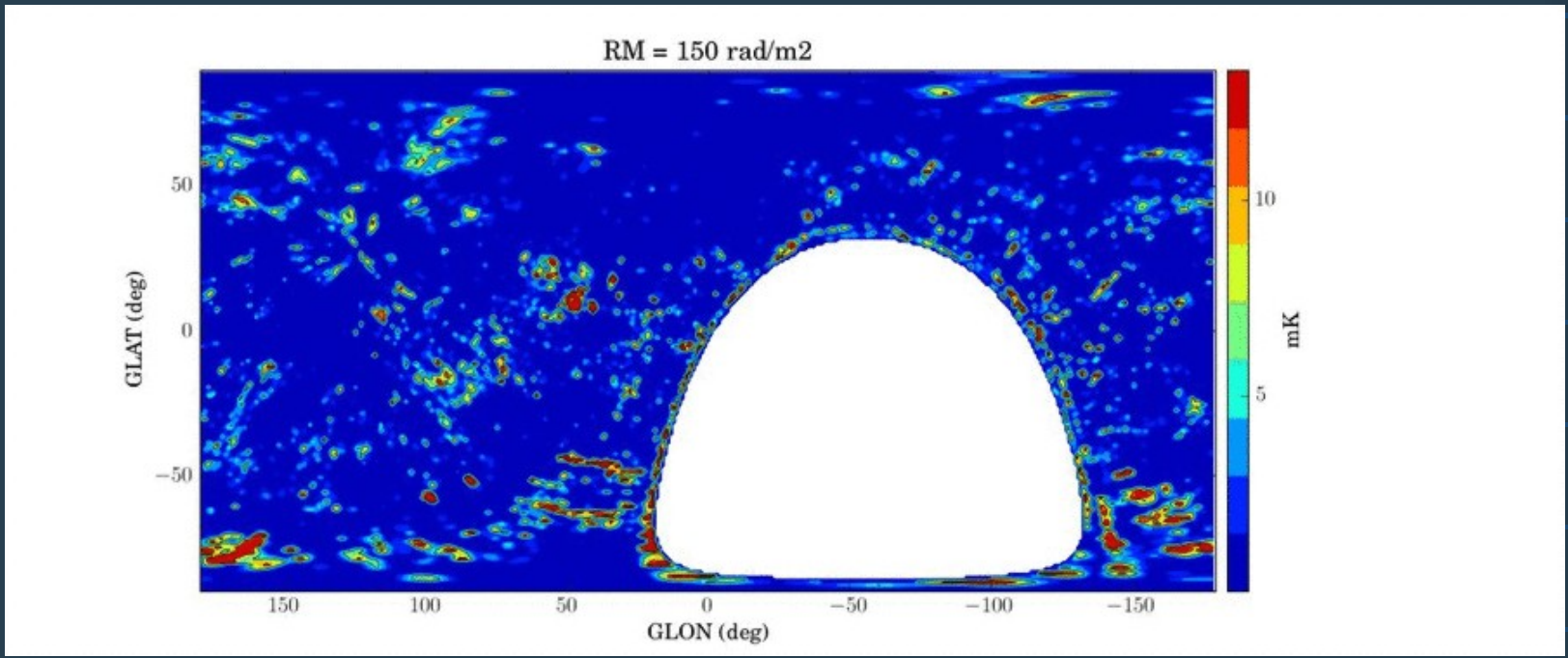
Univ. of Calgary, Canada	R. Taylor
DRAO, Canada	M. Wolleben (PI)

