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CIM Kick-off: Astrophysical Observations

Ralf-Jürgen Dettmar

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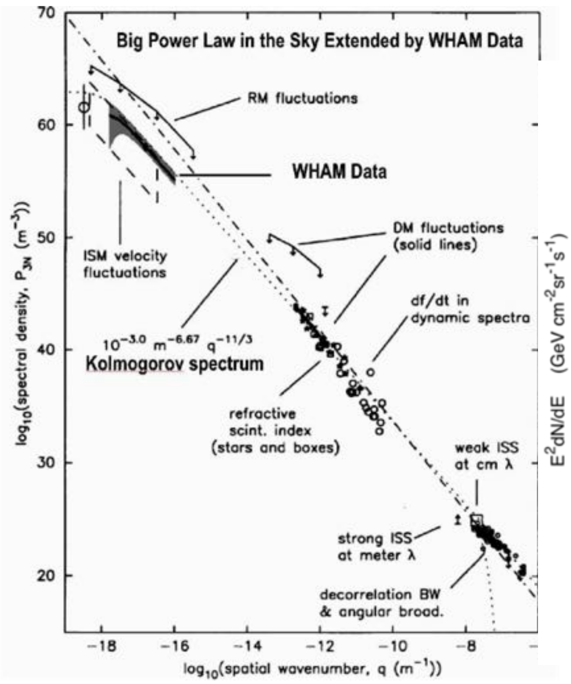

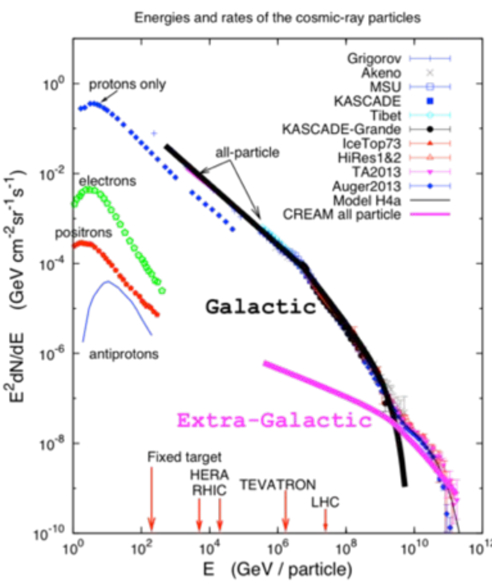

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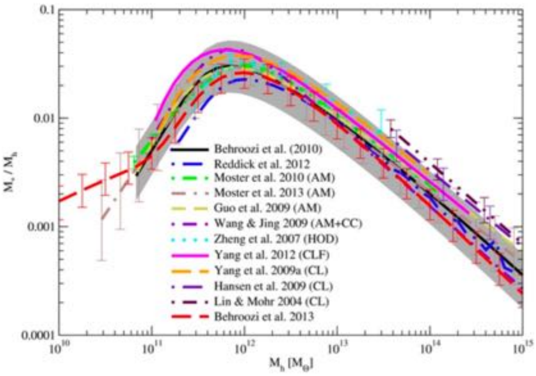
© Y. Stein, J. Englisch (CDS, RUB, UManitoba)

SFB 1491

Das Wechselspiel der kosmischen Materie

"structure formation"



Behroozi+ 2013

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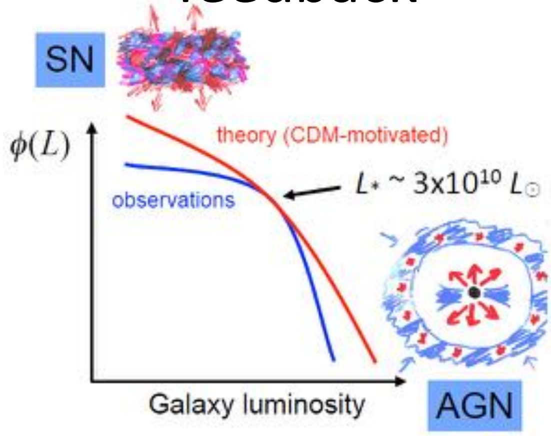
feedback



Silk 2013

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Cosmic ray-driven winds:

Magnetic Fields and Cosmic Rays contribute significantly to the energy density, i.e. pressure:

U_{rad} ˜ U_B ˜ U_{CR} ˜ U_{kin}

LAUNCHING COSMIC-RAY-DRIVEN OUTFLOWS FROM THE MAGNETIZED INTERSTELLAR MEDIUM

Philipp Girichidis[1], Thorsten Naab[1], Stefanie Walch[2], Michał Hanasz[3], Mordecai-Mark Mac Low[4,5], Jeremiah P. Ostriker[6], Andrea Gatto[1], Thomas Peters[1], Richard Wünsch[7], Simon C. O. Glover[5], Ralf S. Klessen[5], Paul C. Clark[8], and Christian Baczynski[5] — Hide full author list

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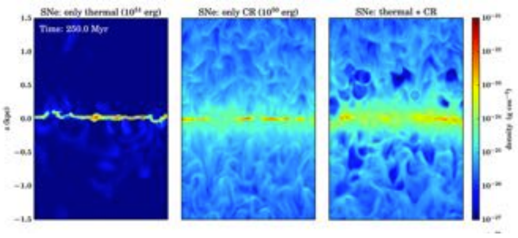
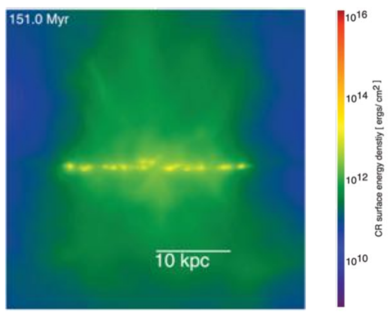
The Astrophysical Journal Letters, Volume 816, Number 2





Salem & Bryan (2014)

