



Max Planck Institute  
for Radio Astronomy



# Recent Observations of Nearby Spiral Galaxies

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# List of Galaxies Observed

- M51 → Effelsberg 11cm  
→ LOFAR HBA (114 -163 MHz)
- M31 → Effelsberg 11cm
- NGC0628 (M74) → Effelsberg 6.2cm
- M101 → WSRT 90cm
- NGC6946 → WSRT 90cm















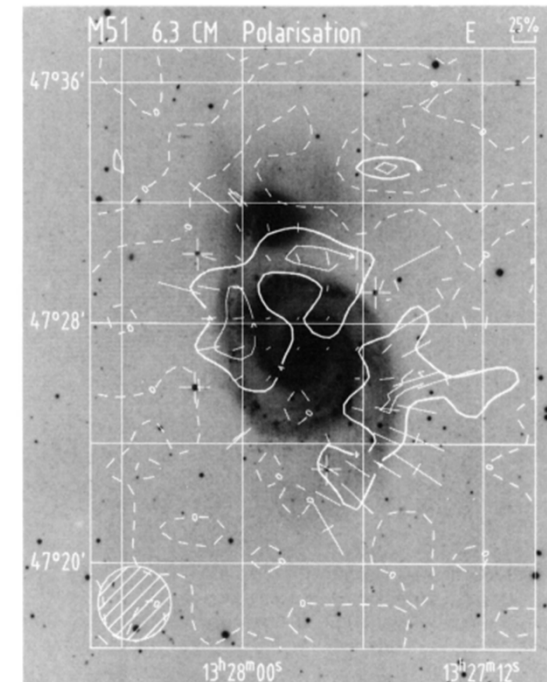
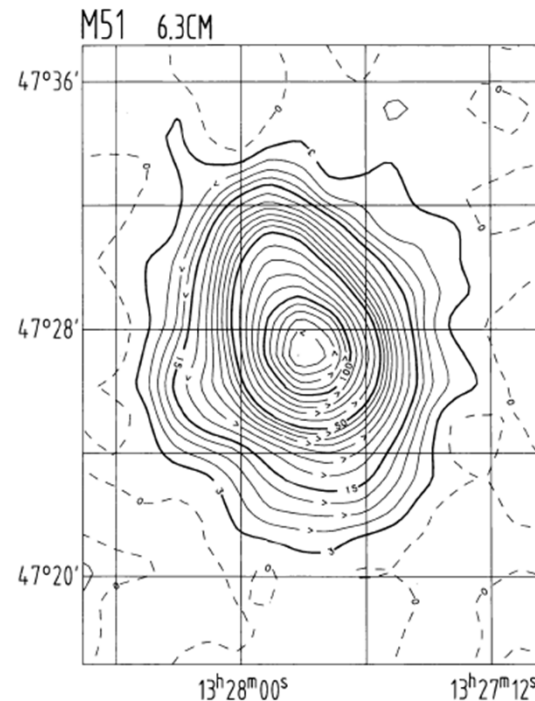






## The Magnetic Field of M51

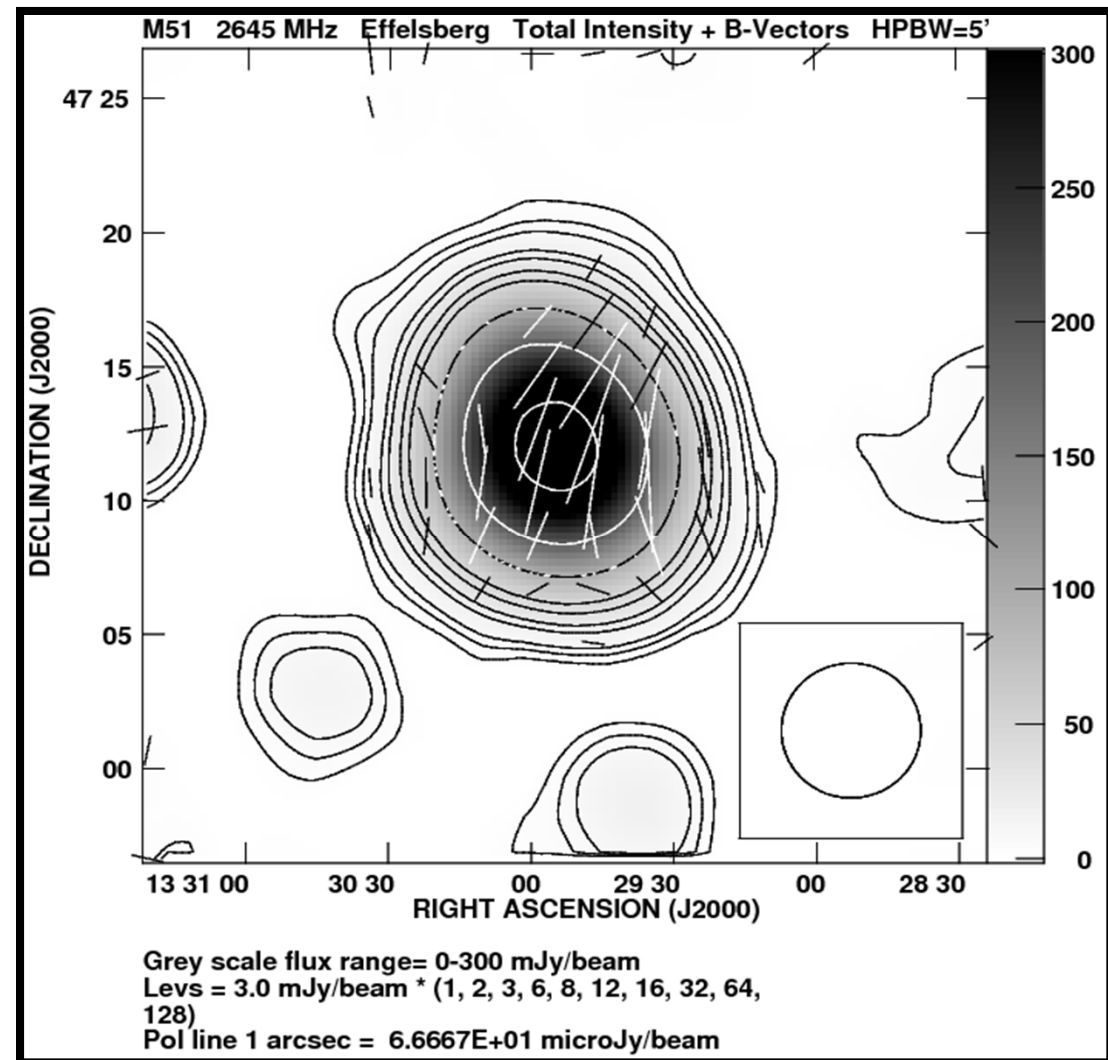
- M51 is a grand-design spiral galaxy with two very prominent spiral arms.
- Perturbed by its close companion NGC5195 which may have resulted in two systems of density waves.
- Orientation of the magnetic field lines follow very closely the spiral arms. (Berkhuijsen et al. 1996)



Beck, R.; Klein, U.; Wielebinski, R. (1987)

## M51 Observations

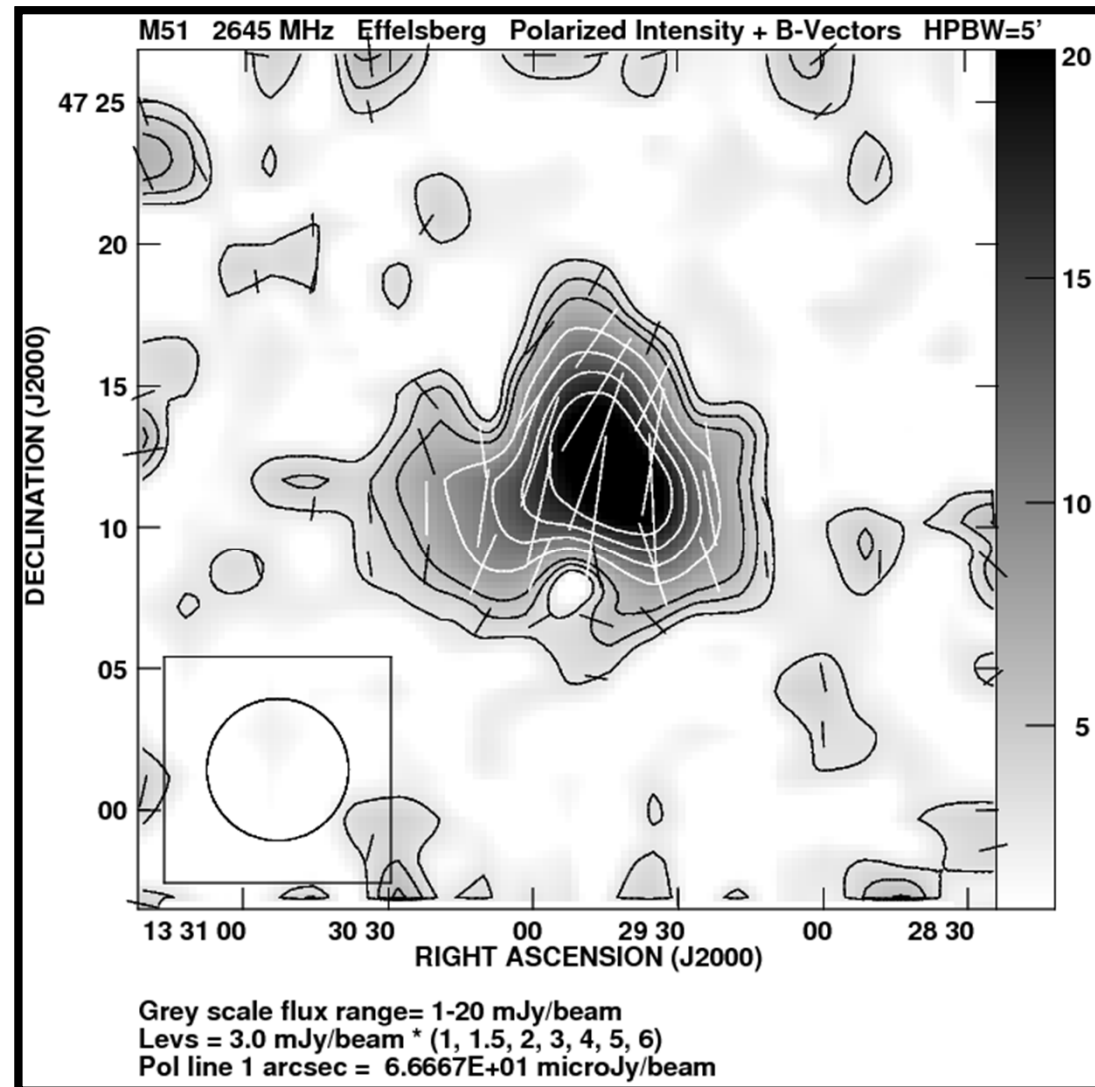
- M51 was observed during test observations of the new observing software in August 2010.
- First time M51 has been observed at 11cm .
- Approximately 10 coverages were performed.
- HPBW=5 arcmins which corresponds to 14kpc in linear resolution.