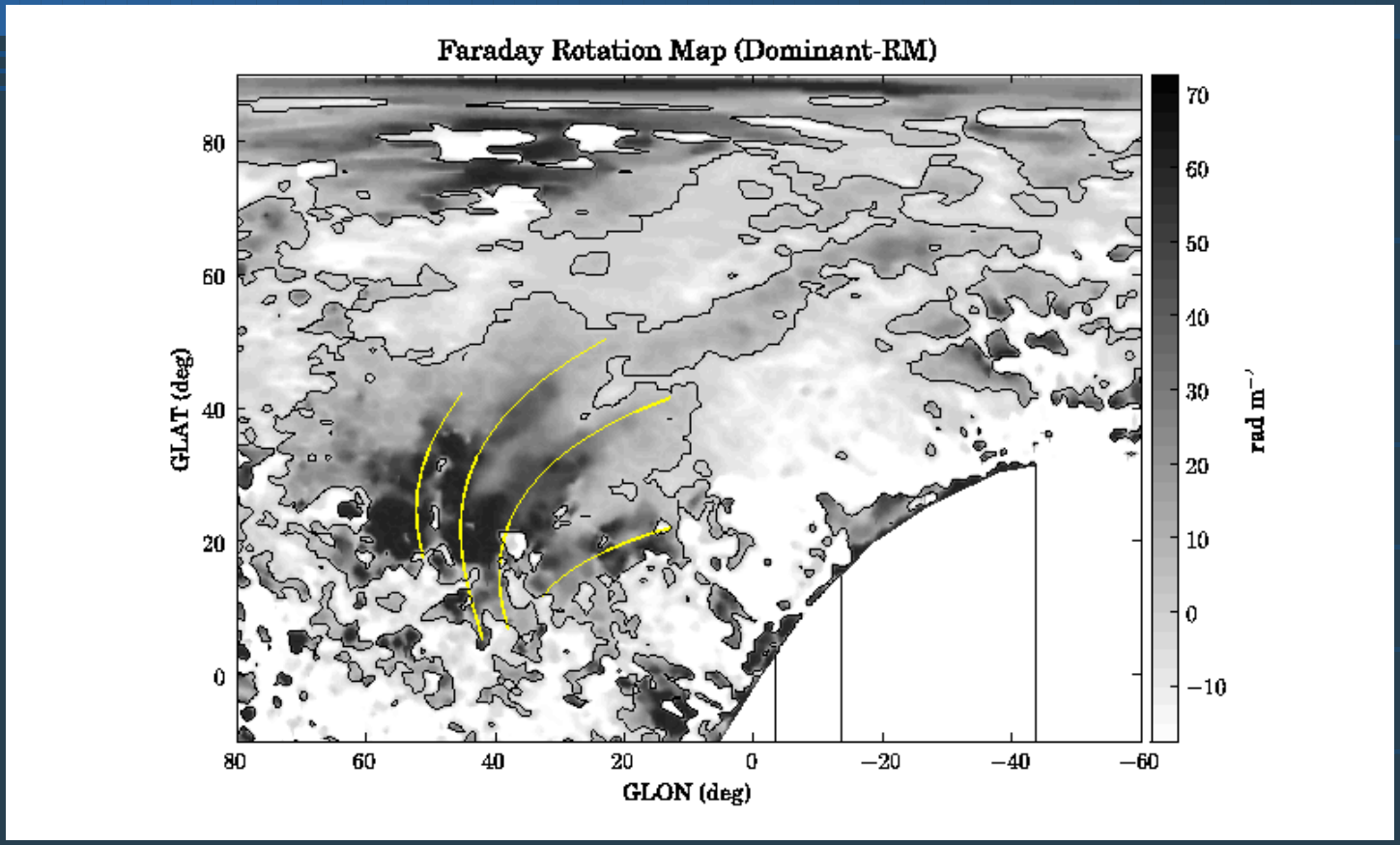
300 -800 MHz	Effelsberg 100-m	Rx under constr.
800 -1300 MHz	Kunming 40-m	feas. study
1300-1800 MHz	DRAO 26-m	55% complete
300 -900 MHz	Parkes 64-m	30% complete
800 -1300 MHz	?	
1300-1800 MHz	STAPS,Parkes 64-m	100% complete, PI: M. Haverkorn

