Dwarf Galaxy NGC1569 at 90 cm

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Magnetic Fields: From Star-forming Regions to Galaxy Clusters and Beyond

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Outline

- Magnetic fields in galaxies
- Can starburst dwarfs magnetize the IGM?
- Synchrotron halos around dwarf galaxies
- Why NGC1569?
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Magnetic Fields in Galaxies

- Two mechanisms can explain the transport of magnetic fields produced in galaxies into the ICM/IGM
  - Jets and radio lobes emerging from powerful radio galaxies
  - **Galactic winds from star-forming galaxies**

Can Starburst Dwarfs Magnetize the IGM?

- Idea first put forth by Kronberg et al. (1999). They described models to establish that a significant fraction of the IGM could have been magnetized by outflows from dwarfs.

- Bertone et al. (2006) used high-resolution simulations of galaxy formation to predict the strengths of magnetic seed fields, which were amplified by large-scale dynamos over cosmic time.

Can Starburst Dwarfs Magnetize the IGM?

- The two prime arguments for dwarf galaxies as agents (in competition with AGNs) are:
  - Large number, predicted in ΛCDM cosmology, and observed as well
  - Shallow gravitational potentials, rendering outflows of hot gas and relativistic plasma feasible

Synchrotron Halos Around Dwarf Galaxies

- Hard to detect at cm wavelengths
- Characterized by a break at some frequency ν_b
- In low frequencies, one should detect the flatter low-frequency part of the spectrum, hence find non-thermal halos wrapped around

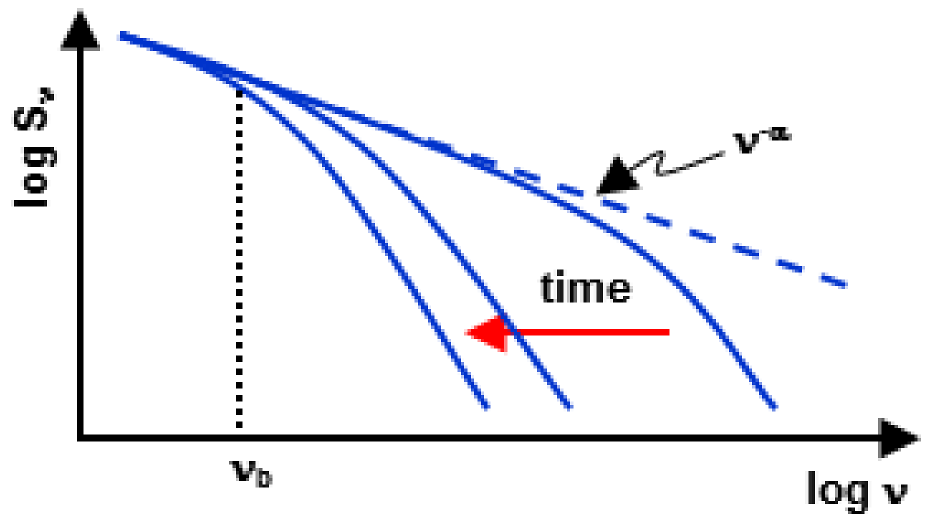
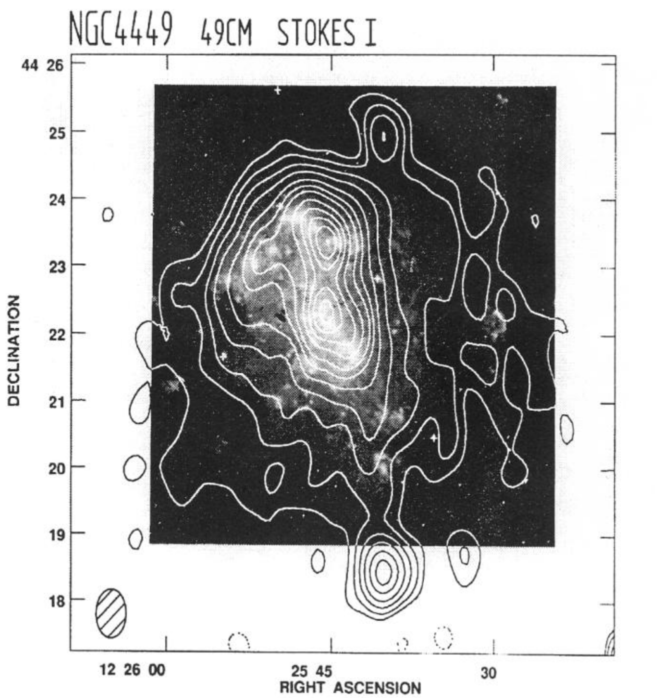
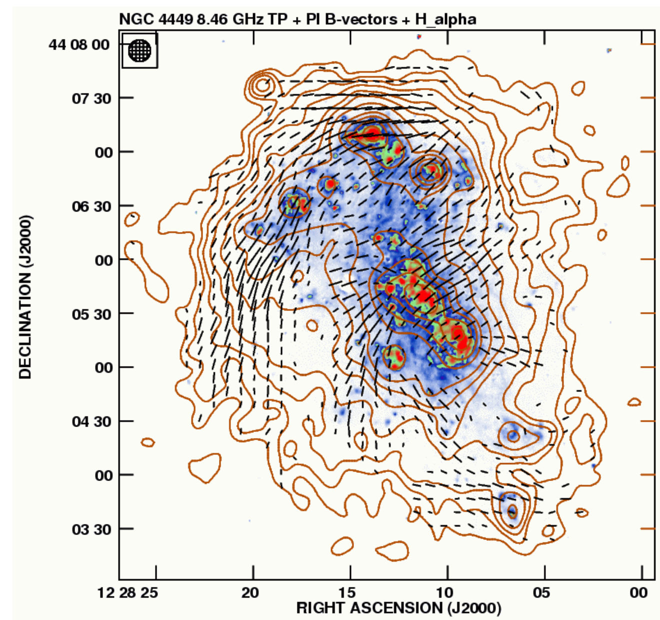