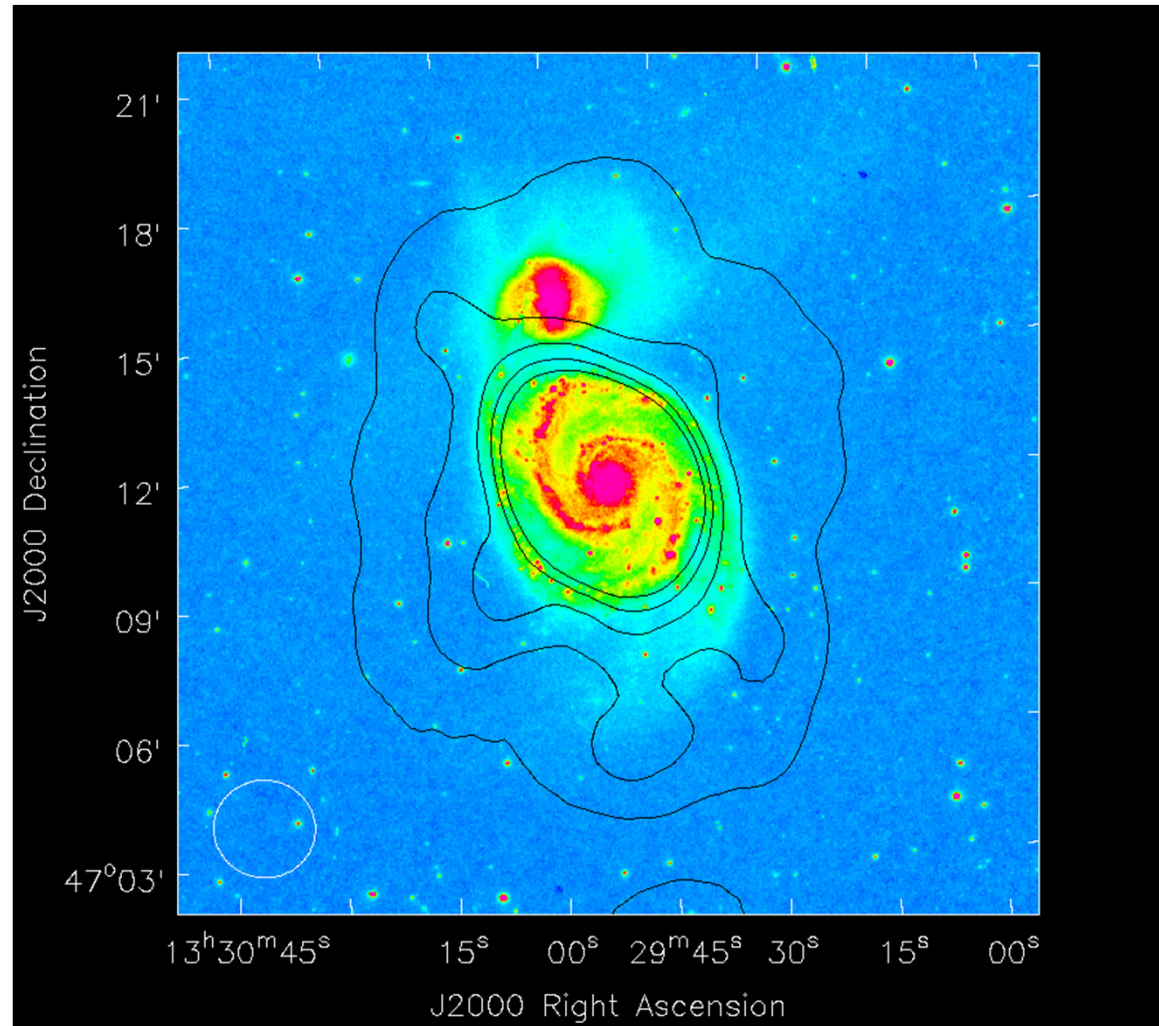
## M51 observations

- High-degree of polarization of low-inclination galaxies indicate large scale departures from axially symmetric magnetic fields. (see Stil, Krause, et al. 2009)
- Due to lack of observations, polarized intensity map is not reliable especially emission to the west of the map.
- More coverages are needed, however, method of polarization calibration must be found before more coverages are taken.

