Magnetisation of Interstellar and Intergalactic Media: The Prospects of Low-Frequency Radio Astronomy

DFG Research Unit



M. Brüggen

Magnetisation of Interstellar and Intergalactic Media: The Prospects of Low-Frequency Radio Astronomy



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Projects:

- Magnetic fields in the Milky Way
- Magnetic fields in nearby galaxies
- Low-frequency radio halos around dwarf galaxies
- Dynamo models of galaxies with winds
- Magnetic fields in galaxy clusters (simulations)
- Radio relics and halos (observations)
- RM Synthesis and magnetic field statistics
- LOFAR: Pilot and commissioning observations

11 PIs/Cols

- 7 Ph.D. students
- 3 Postdocs
- 1 secretary
- 1st Meeting, Kloster Irsee, October 2010
- 2nd Meeting, Ringberg Castle, July 2011
- 3rd Meeting, Mainz, July 2012



- Workshop on galaxy clusters, Tautenburg/Jena, Dec. 2011
- Workshop on galaxies, Bonn, March 2012
- training of students, postdocs:
- 1st GLOW Interferometer School, Hamburg, Aug./Sept. 2010
- 2nd GLOW Interferometer School, Bielefeld, Feb. 2012
- European Single Dish School, Bonn, Sept./Oct. 2010
- + long series of 'LOFAR busy weeks' ...

modern education ...



most important ingredients:



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simulation by van Leuwen & Stappers 2010

wavelet reconstruction of n_e -weighted magnetic field in the Milky Way



Stepanov 2012

pulsars with LOFAR (Sobey, Noutsos, Kramer et al.):



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nearby galaxies at lowest radio frequencies

calibration strategies, e.g. M 51 at 145 MHz (Mulcahy et al.)



NGC 3079 @ 22 cm (Sotomayor-Beltran et al.)



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... and thus obtain useful final products



NGC 3079 22 cm NGC 4631, spectral index 90/2 cm (Sotomayor-Beltran et al.)

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NGC 1569 and NGC 4449 at 350 MHz (A. Purkayastha et al.)



WSRT 'legacy project': 10 galaxies being observed at $\lambda = 92$ cm (PI: U. Klein)

key points:

- cosmic ray propagation
- magnetic fields in galactic halos.
- Faraday rotation, Rotation Measure Synthesis
- calibration strategies \Rightarrow LOFAR

... man(y) years of work!

theory: dynamo models, A. Bendre, D. Elstner et al.



galaxy clusters: disclosing the nature of diffuse radio sources: halos & relics

radio halos:

- secondary electrons (from hadronic collisions of relativistic protons with the thermal nuclei)
- in-situ (Fermi-II) re-acceleration by MHD turbulence generated in the ICM during cluster mergers

radio relics:

- compression of fossile radio plasma
- direct (Fermi-I) particle acceleration

WSRT 'legacy project': 10 clusters being observed at $\lambda = 92$ cm (PI: R. Pizzo)

- detecting extended diffuse low-surface emission in clusters
- establishing low-frequency synchrotron spectra of halos and relics
- investigating polarization properties of relics at low frequencies
- performing RM synthesis for halos and relics
- working out detailed models for cluster radio emission



WSRT (13 cm) + Effelsberg (11 cm)

MACS J1752 at 323 MHz (Bonafede et al. 2012)



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CIZA J2242.8+5301 (z = 0.1921) (van Weeren et al. 2011) simulation of radio and X-ray emission from a merging cluster (Hoeft et al. 2008)



simulations of (Vazza, Brüggen et al.)



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The Role of Simulations in Understanding Cosmic Magnetism

C Klaus Dolag

A.Bonafede, J.Donnert, H.Kotarba, A.Geng, A.Beck and F. Stasyszyn



PLASMA STUDIES III THE SEARCH FOR THE MAGNETIC FIELD



Prospects of Research Unit:

- high-latitude Galactic magnetic field (LOFAR: hundreds of pulsars)
- magnetic fields in and around spiral and irregular galaxies
- structure of magnetic field disks and halos
- simulations of SN-driven turbulence in the ISM
- M-Gadget: simulations of global galaxy evolution in cosmological context
- relics in galaxy clusters: comparison of LOFAR polarimetry observations with magneto-hydrodynamical simulations
- investigate bi-modality of cluster halos using radio (LOFAR) and SZ measurements (Planck, ...)

- establish tools for 'cutting-edge' images and analyses
- unification of the statistical analysis and the imaging algorithms
- LOFAR commissioning, especially for polarisation
- LOFAR surveys: statistics of galaxies and clusters of galaxies at the lowest radio frequencies