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ApJ 777, L16 (2013)

SIMULATIONS OF DISK GALAXIES WITH COSMIC RAY DRIVEN GALACTIC WINDS

C. M. Booth[1], Oscar Agertz[2,1], Andrey V. Kravtsov[1,3,4], and Nickolay Y. Gnedin[5,1,3]

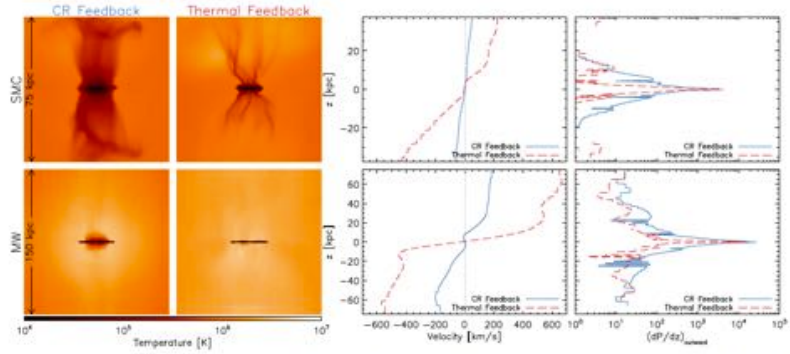
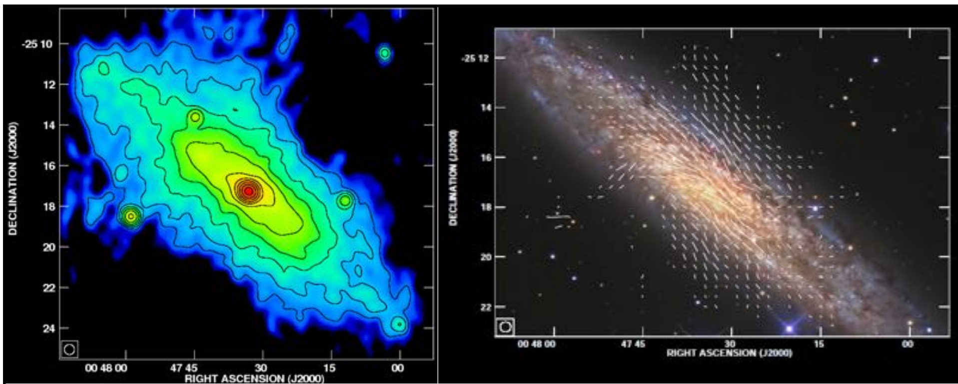


Fig. 3.— Edge-on maps of the temperature in a thin slice around the MW (*top panels*) and SMC galaxies (*bottom panels*) for both the thermal feedback *left panels*) and CR feedback (*right panels*). CR feedback has a large effect on the temperature structure of the halo gas. The plots show the median velocity (*left panels*) and outward pressure force (*right panels*) as a function of height from the disk for the same two simulations. All quantities are calculated in a cylinder of radius 3kpc, centered on the galactic disk. It is clear that the effect of the CRs is to increase the outward pressure forces in the halo by a factor of 3-5 at all z. This pressure gradient slowly accelerates the wind into the halo. The wind in the thermal feedback simulations is accelerated abruptly from the disk and maintains a constant velocity thereafter.



NGC 253 radiocontinuum study at 3, 6, 20, 90 cm (Heesen, Krause, Beck, Dettmar 2009 A&A)

What we can measure:

Polarized emission (and angles):

$I \propto \int n_{CR} B_{\perp}^{1+\alpha} dl$

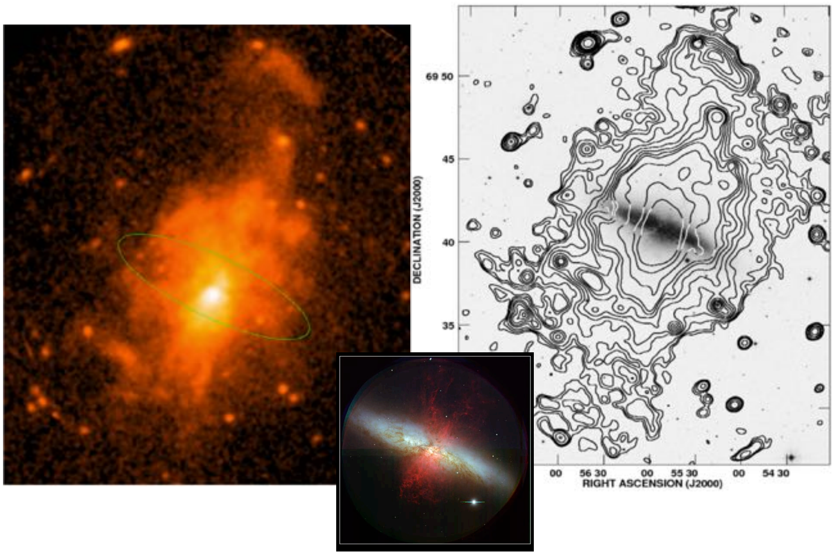
Faraday rotation measures of the diffuse polarized emission:

$RM \propto \int n_e B_{\parallel} dl$ and $c(l)= c_0+RM \cdot l^2$

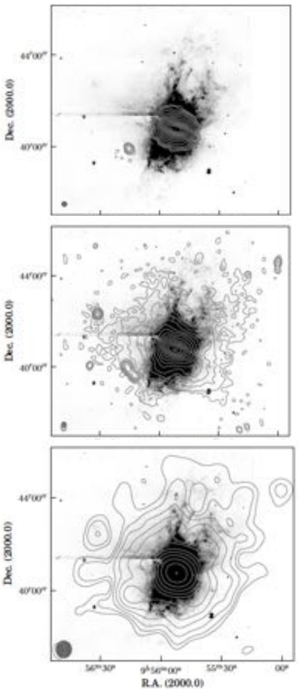
the prototypical galactic wind M82 (?)