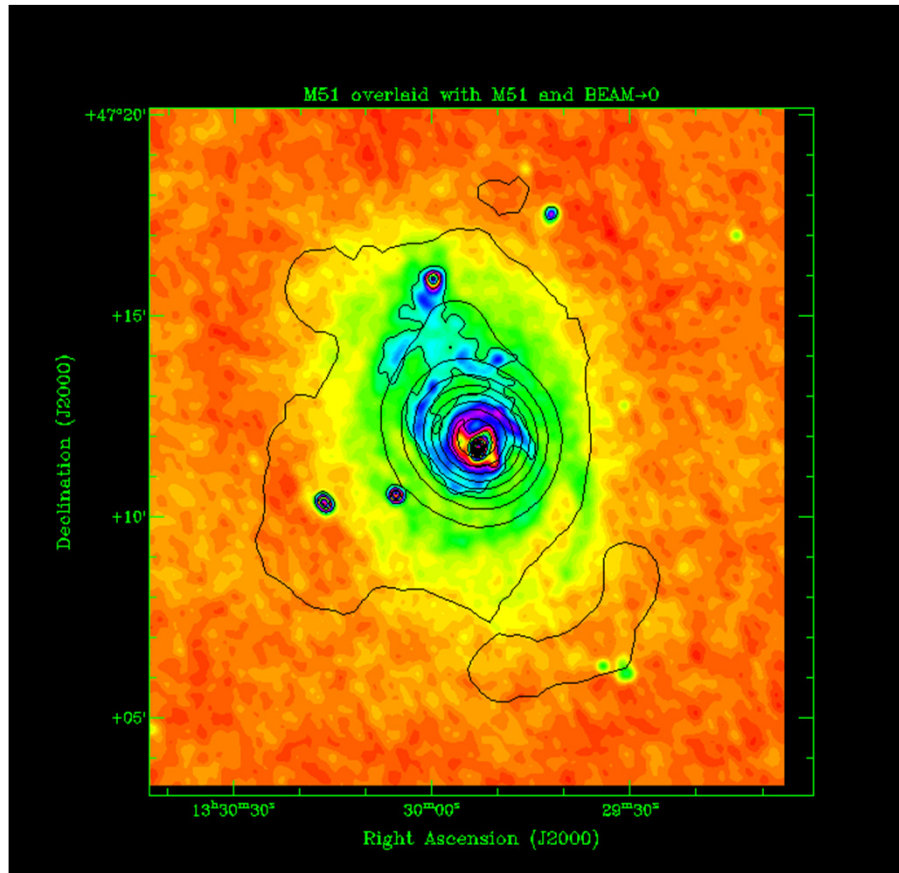


## Observing M51 with LOFAR

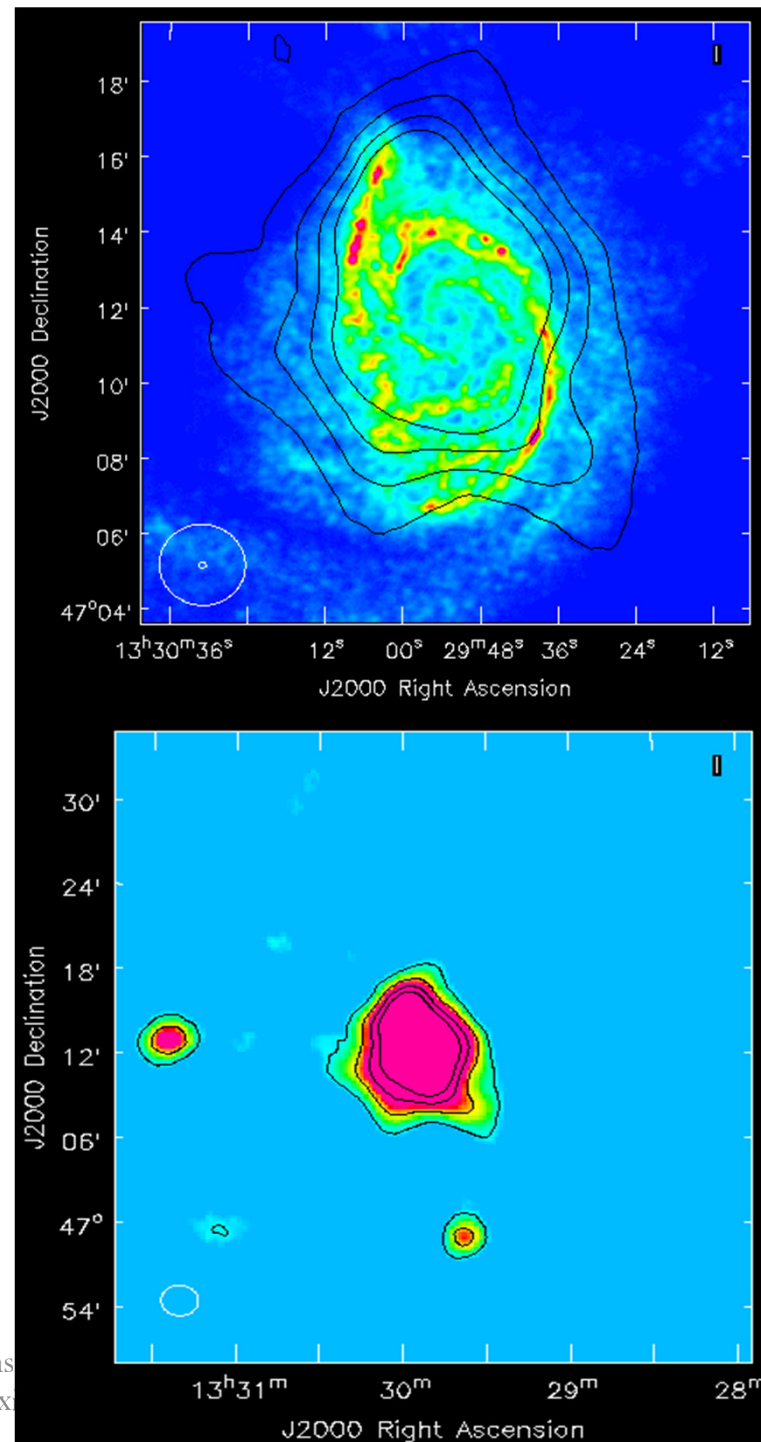
- Currently, working on a single subband (SB60 - 139MHz) from a 6hr observation.
- 3C295 was observed simultaneously.
- Experimenting on several methods of calibration:
  1. Using simple WENSS skymodel
  2. Using a model created from GMRT FITS file supplied by Andrew Fletcher. Created through PYBDSM.
  3. Transferring the Gain solutions from calibrator to source. (See George Heald's Busy Week presentation on procedure)



# Observing M51 with LOFAR



Recent Observations  
Galaxy

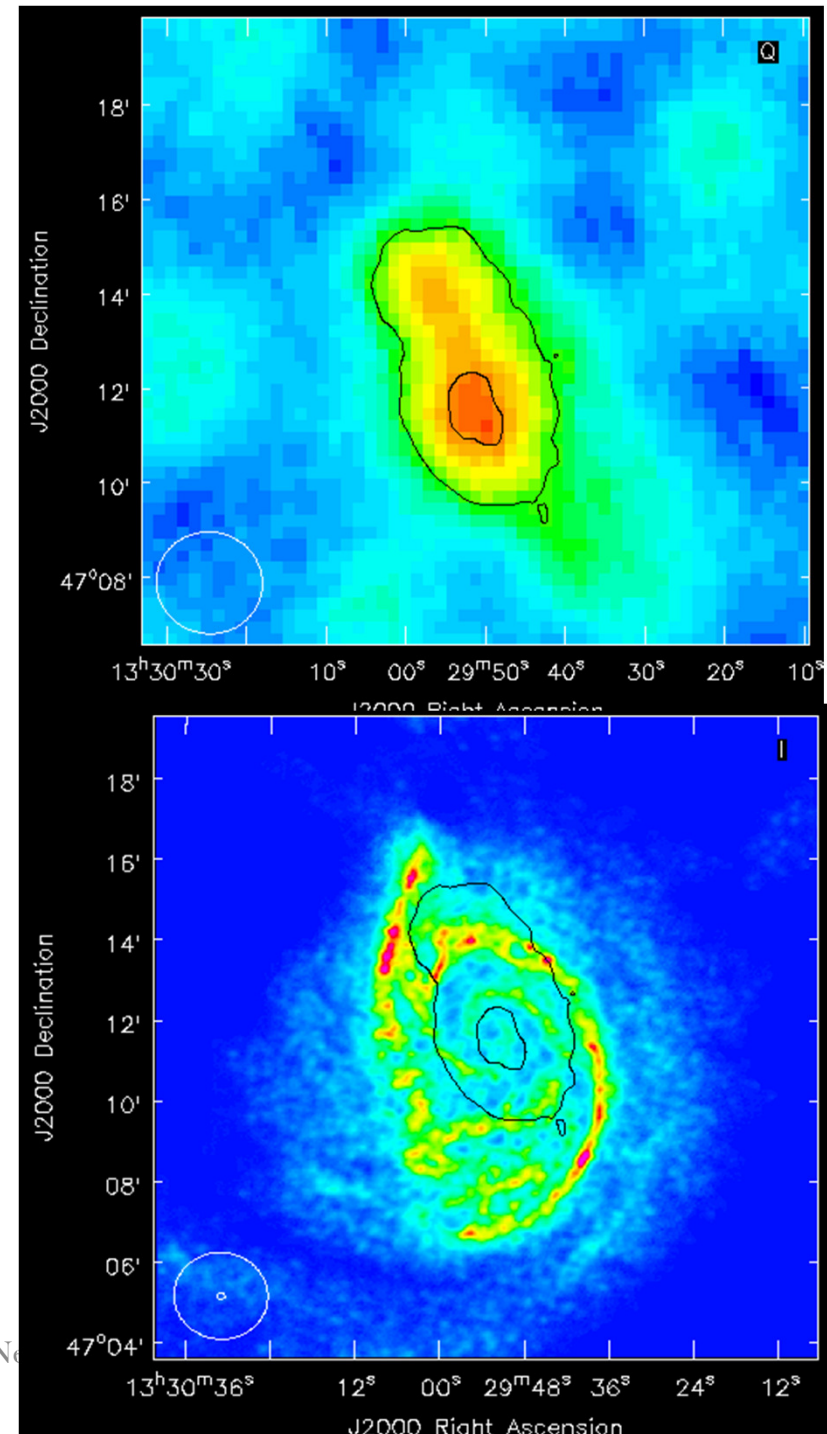




## Observing M51 with LOFAR

- Observed polarization in Stokes Q which has a polarization degree from 4-3%.
- No polarization seen in this region for Stokes U & V.
- Likely to be instrumental but will check more Subbands to see any variation.
- RM Synthesis needed to positively verify if polarization exists.