GMIMS: The Global Magneto Ionic Medium Survey



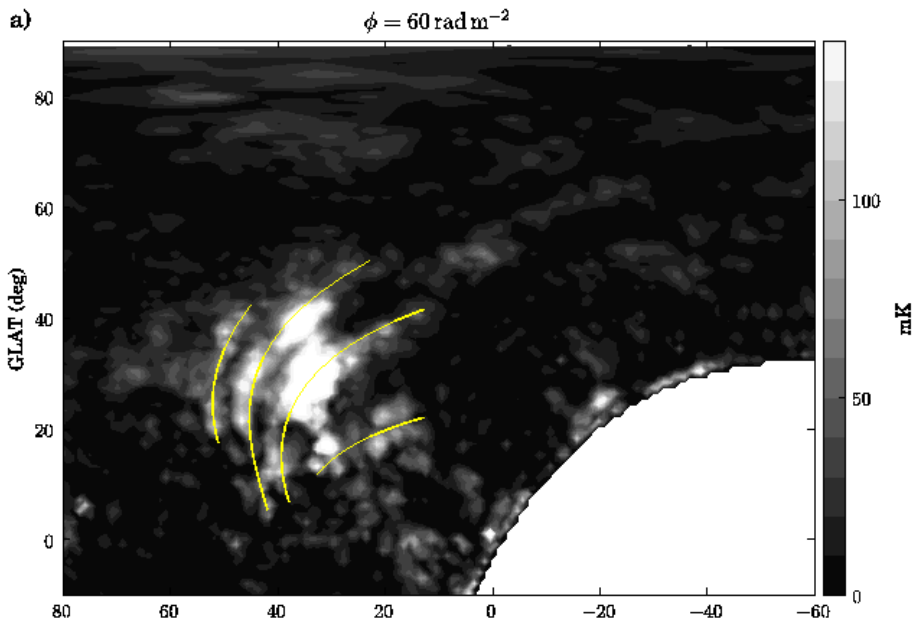
- RM-Synthesis Cube, Galactic coordinates, third dimension: Faraday depth φ
- First data from GMIMS North (1.3 – 1.8 GHz), 2048 frequency channels
- rms noise: 25 mK in a single channel, 1 mK in an RM-Synthesis frame
- RM cleaning performed
- Resolution in Faraday depth: 132 rad/m^2
- Largest scale in Faraday depth: 106 rad/m^2