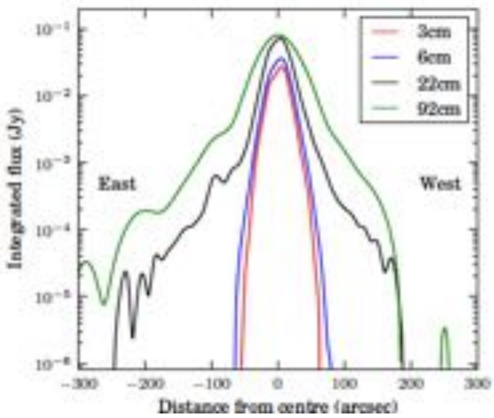
Subaru

M82 in X-rays / XMM (Wezgowiec, et al. in prep.)



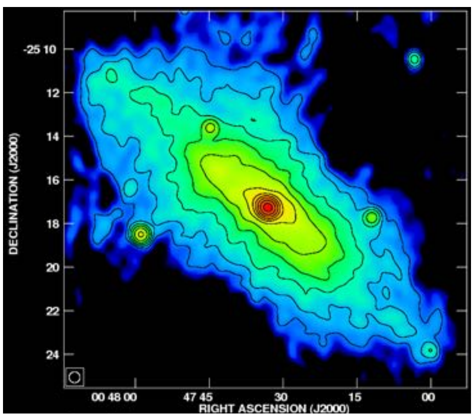
Transport of Cosmic Ray Electrons example: M82





Adebahr et al. 2013, A&A

What we can measure: synchrotron emission from CR Electrons



NGC 253 radiocontinuum study at 3, 6, 20, 90 cm

$I \propto \int n_{CR} B_{\perp}^{1+\alpha} dl$

(Heesen, Krause, Beck, Dettmar 2009 A&A)

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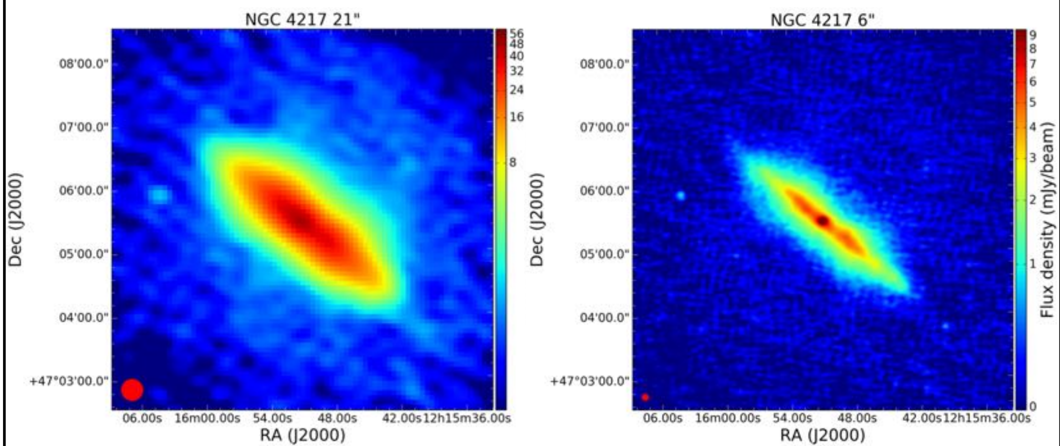
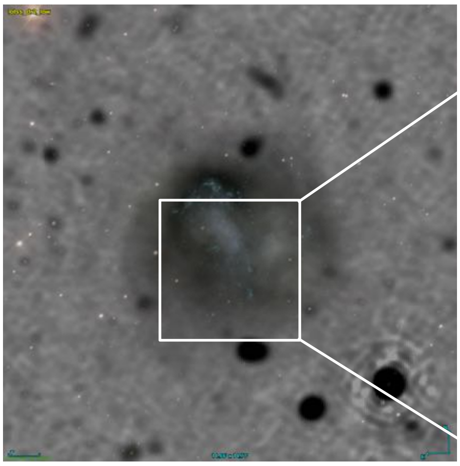
LOFAR Station DE605 Jülich

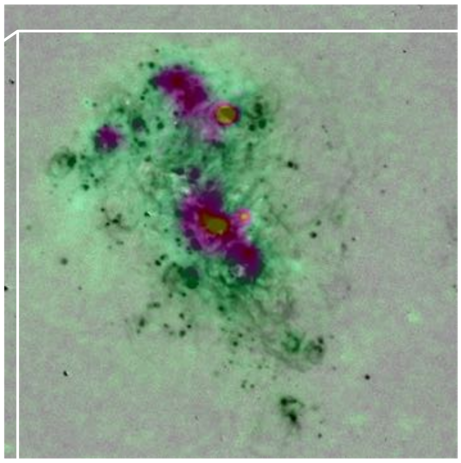
Transport of Cosmic Ray Electrons



~0.1 mJy rms noise, 0.46Jy total flux (A. Miskolczi)

A2: NGC 4449 at 150 MHz



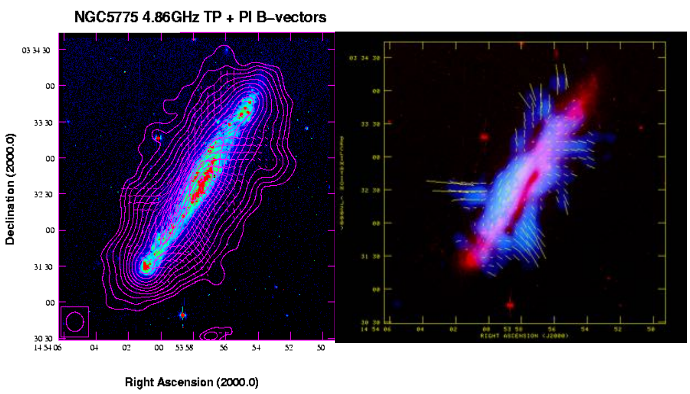


20” resolution (gray-scale) radio data with SDSS color image overlayed:
- Synchroton halo far beyond starforming disk
- complex structures at low radio surface brightness

Bomans, Chyzy, et al., in prep.