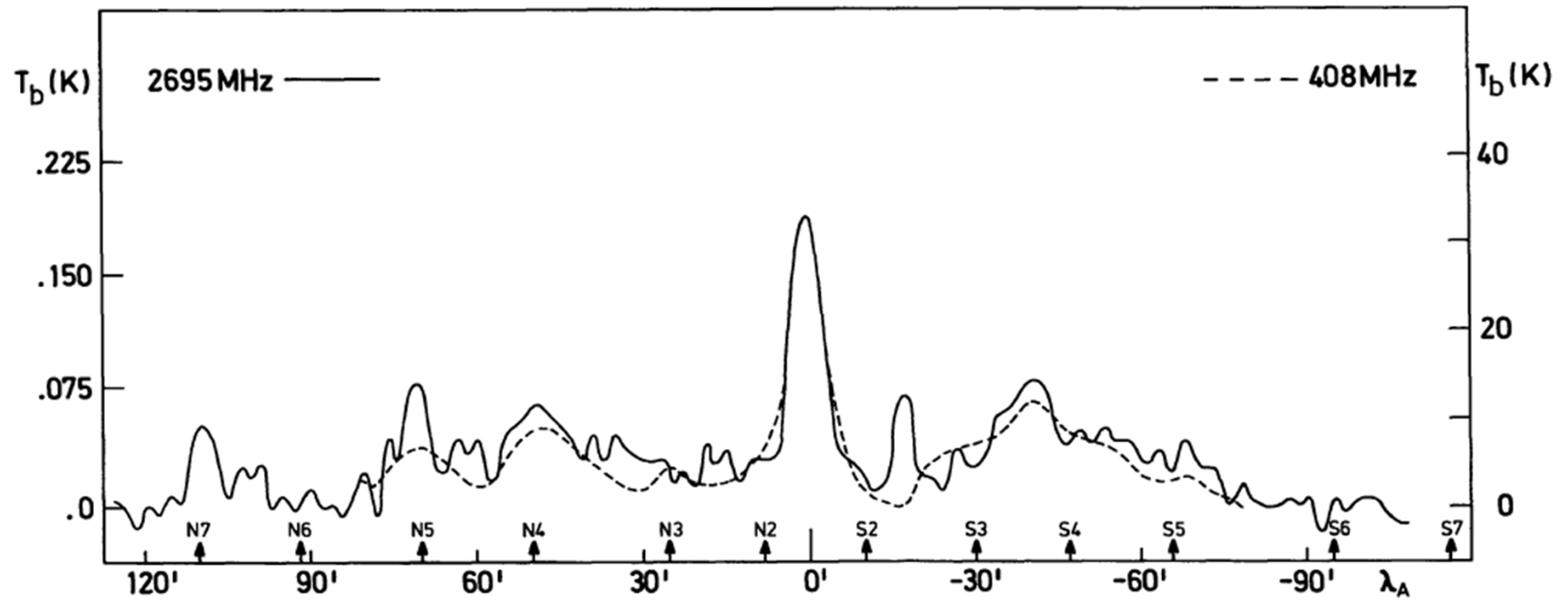
Recent Observations of Nearby Galaxies



## The Magnetic Field of M31

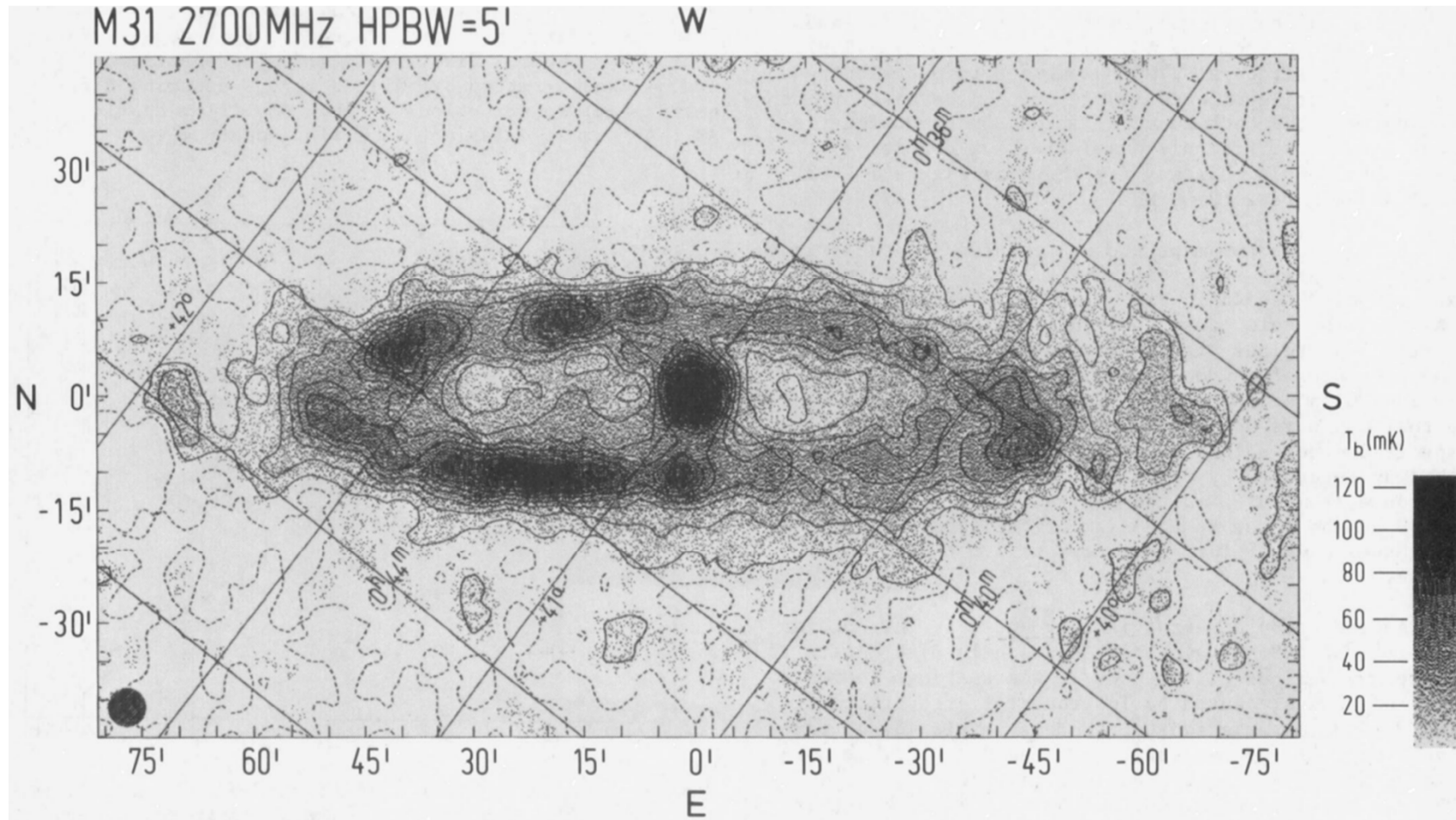
- The Andromeda Galaxy (M31) is the nearest spiral galaxy with an average inclination of  $77.5^\circ$ .
- Due to its large size in the sky, it is very hard to observe with interferometers, it is ideal for single dish observations.
- Continuum emission is concentrated in a ring of radius of approximately 10kpc which is composed of several arm segments; Berkhuijsen (1974) found that emission corresponds to mainly optically defined arms 4 & 5.
- Berkhuijsen also found continuum emission at the arm N7 which is approximately 28kpc from the center.





Total Intensity distribution along the major axis of M31 at 408MHz (Pooley 1969) & 2695MHz (Berkhuijsen 1974).

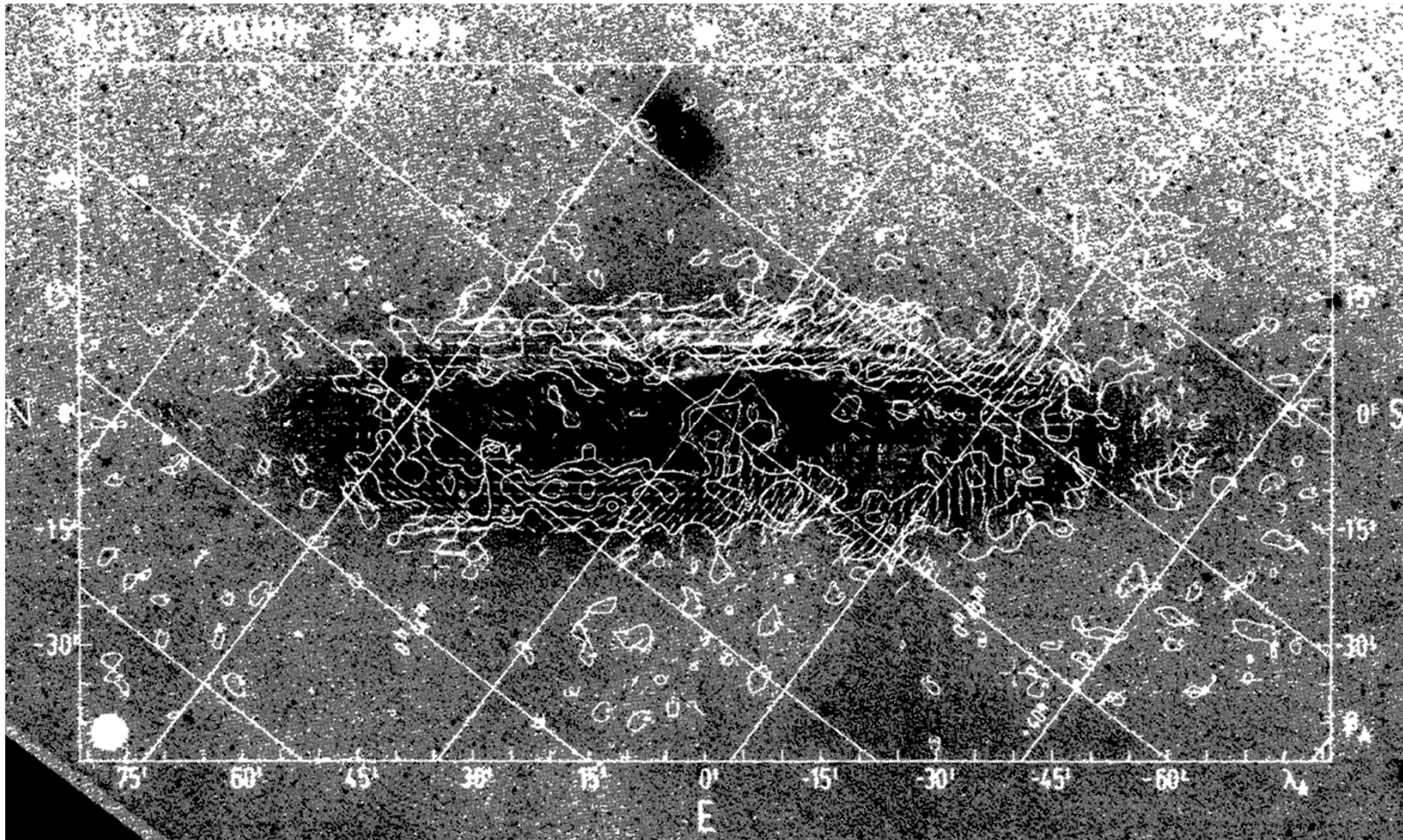
# Previous 11cm Map (Total Intensity)



From Beck &  
Grave (1981)