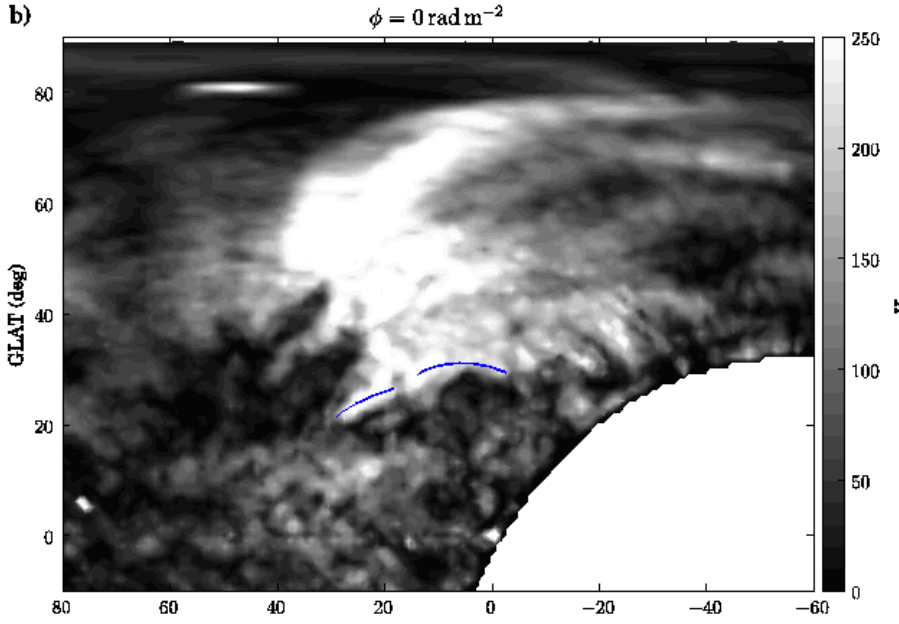
Faraday Rotation Map

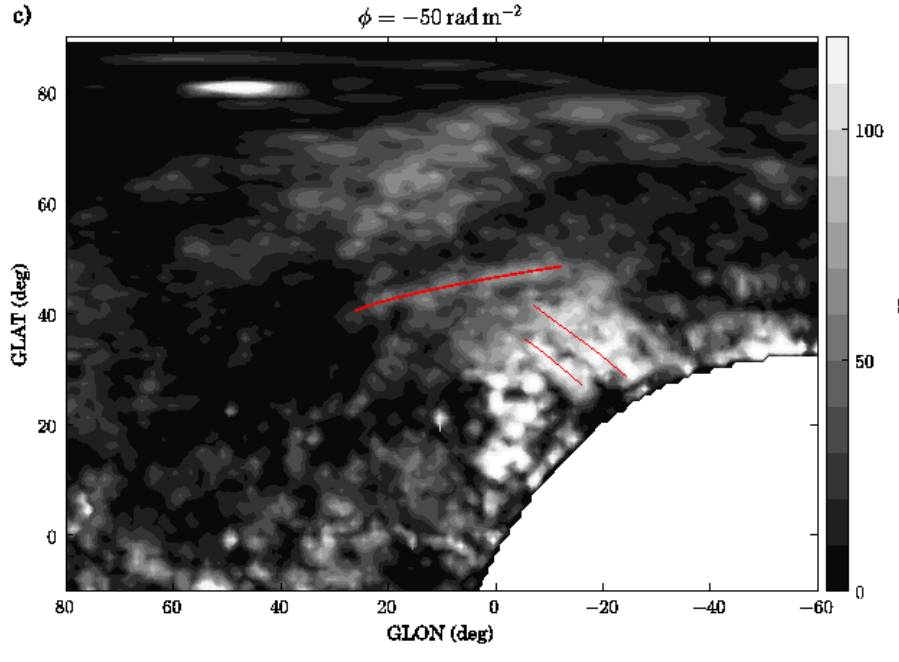


- Map shows φ of the dominant emission in each pixel
- (the position of the peak in the RM-Synthesis spectrum for each pixel)
- Grey scales chosen to make structures with positive φ more visible
- Contour line corresponds to φ = 0 rad/m^2
- Four yellow lines, fitted by eye, indicate location of four filaments identified in the Faraday rotation map

RM-Synthesis Frames



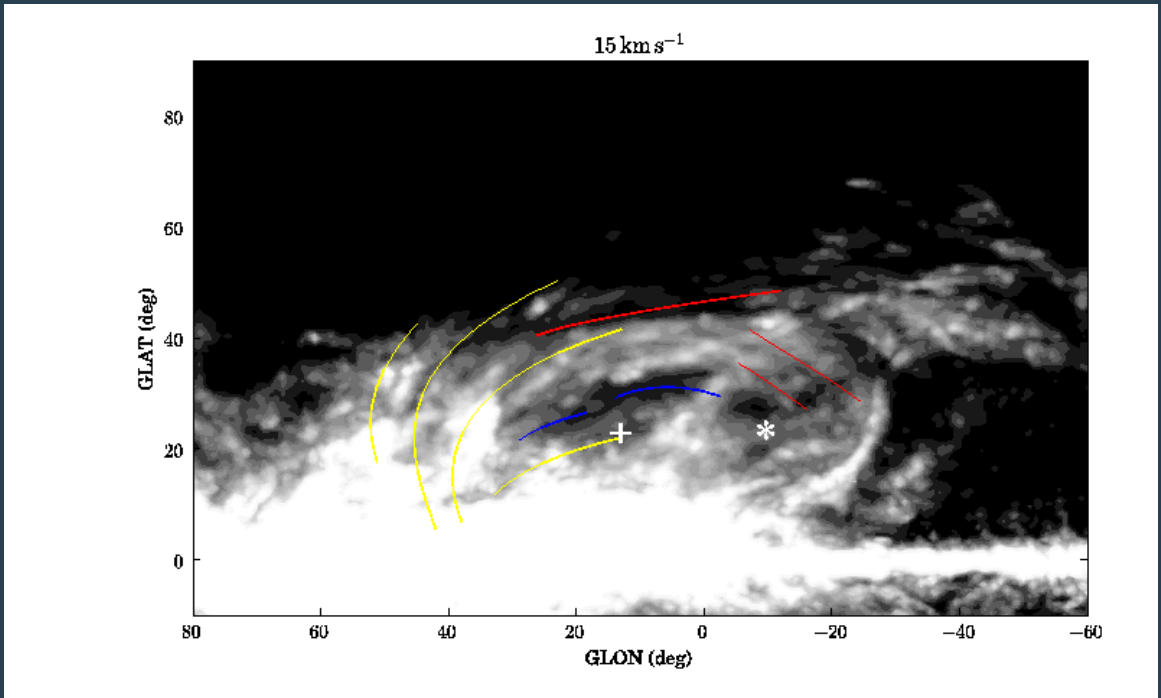




- RM-Synthesis frames showing polarized intensity at various Faraday depths
- Four yellow lines are repeated at 60 rad/m^2
- Blue and red lines indicate polarized filaments identified in the RM-Synthesis cube