Continuum subtracted Hα image (gray-scale) with 6” resolution radio data overlayed:
- bright synchroton emission correlates with HII regions
- faint synchroton emission mostly follows diffuse Hα´ filaments

NGC 5775



Soida, Krause, Dettmar, Urbanik A&A 2011
Tüllmann, Dettmar, Soida, et al. A&A, 2000 364,L36

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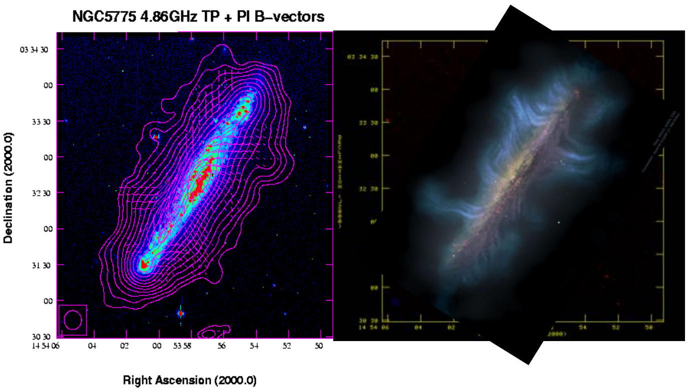
NGC 5775



Soida, Krause, Dettmar, Urbanik A&A 2011, 531, A127
Tüllmann, Dettmar, Soida, et al. A&A, 2000 364, L36

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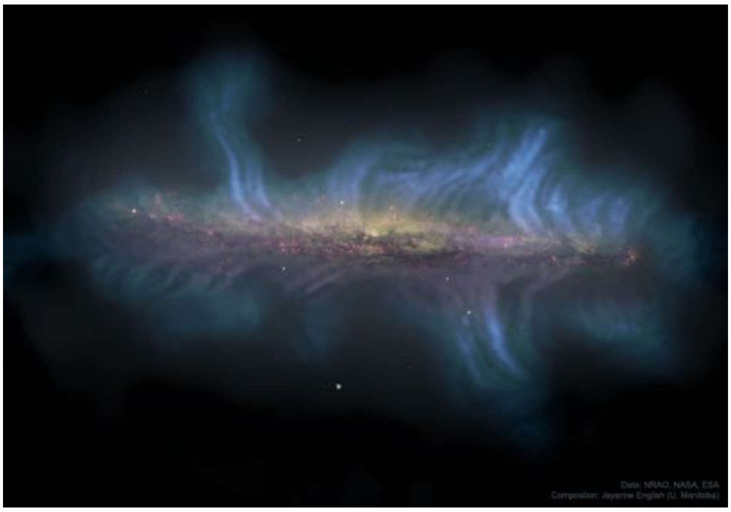
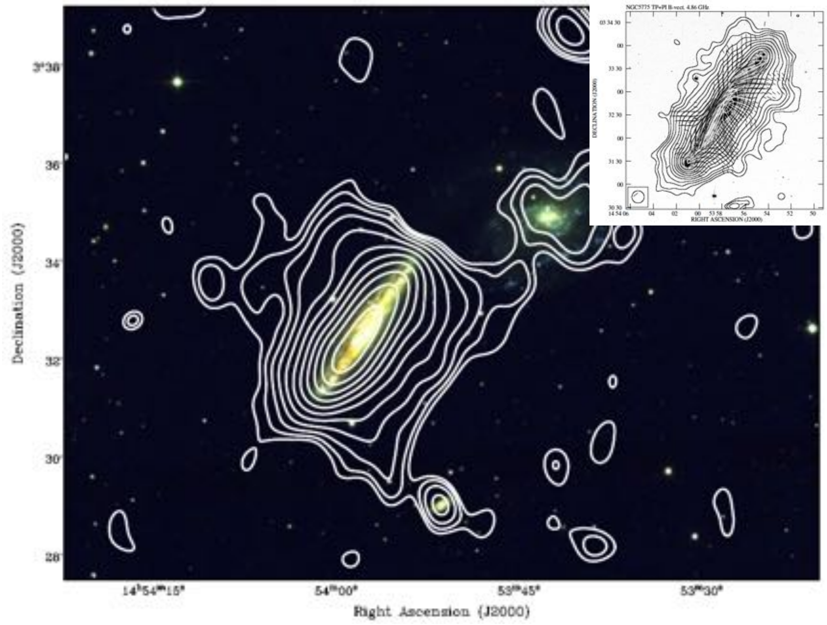


NGC 5775 APOD 27.1.2021

LOFAR HBA 10hrs 118-192 MHz (Heald, Shridar + LOFAR MKSP)



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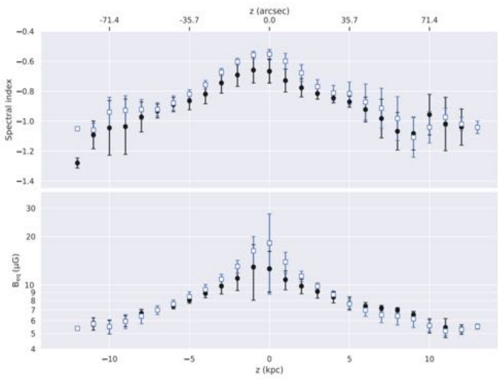
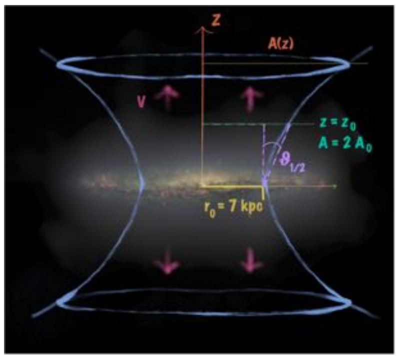
best modeled by an accelerating wind