# Previous 11cm Map (Polarized Intensity)

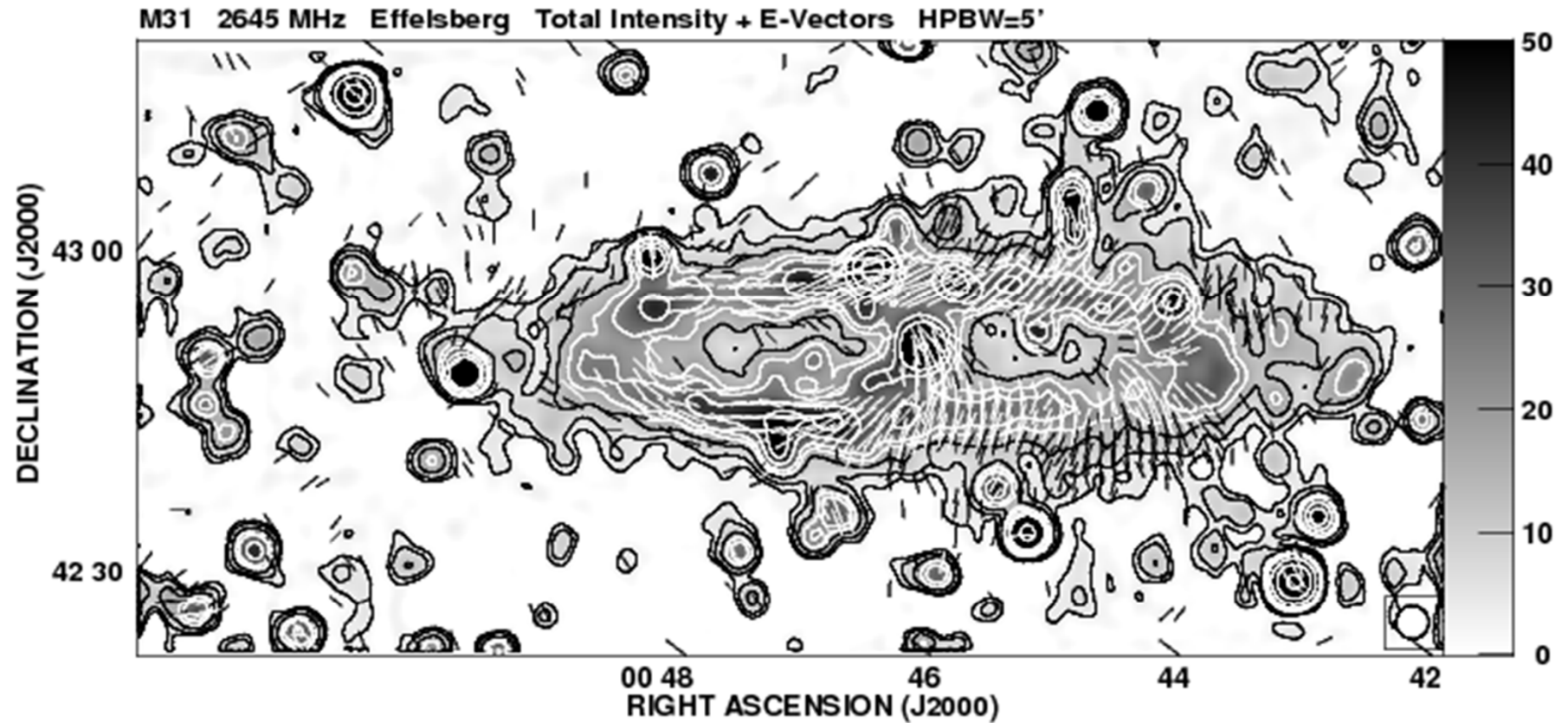


## Details of Observations

- Observations were performed between August – December 2010 at the Effelsberg 100m radio telescope operated by the MPIfR.
- 11cm receiver, 2600-2680 MHz divided into 8 sub-bands, each sub-band consists of 4 channels; Left & Right Stokes I, Stokes Q and Stokes U.
- Extent of area of observation:  $198 \times 94.5$  arcmins; 20 arcmin offset to the north of M31.

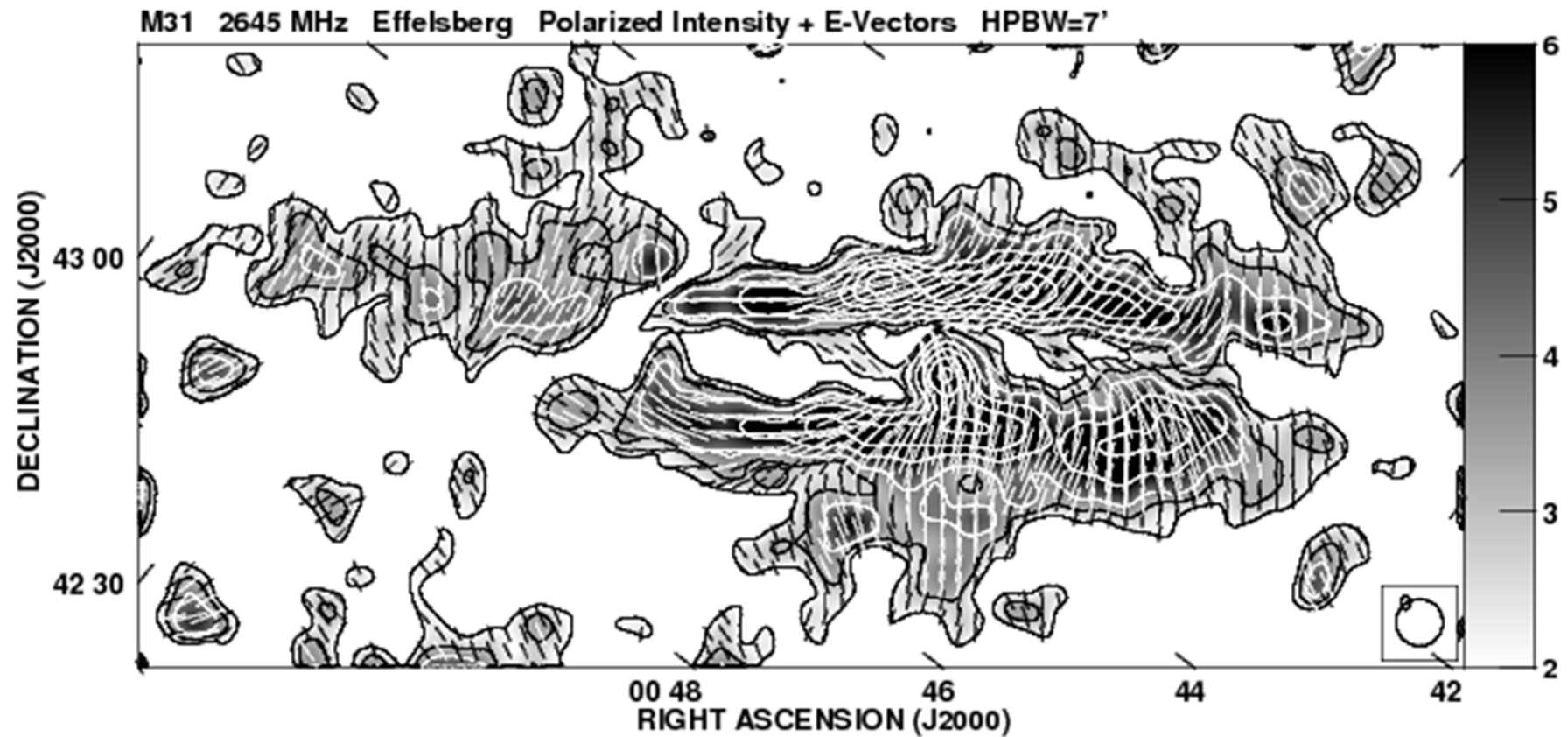


## Final Map of M31 at 5 arcmin resolution (Total Intensity)



Grey scale flux range= 0-50 mJy/beam  
Levs = 3.0 mJy/beam \* (1, 2, 4, 6, 8, 12, 16, 32, 64, 128)  
Pol line 1 arcsec = 1.6667E+01 microJy/beam  
Rotated by 53.0 degrees