HI Bubble

(LAB HI Survey, Kalberla 2005)

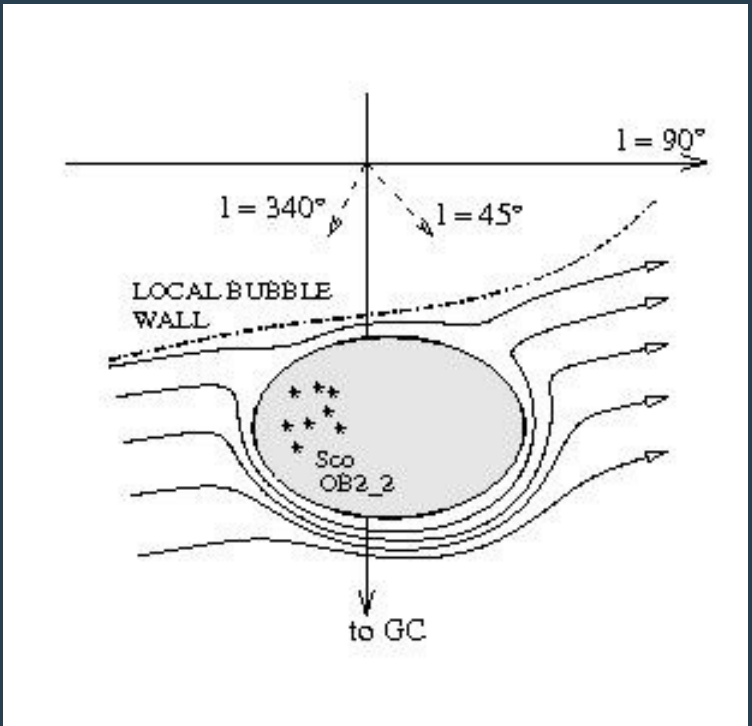


- Map of HI temperature at 15 kms^{-1}
- Polarized filaments associated with HI bubble
- correlations and anti-correlations between polarized intensity and HI
- Position of the Upper-Scorpius OB association today and 5 Myr ago

Distance and Origin

- Expanding HI shells associated with stellar winds and supernovae explosions originating in the stars of the Scorpius-Centaurus OB association
- Upper Scorpius sub-group is the furthest away (145 pc), in the centre of the western side of the HI shells.
- Linear size of bubble of the order of 200pc x 100pc
- Nearside is 95pc away, far side 195pc away
- Wall of Local Bubble about 80pc away in this direction
- The shells act as a Faraday-rotating screen to the strong background emission and also as a weaker mixed emitting and rotating slab
- These structures are not associated with the North Polar Spur as they do not resemble the shape of the spur