Heald+, A&A, 2021

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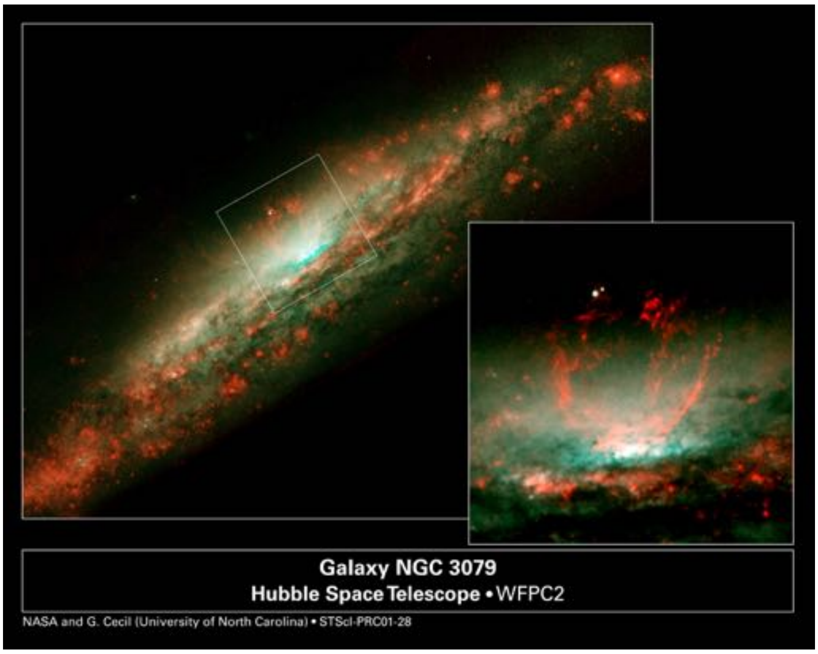
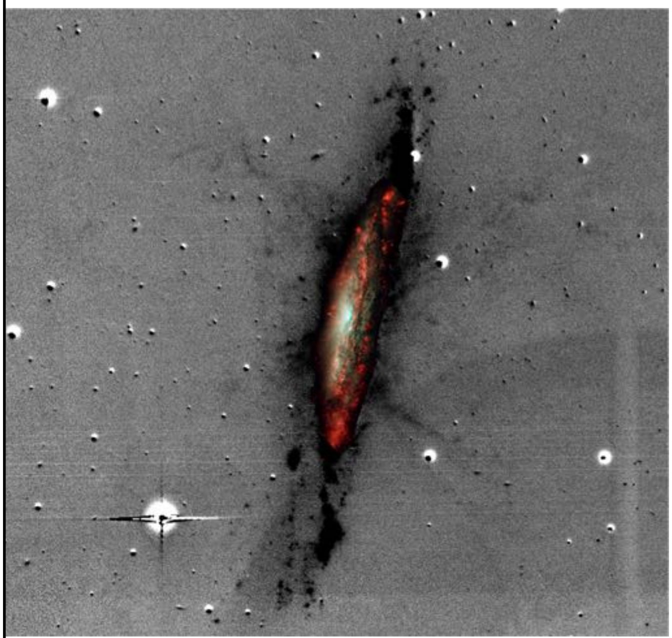




Hα image combined with HST image (D. Bomans)

new observing techniques

- Better calibration of interferometric data with strong off-axis sources (Peeling, Oosterloo, de Bruyn)
- Single-dish cleaning technique for high-dynamic range single dish imaging (strong sources observed with Effelsberg)
- Use of multichannel receivers for calibration and
- Rotation Measure-synthesis (demonstrated with WSRT data), f Faraday depth

$$P(\lambda^2) = \int_{-\infty}^{+\infty} pIe^{2i[\chi_0+\phi\lambda^2]}\mathrm{d}\phi$$

$$P(\lambda^2) = \int_{-\infty}^{+\infty} F(\phi)e^{2i\phi\lambda^2}\,\mathrm{d}\phi,$$ F(f) Faraday dispersion function

new observing techniques

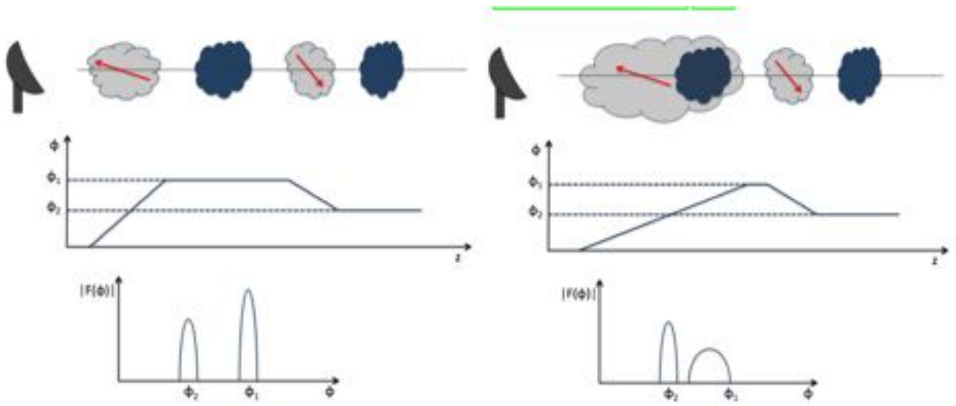
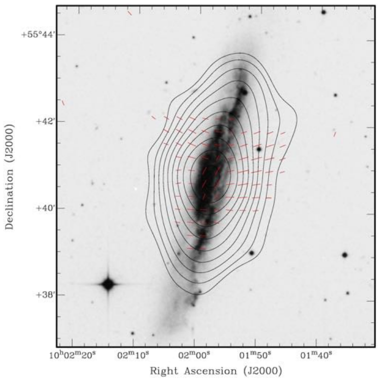
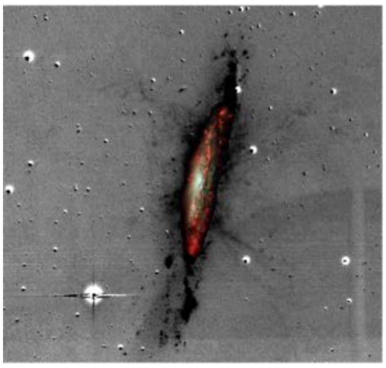