Fig. 3: Sketch of the time evolution of a radio synchrotron spectrum.

The first detection of a synchrotron halo: NGC4449



Total radio emission of NGC 4449 at 610 MHz, superimposed onto Hα (Klein et al. 1996)



Total radio emission of NGC 4449 at 8 GHz, and orientation of the magnetic field; the coloured image is Hα (Chyży et al. 2000)

Why NGC1569?

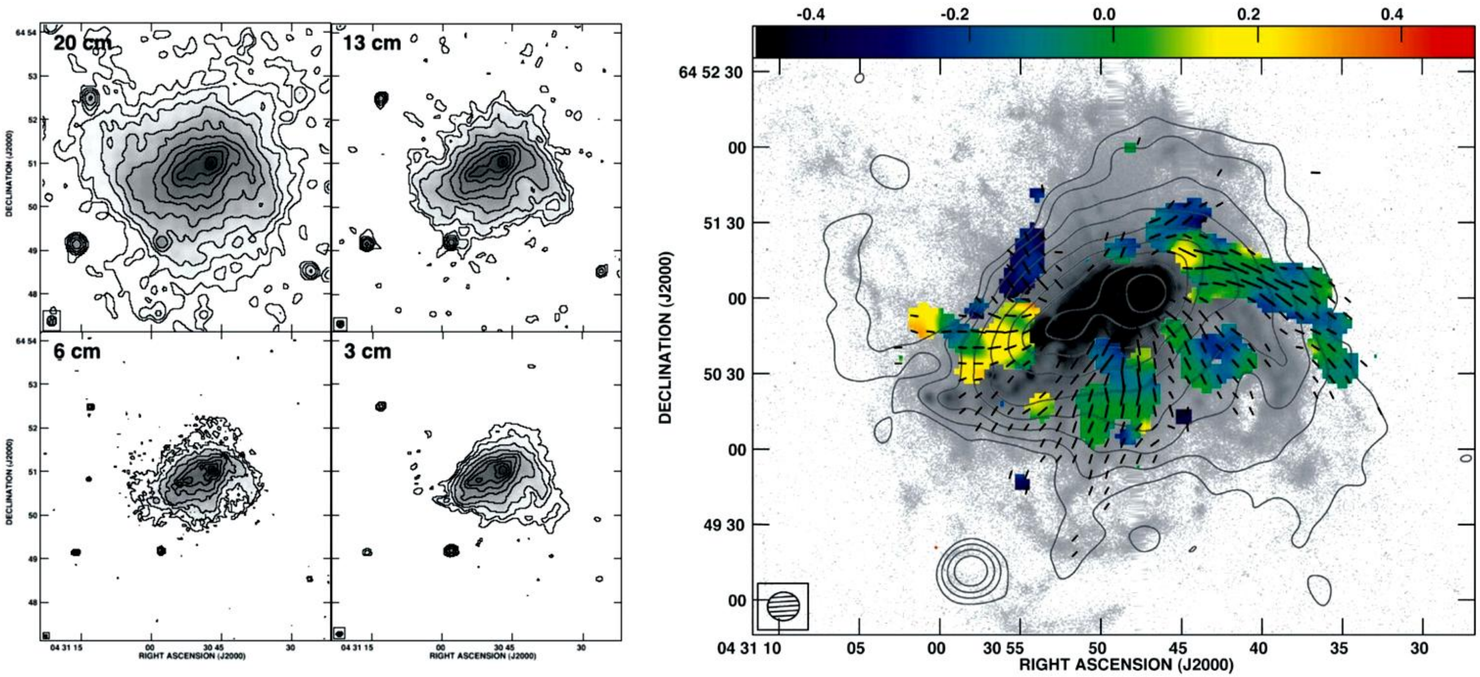
- Sufficiently nearby at a distance of 3.4 Mpc
- Strong starburst, ceased 5 Myr ago, inferred from a break in its overall synchrotron spectrum (Israel & de Bruyn 1988)
- Bright in the radio continuum, hence, observations possible, with good sensitivity and resolution using the WSRT
- It is pretty well-studied, as we will see later.