Magnetic Field

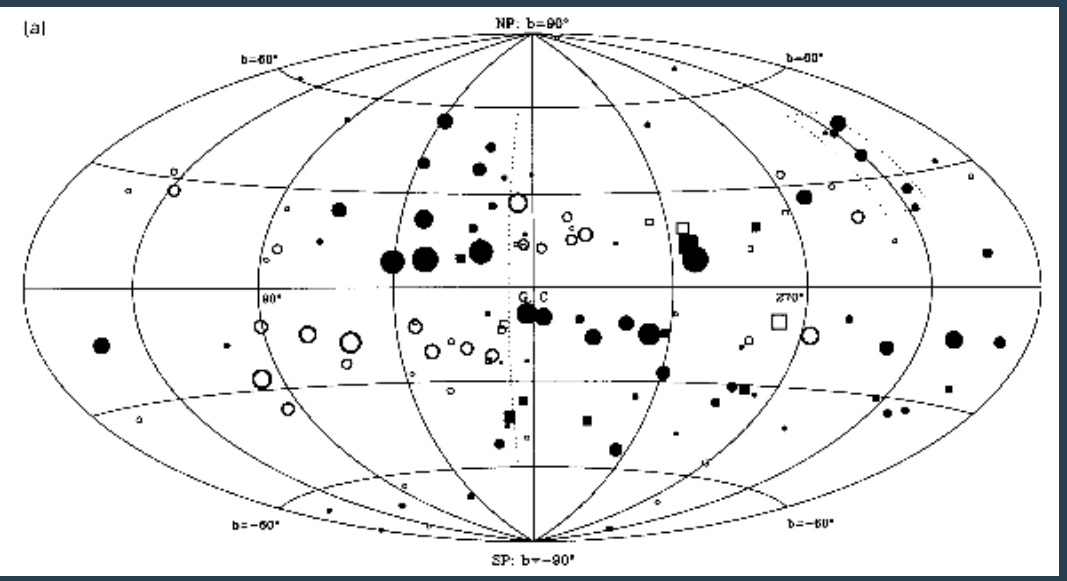


- Positive φ in the east changes to negative φ in the west, suggesting that the B-field is wrapped around the bubble
- Polarized emission at φ=0 rad/m^2 along the centre of the bubble links these two regions
- Shape and implied B-field configuration of this HI bubble suggest that is has expanded asymmetrically
- Expansion constrained to only one direction along the line-of-sight

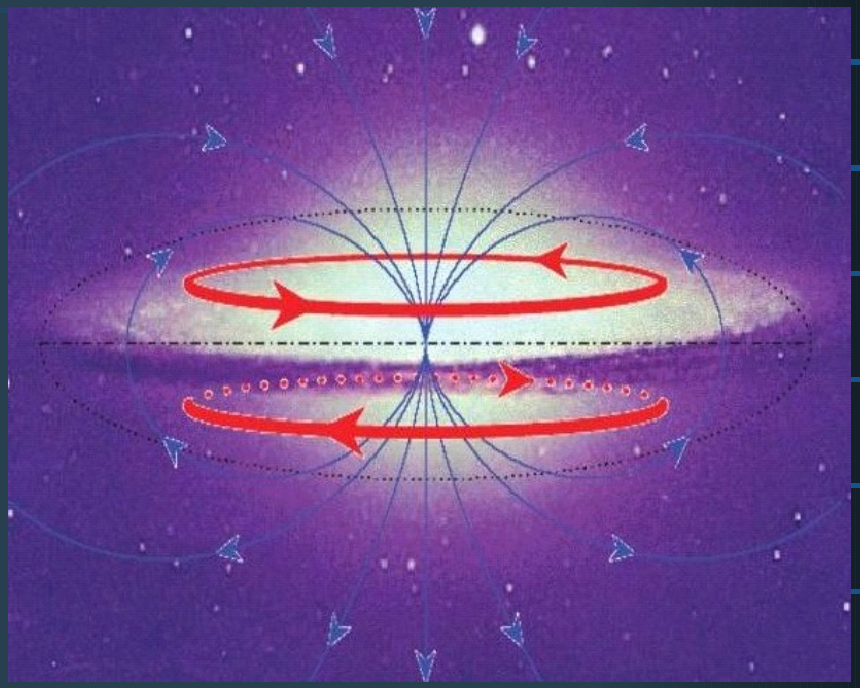
Magnetic Field

- No Hα emission found (VTSS/WHAM)
- RM must be due to enhanced B-field
- average n_e approx 0.02 cm^{-3}
- shell thickness ~13pc, path length ~100pc
- 50-60 rad/m^2 corresponds to $B_{\parallel}$ approx 20-34 μG