Fig. 1. Illustration of the principle of Faraday tomography. See main text for details. **Left:** The Faraday-rotating clouds (light grey) and the synchrotron-emitting clouds (dark blue) are spatially separated. **Right:** The closer synchrotron-emitting cloud is embedded in the closer Faraday-rotating cloud.

Alves, Ferriere+2016

N3079 (WRST)





Carlos Sotomayor (PhD Bochum 2014)

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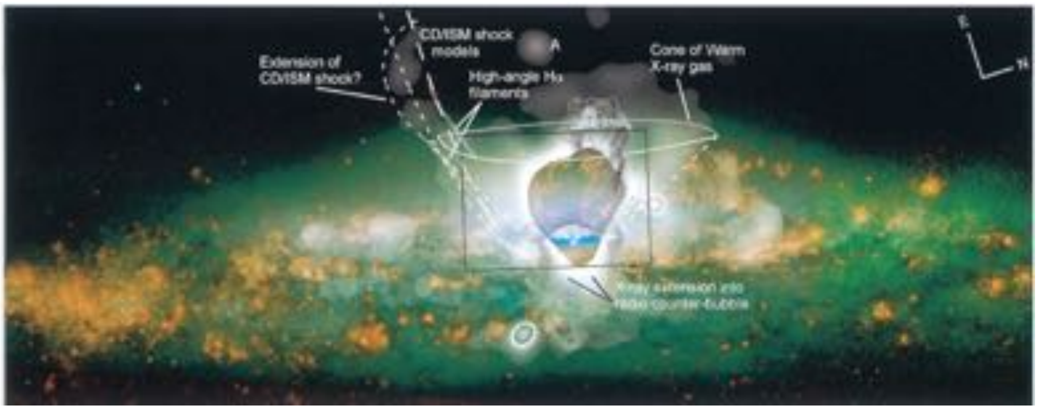

Cecil + 2002

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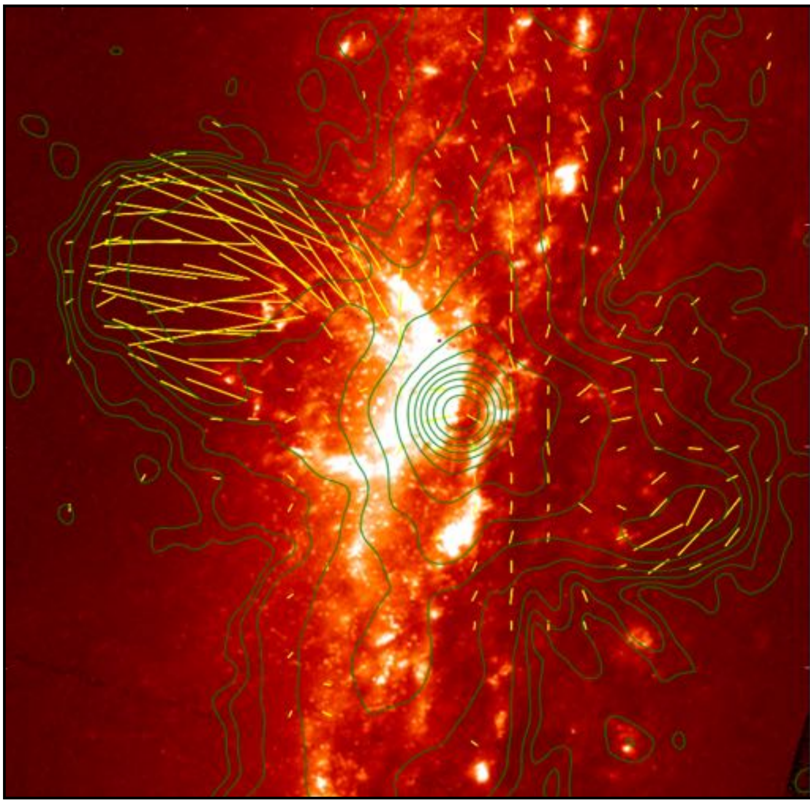
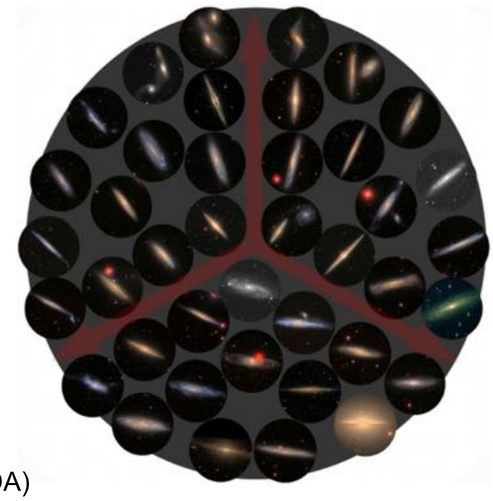