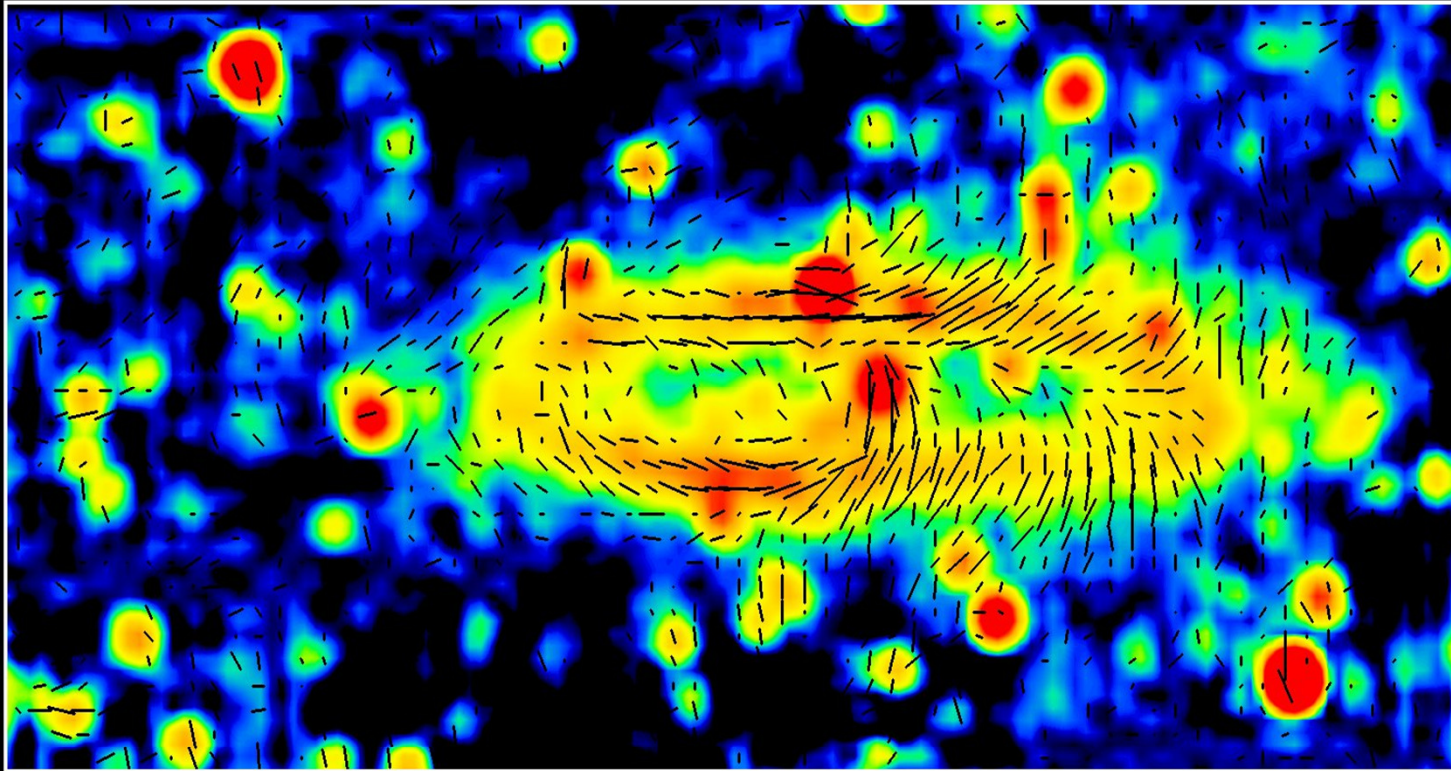
## Final Map of M31 at 7 arcmin resolution (Linearly Polarization)



Grey scale flux range= 2-6 mJy/beam  
Levs = 2.0 mJy/beam \* (1, 1.5, 2, 3, 4, 5, 6)  
Pol line 1 arcsec = 1.6667E+01 microJy/beam  
Rotated by 53.0 degrees

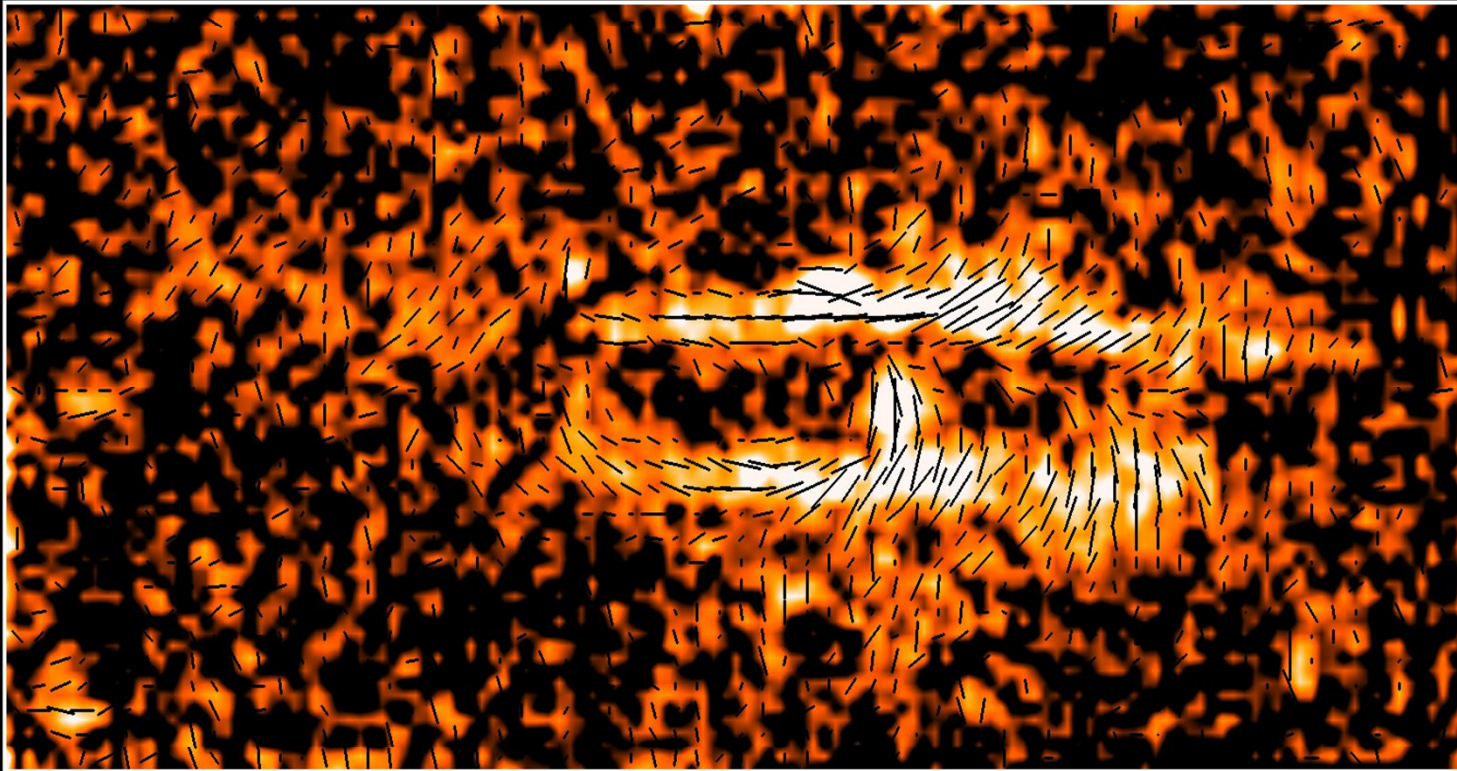


M31 11cm Total Intensity + E-Vectors (Effelsberg)



Copyright: MPIfR Bonn (D.Mulcahy & R.Beck)

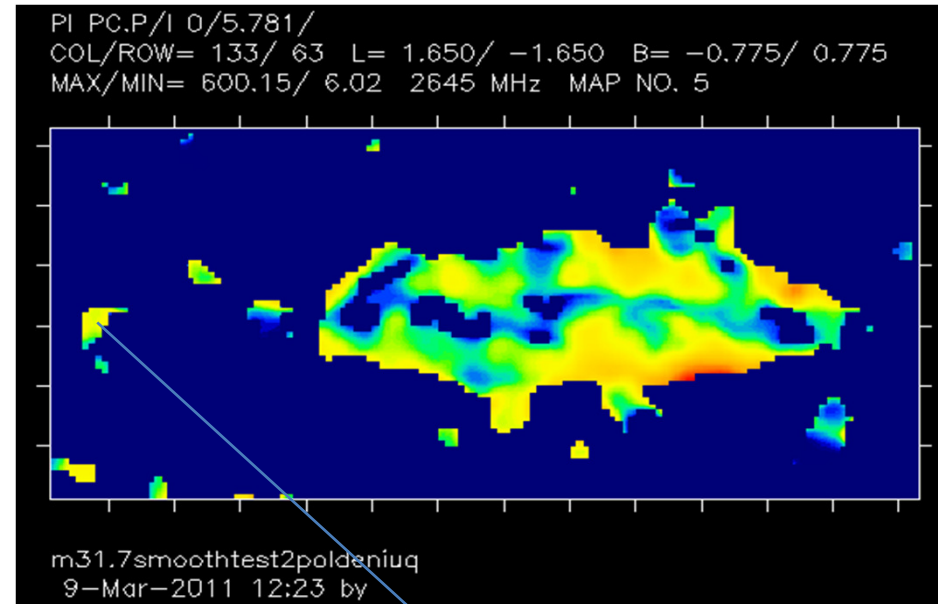
M31 11cm Polarized Intensity + E-Vectors (Effelsberg)



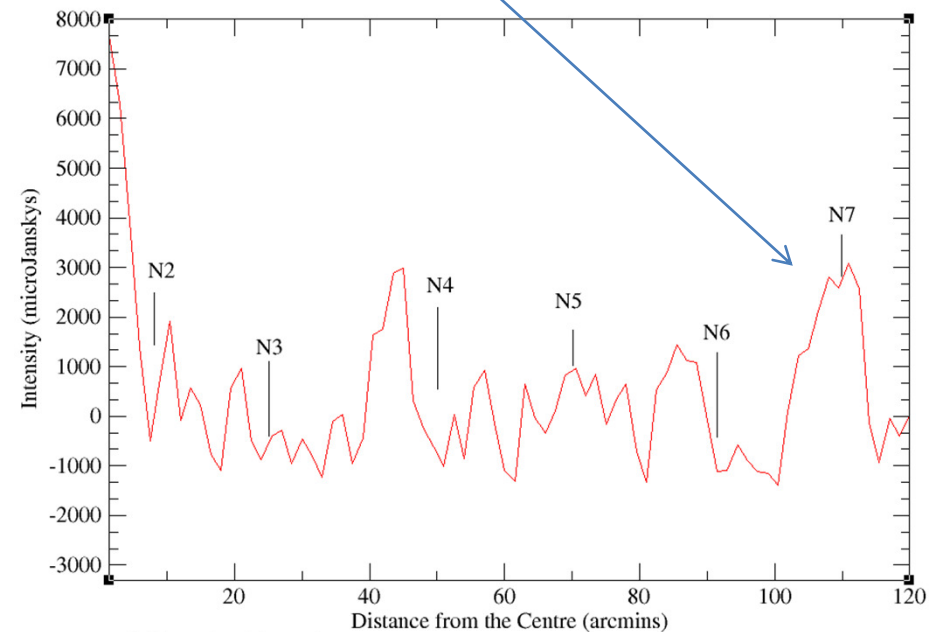
Copyright: MPIfR Bonn (D.Mulcahy & R.Beck)

## Polarized Emission Found in N7

- Polarized Emission was found at the N7 spiral arm which is 28kpc from the center of M31. Degree of Polarization was found to be between 10-20%.
- This could signify the presence of ordered magnetic field at a radial distance of 28kpc from the center of M31.
- This is much further out that has ever been observed in any non-interacting galaxy.
- Further observations at different frequencies of the northern section will be considered.