NGC1569: Previous observations

The transport of a relativistic plasma out of this post-starburst galaxy was suggested by two observations (Mühle 2003):

- NGC1569 has a radio halo, extending out to about 2 kpc at 20 cm
- The projected orientation of its magnetic field is radial throughout

NGC1569: Previous observations



Radio images of NGC1569. Left: Continuum maps at four wavelengths (VLA, WSRT). At 20 cm, the first contour is at 50 μJy/b.a. Right: Magnetic field structure obtained at 3.6 cm (VLA), along with the rotation measure (colour wedge in units of 10^3 rad m−2), superimposed onto an Hα image (from Kepley et al. 2010).

My Goals : A brief overview

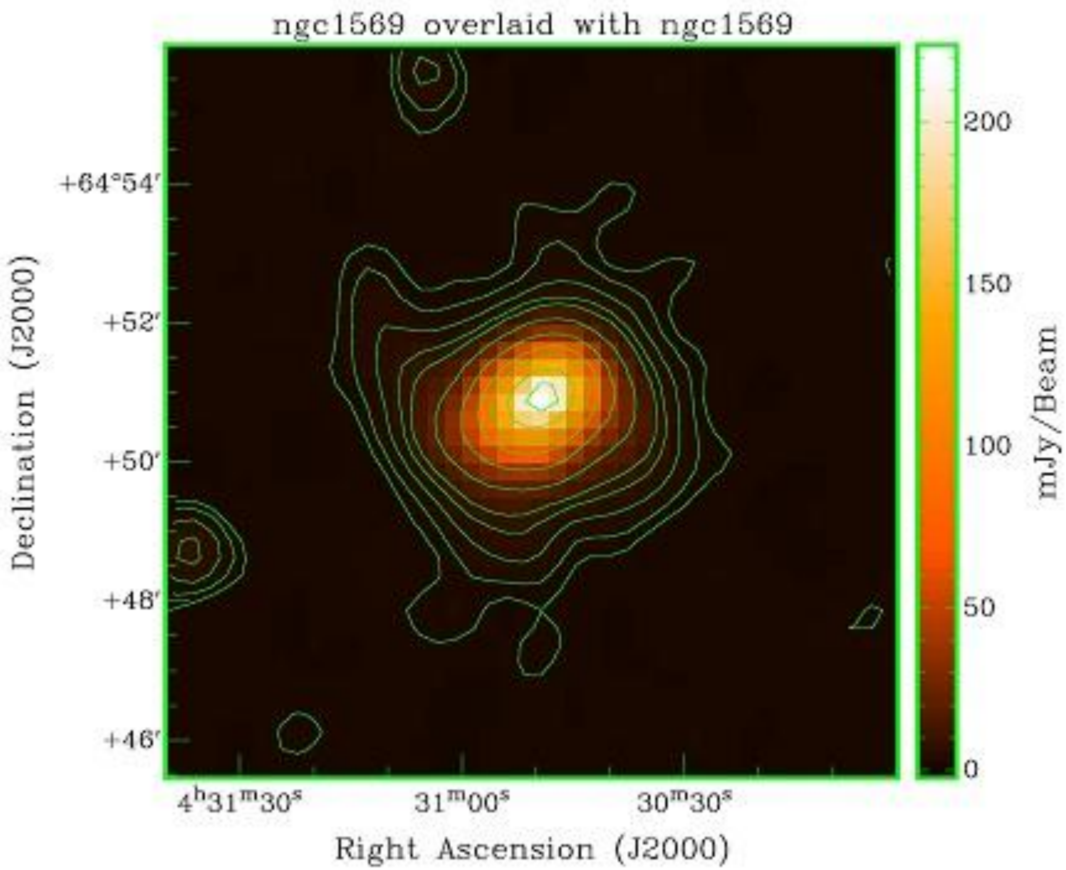
Bridging the gap between the higher frequencies and future observations with LOFAR:

- Size of the synchrotron halos ->find the relativistic particles
- Spectral index as a function of galacto-centric distance -> ages of the relativistic particles.
- Perform a rotation-measure analysis -> magnetic field structure around the dwarf galaxy-> RM Synthesis

Observations: WSRT set-up

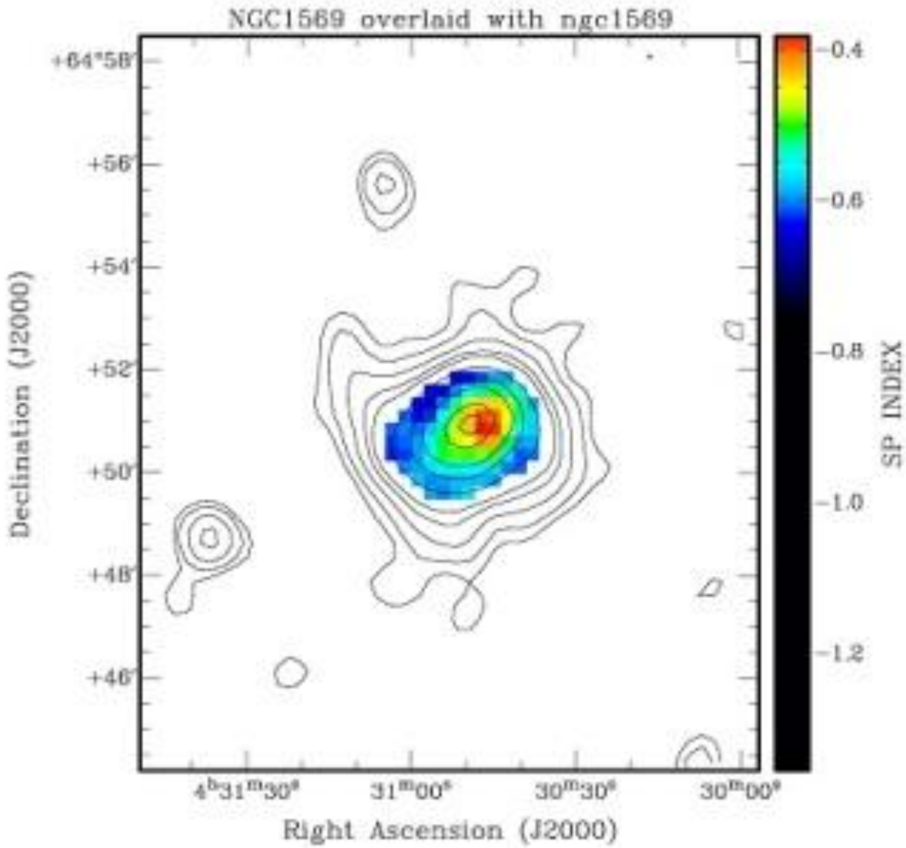
- Frequency : 92 cm, 350 MHz
- One 12 hour long run, night time, winter
- Maxi-short configuration
- 128 channels, 4 polarisations, 8 bands and 10 MHz bandwidth.
- Calibrators: 3C48, 3C286, both unpolarized at this frequency! (??)