Making use of the JVLA

CHANGES:
Continuum HAlos in Nearby Galaxies
- an Evla Survey

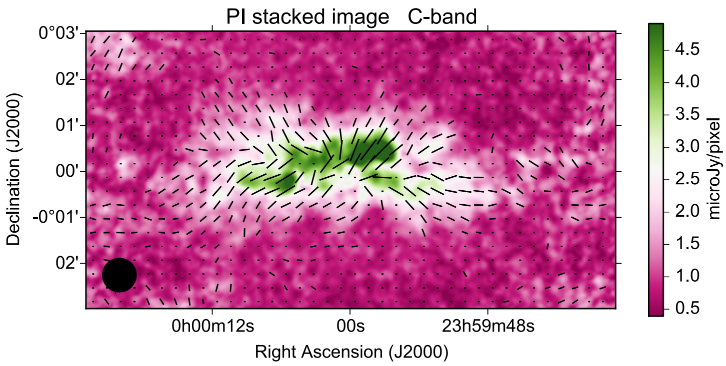


35 edge-on galaxies

inclination > 75 deg
DEC > 25 deg
4 arcmin > D < 15 arcmin
flux > 23 mJy

PI: Judith Irwin, Kingston (ONT/CANADA)

CHANGES result: stacked magnetic field



Krause+, 2020 A&A 639, A112

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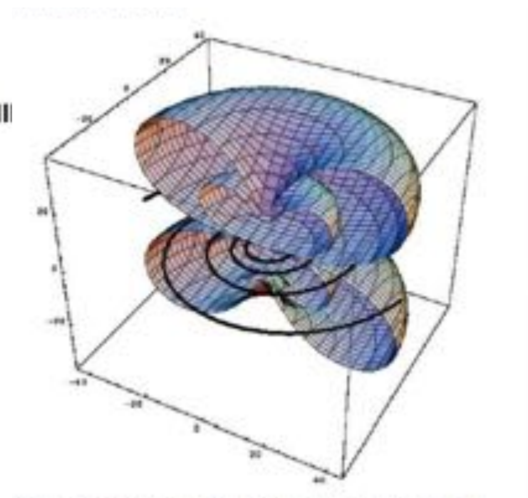
possible solution by quadrupol halo field

The Westerbork SINGS survey III

Global magnetic field topology

R. Braun[1], G. Heald[2], and R. Beck[3]



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general description of B-field:

Analytical models of X-shape magnetic fields in galactic halos

Katia Ferrière[1] and Philippe Terral[1]

[1] IRAP, Université de Toulouse, CNRS, 9 avenue du Colonel Roche, BP 44346, F-31028 Toulouse Cedex 4, France

Received ; accepted

ABSTRACT

Context. External spiral galaxies seen edge-on exhibit X-shape magnetic fields in their halos. Whether the halo of our own Galaxy also hosts an X-shape magnetic field is still an open question.
Aims. We would like to provide the necessary analytical tools to test the hypothesis of an X-shape magnetic field in the Galactic halo.
Methods. We propose a general method to derive analytical models of divergence-free magnetic fields whose field lines are assigned a specific shape. We then utilize our method to obtain four particular models of X-shape magnetic fields in galactic halos. In passing, we also derive two particular models of predominantly horizontal magnetic fields in galactic disks. All our field models have spiraling field lines with spatially varying pitch angle.
Results. Our four halo field models do indeed lead to X patterns in synthetic synchrotron polarization maps. Their precise topologies can all be explained by the action of a wind blowing outward from the galactic disk or from the galactic center. In practice, our field models may be used for fitting purposes or as inputs to various theoretical problems.

Key words. Galaxies: magnetic fields – galaxies: halos – galaxies: spirals – Galaxy: halo – Galaxy: disk – ISM: magnetic fields

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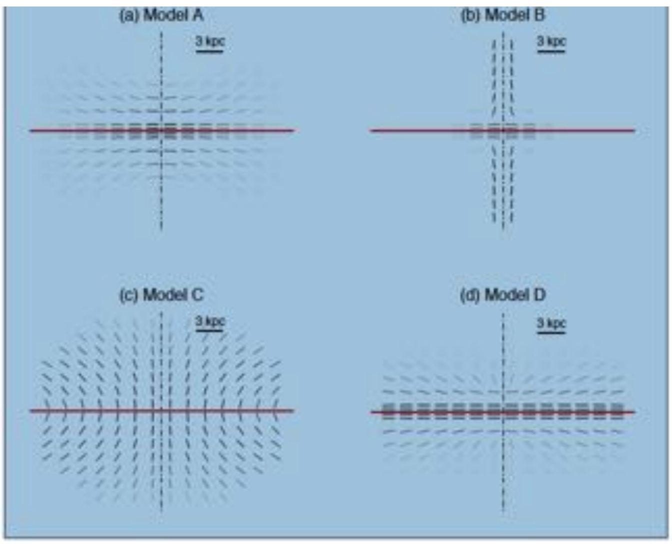
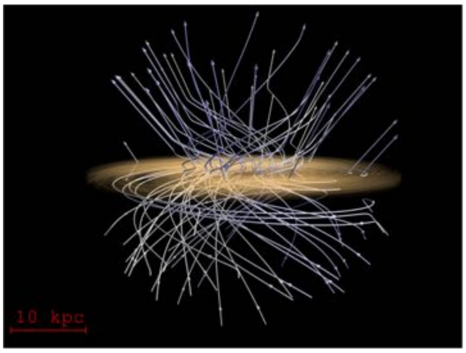


"the challenge": Galactic magnetic field



Farrar

A&A 644, A71 (2020)
https://doi.org/10.1051/0004-6361/201936081

Astronomy & Astrophysics

A novel analytical model of the magnetic field configuration in the Galactic center