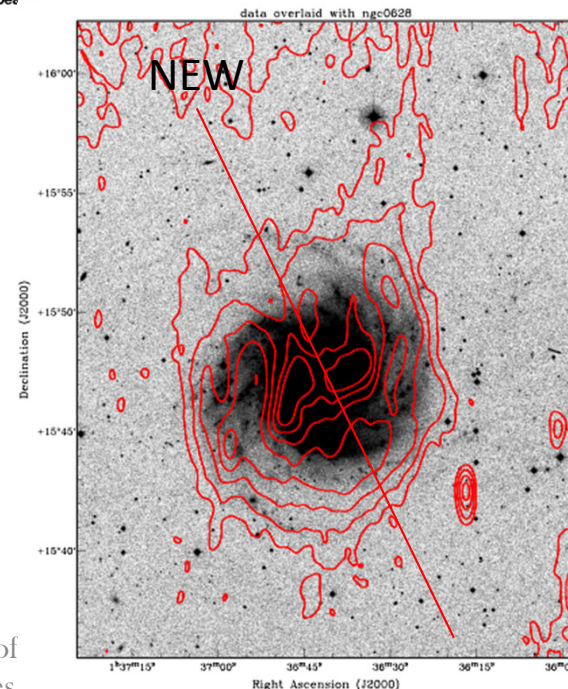
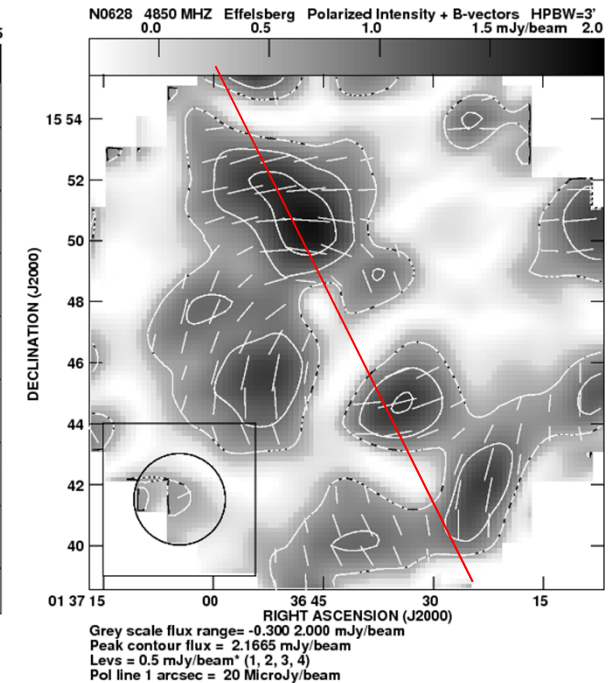
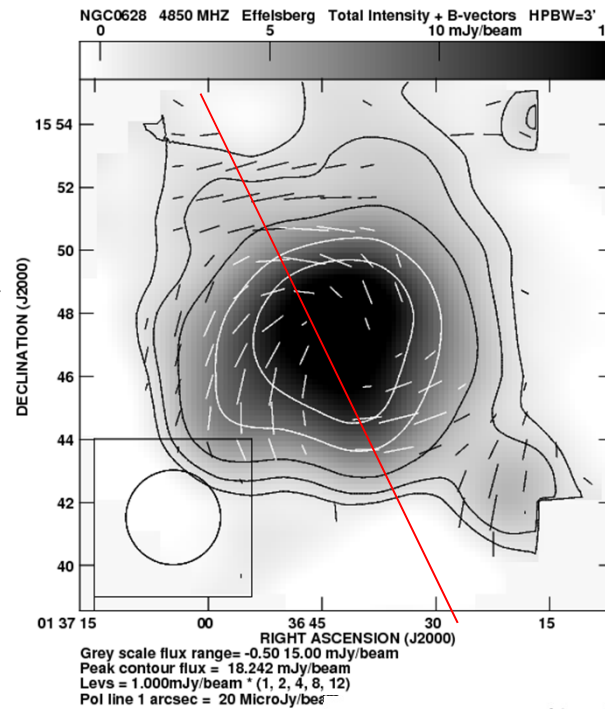
Polarized Intensity along the Northern Major Axis of M31





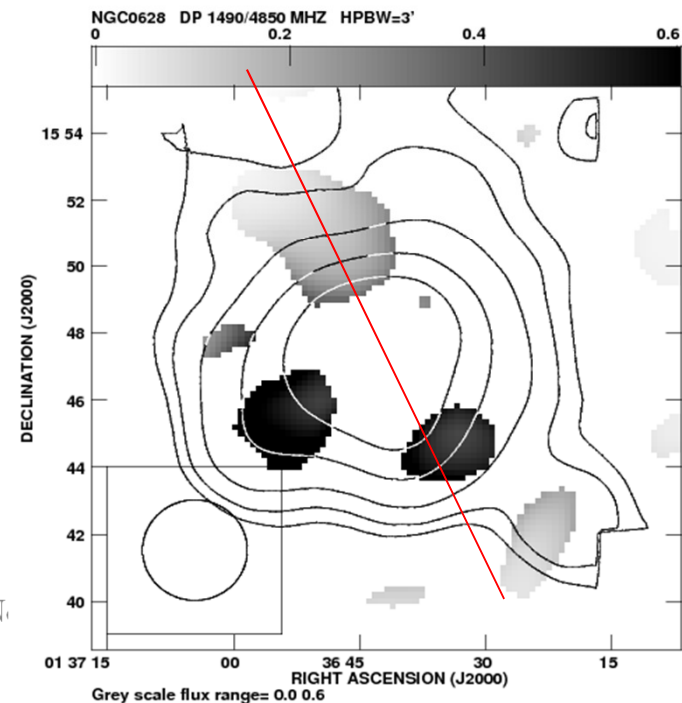
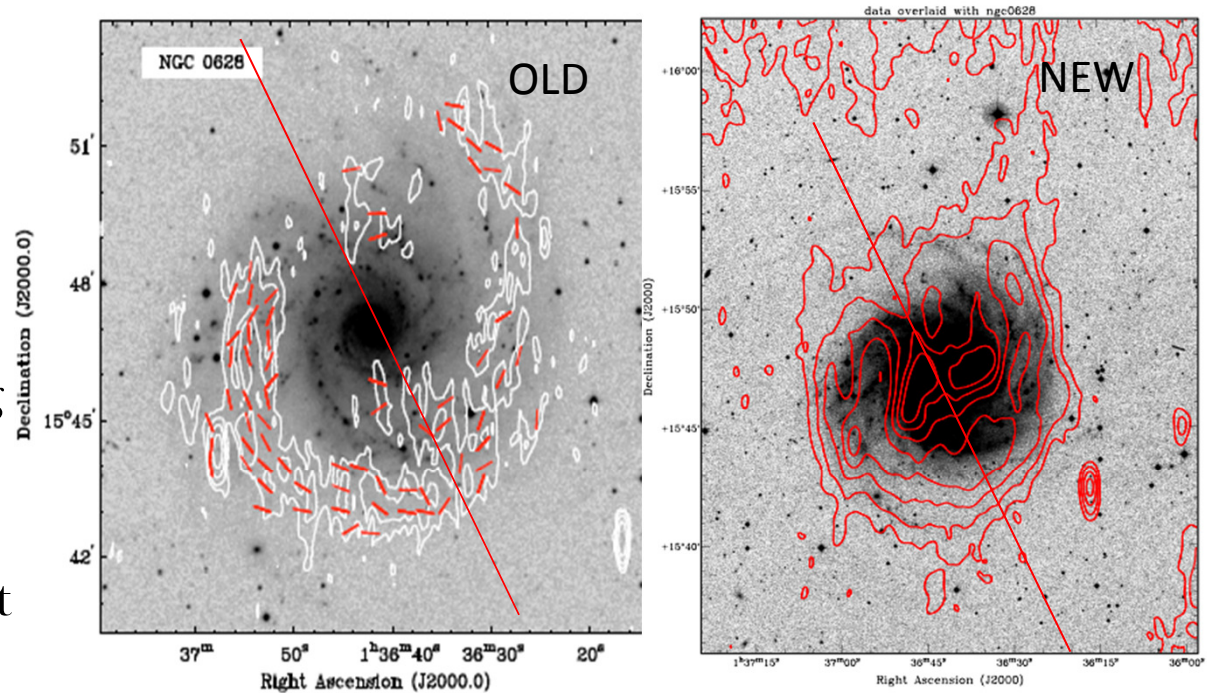
## NGC0628

- NGC0628 was observed with Effelsberg at 6.2cm. It was observed by Eva Schinnerer & postdocs (MPIA) for the KINGFISHER survey of over 30 galaxies.
- Extended emission can be seen to the north in Stokes I, however, the area observed is too small in order to see full extent of this emission.
- Revised map of SINGS map from George Heald shows polarized emission extends much further out than before.
- Will hopefully observe in 11 & 3cm and perhaps 6.2cm again but with a larger observing area.