Antisymmetries in the FR Sky

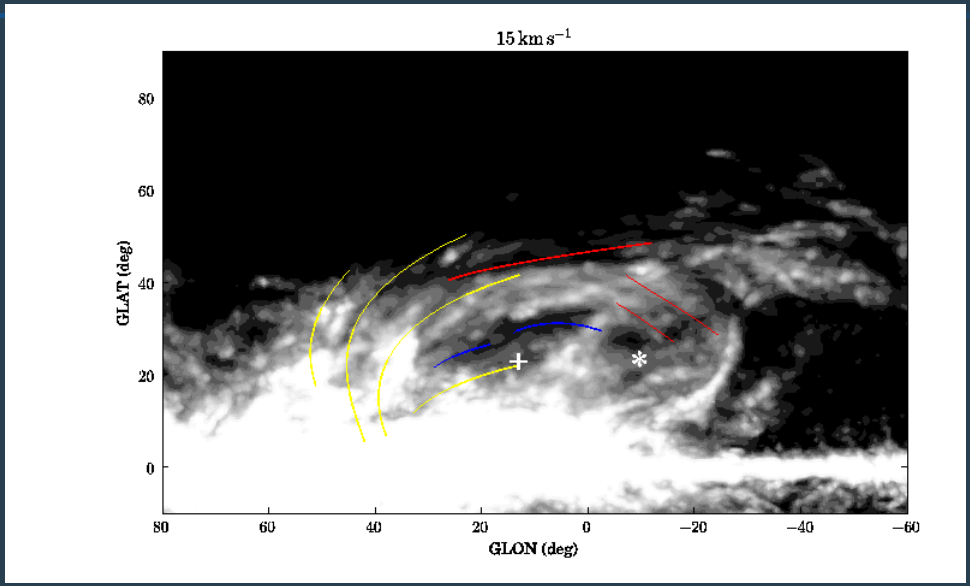


(Han et al, 1999)



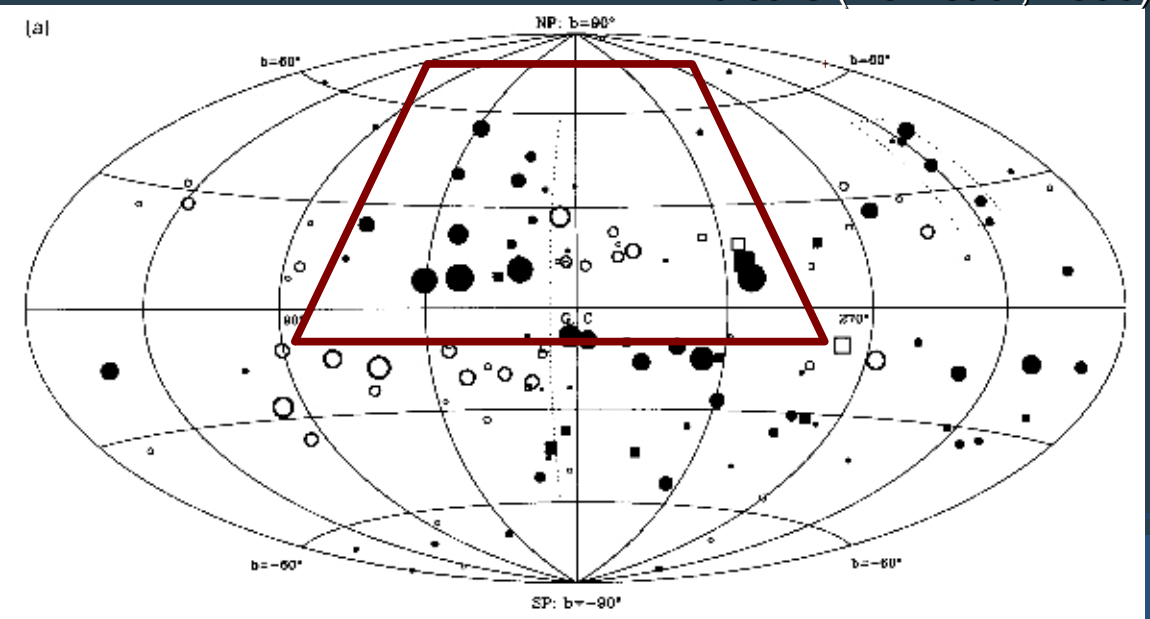
- Observed antisymmetry of RMs in the inner Galaxy.
- Indicates azimuthal B-field with reversed field directions.
- This seems to suggest an A0 dynamo acting in the halo.