M. Guenduez[1], J. Becker Tjus[1], K. Ferrière[3], and R.-J. Dettmar[2]

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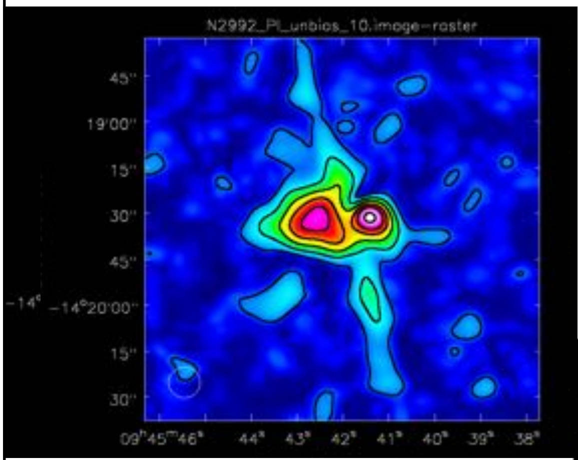
e-mail: mehmet.guenduez@rub.de
[2] Ruhr University Bochum, Faculty of Physics and Astronomy, RAPP Center, Astronomical Institute (AIRUB), 44780, Bochum, Germany
[3] IRAP, CNRS, University of Toulouse, 31028 Toulouse Cedex 4, France

Received 12 June 2019 / Accepted 7 September 2020

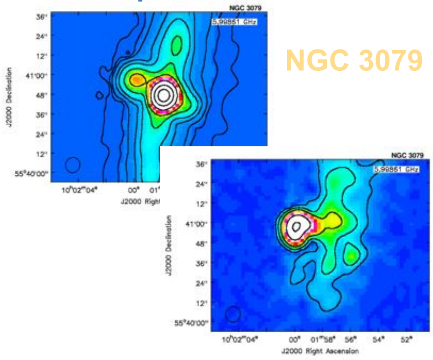
CHANG-ES VIII: Irwin et al. –

uncovering hidden AGN-related structure in radio polarization

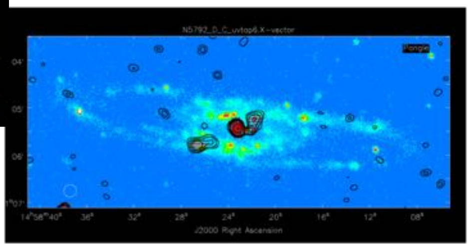
NGC 2992



NGC 3079



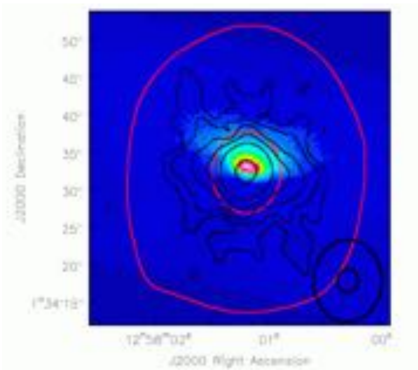
NGC 5792

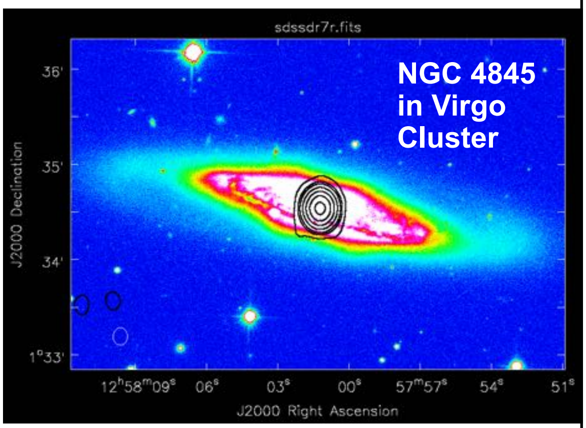


Faraday corrected by RM synthesis

CHANG-ES V and CHANG-ES XI:

Irwin et al.: a TDE and circular polarization



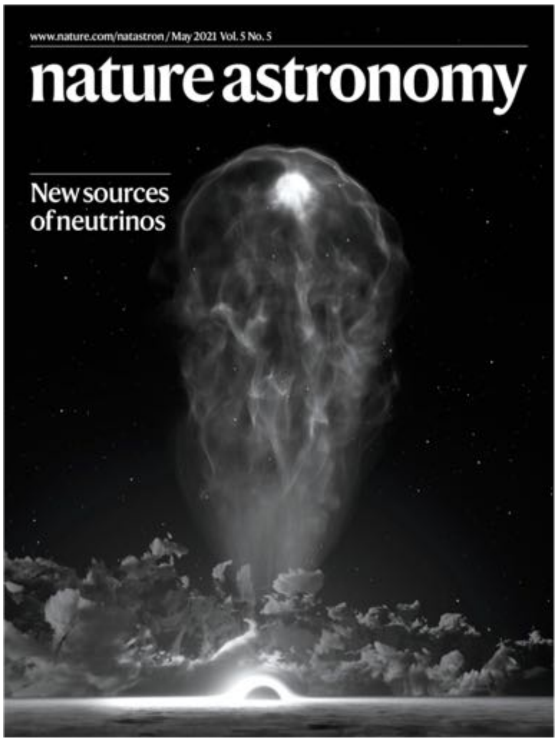


Darray Cband (red contours) – large red contour (10σ)

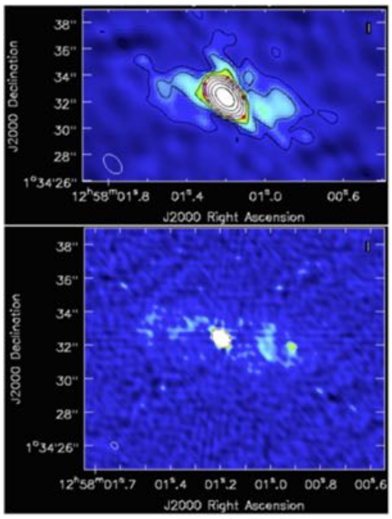
Carray Cband (black contours) – show a small disk (2.8 kpc diam)

Note the optical cone

There is an unresolved AGN in this source that is variable – and Circularly Polarized at the 2% level.



VLBA observations of NGC4845



Perlman+ 2017, ApJ 842, 126

Thank you for your attention