## NGC0628

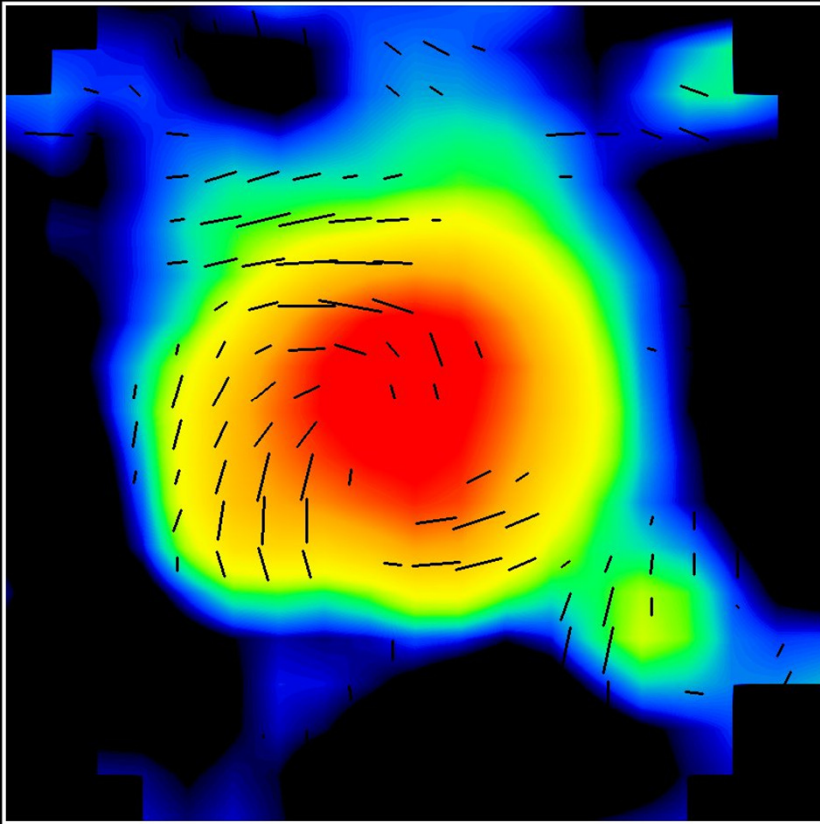
- Depolarization is strongest in the receding side.
- Confirms that depolarization is greatest at the receding side of the galaxy due to the turbulent magneto-ionic structures in the star-forming midplane and halo as mentioned in Braun et al. (2010)



Recent Observations of  $N_{\text{H}}$  Galaxies

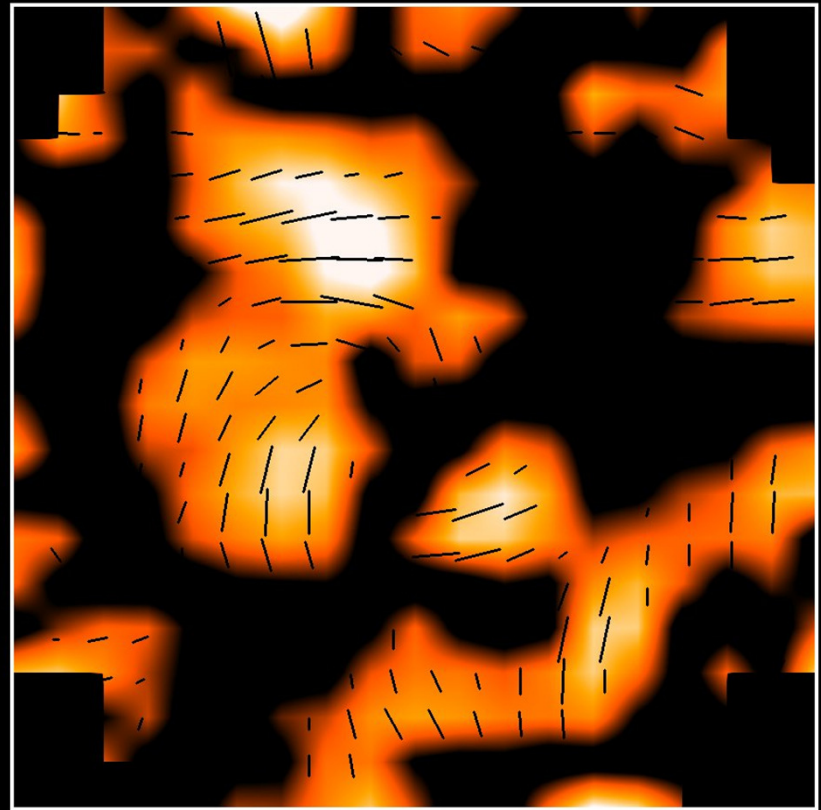
# NGC0628

NGC0628 6.2cm Total Int. + B-Vectors (Effelsberg)



Copyright: MPIfR Bonn (D.Mulcahy & R.Beck)

NGC0628 6.2cm Pol. Int. + B-Vectors (Effelsberg)



Copyright: MPIfR Bonn (D.Mulcahy & R.Beck)

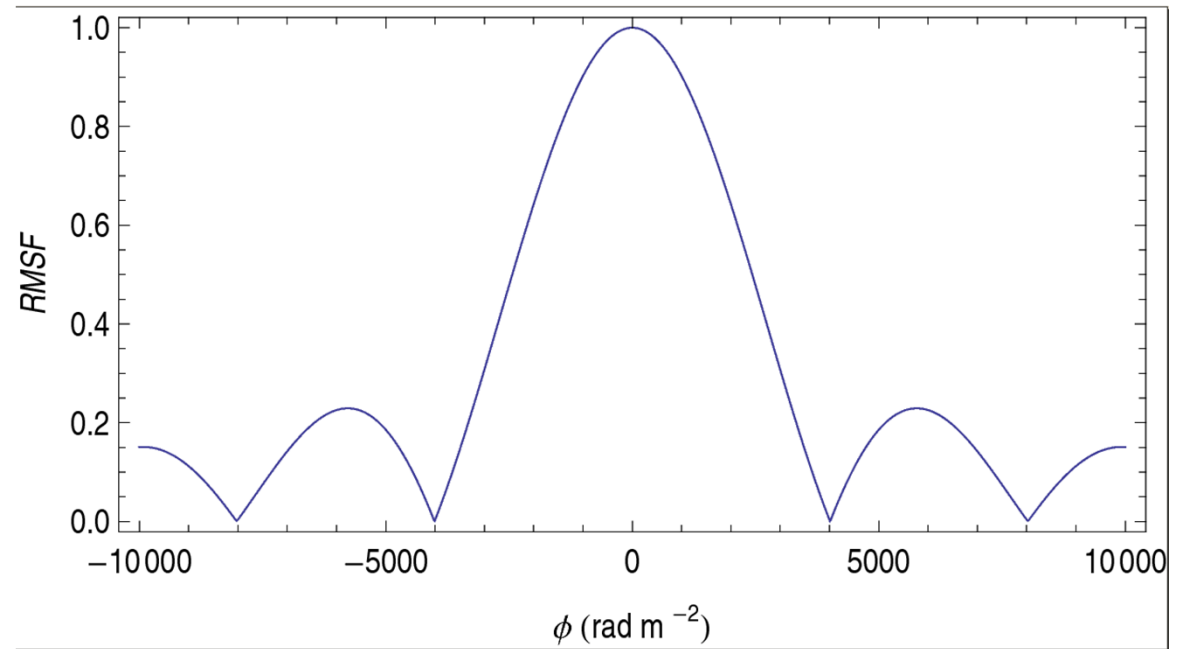


# Conclusions from M51 observations

- M51 was found to be polarized on a scale of 14kpc: the field pattern is not axisymmetric.
- More observations needed to create a more reliable linearly polarized map. Polarization must be correctly calibrated for before observations take place.
- This map in turn can be used to fill in zero spacings in future EVLA observations at S-band. RM Synthesis can be performed on M51 for the first time using this observation.
- With respect to the LOFAR M51 observation, a calibration strategy needs to be finalized and implemented. In the short term, more subbands (121!) need to be analyzed.

## Conclusions from M31 observations

- Improved Total Intensity map especially in the southern part of the galaxy.
- Polarized Emission found in the outer spiral arm N7.
- RM Synthesis is not possible for 8 channels- awaiting a multi-channel digital polarimeter.
- Effects like MRI will need to be added to current dynamo models to explain the presence of the magnetic field in the outer disks.



*From Rodion Stepanov*

## Conclusions from NGC0628 Observations

- New 6.2cm observation shows extensive polarized emission in the shape of a magnetic spiral arm.
- The interesting extension to the north needs to be investigated. More observations are planned in the coming months.
- Confirms that depolarization is greatest at the receding side of the galaxy due to the turbulent magneto-ionic structures in the star-forming midplane and halo as mentioned in Braun et al. (2010)
- Many more galaxies will be reduced at 6.2cm as part of the KINGFISHER survey in the coming month.