Image in Stokes I



- RMS in the image is ~ 0.3 mJy/beam.
- The first contour is at 1 mJy.
- "boxy" structure, which is reminiscent of the morphology seen in X-rays and Hα.
- The extent of the radio halo is approx 6 kpc, at 20 it was 4.4 kpc
- Western Hα arm not visible anymore

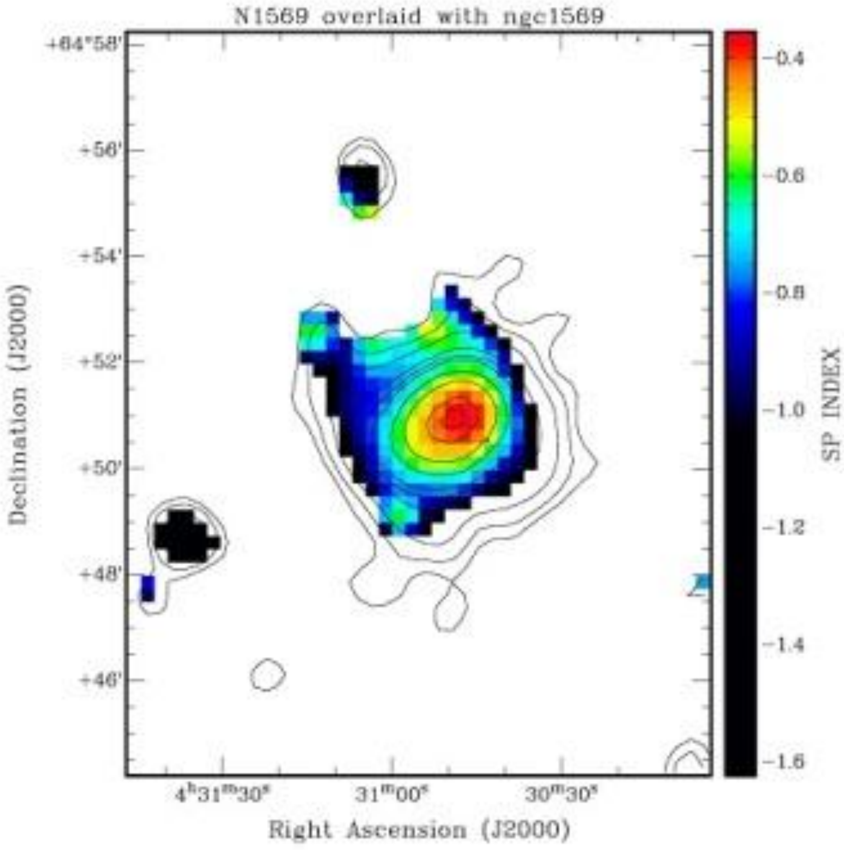
Preliminary Spectral Index Maps



Spectral index map between 90 cm and 20 cm

Artifacts in the 20 cm map caused problems

Preliminary Spectral Index Maps



Spectral index map between 90 cm and 3 cm

- Spectral indices in the galactic disk are close to thermal
- As one moves along the minor axis of the galaxy, away from the disk, the spectral indices become steeper, reaching a value of around -1 at the southern edge

Polarization and Magnetic Fields

- Obtained polarized calibrator datasets DA240 and 3C303 from an observation 5 days later.
- Calibration done on CASA – polarization leakage solution (D-term) and polarization angle (X-term) obtained for the source for each frequency channel (128x8)
- Cleaning and self-calibration going on as we speak
- RM Synthesis to be done soon

NGC 1569: Starburst in a Dwarf Irregular Galaxy

Credit: NASA, ESA, Hubble Heritage (STScI/AURA); **Acknowledgement:** A. Aloisi (STScI/ESA) et al.

Thank you!