Antisymmetries in the FR Sky

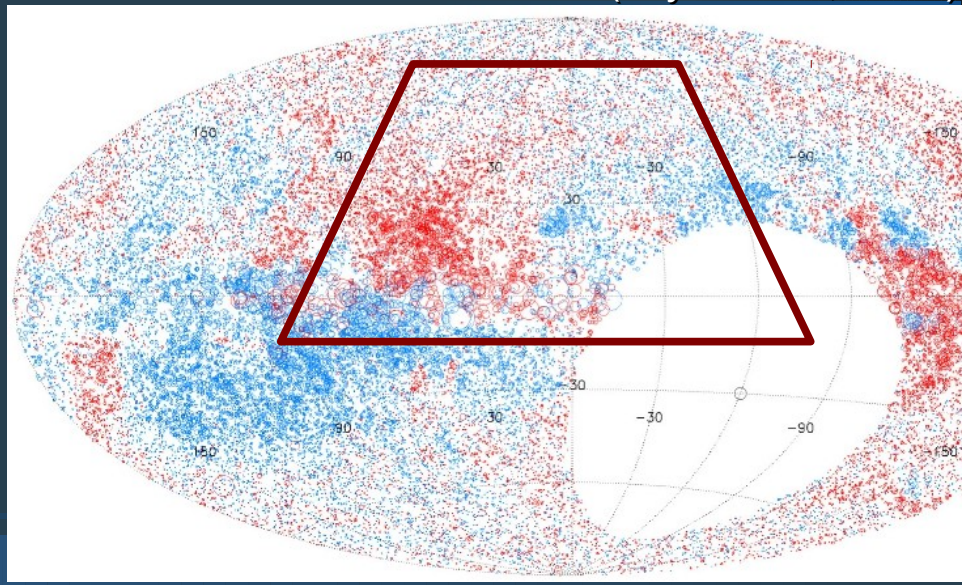


- Several authors have pointed out that the antisymmetry may be due to Loop I
- Our data show that another local object (not the NPS) mimics the antisymmetric pattern of a large scale B-field
- Detection made possible by high angular resolution RM-maps of the diffuse Galactic emission

Pulsars (Han et al, 1999)

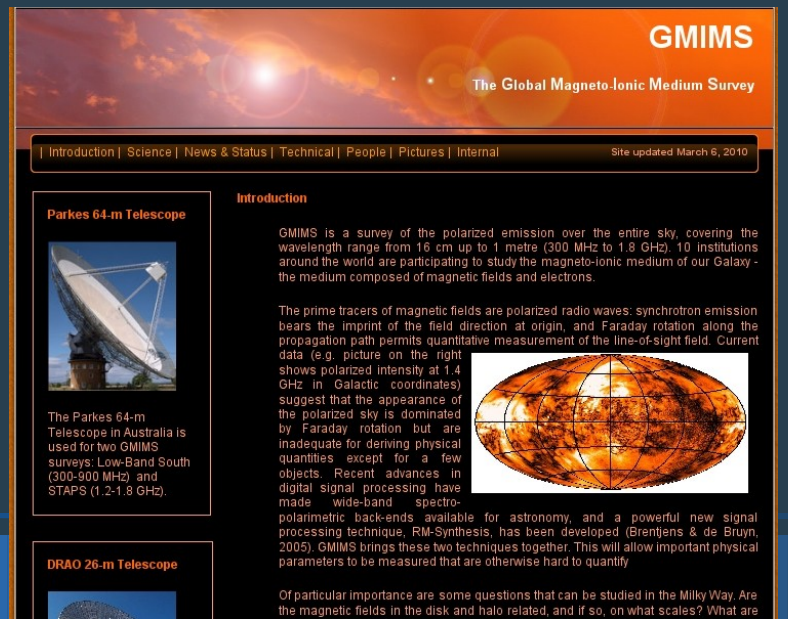


EG sources (Taylor et al, 2009)



Summary

- GMIMS is a wide-band, spectro-polarimetric survey from 300 MHz to 1.8 GHz, using single-dish telescopes
- First RM-Synthesis of the Galactic diffuse emission with a single-dish telescope over the whole Northern sky
- High angular resolution Faraday-rotation map reveals filamentary structures associated with a local HI bubble (not the North Polar Spur)
- These structures can be explained by a B-field wrapped around this bubble
- The resulting signature in the Faraday rotation sky mimics that of a large-scale Galactic B-field
- (Wolleben et al, 2010, in prep.)



https://www.astrosci.ca/users/drao/gmims