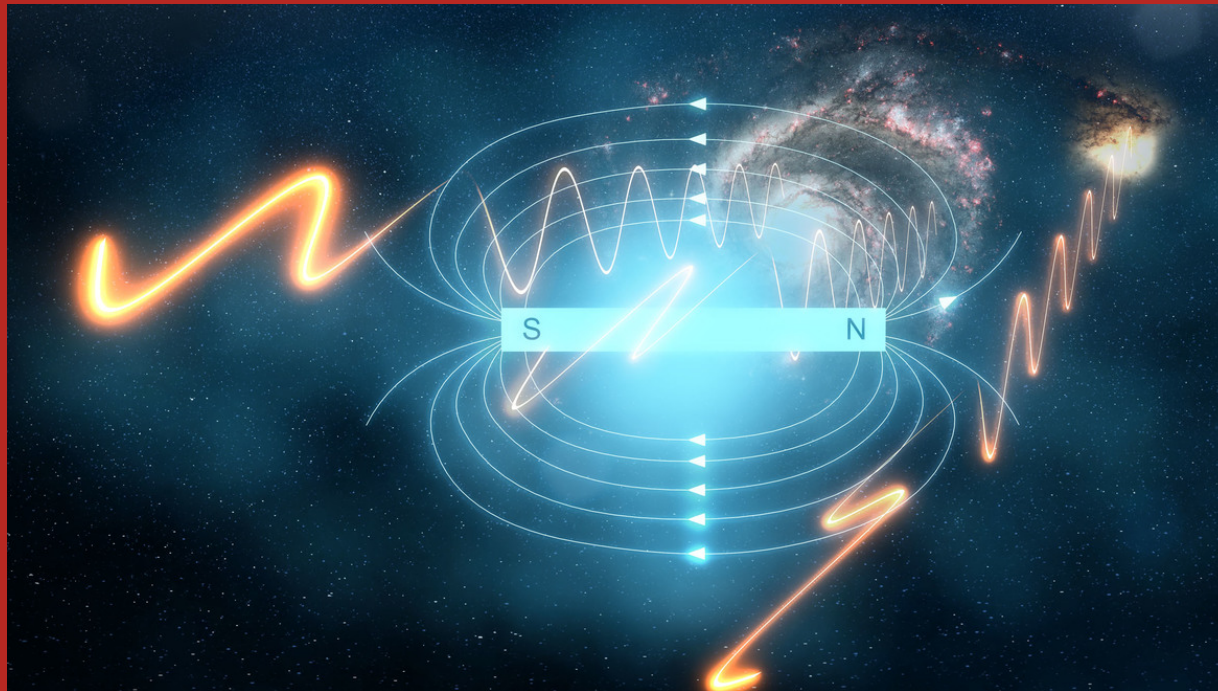


Cosmic Magnetism

Marijke Haverkorn,
on behalf of the SKA Cosmic Magnetism Science Working Group



The Magnetism Science Working Group

Core Members:

Sui Ann Mao (co-chair)

Ivan Agudo

Annalisa Bonafede

Bryan Gaensler

Federica Govoni

Russ Taylor

Shane O'Sullivan

Larry Rudnick

Dominic Schnitzeler

Xiaohui Sun

Anna Bonaldi

George Heald (co-chair)

Takuya Akahori

Luigina Feretti

Gabriele Giovannini

Marijke Haverkorn

Melanie Johnston-Hollitt

Tim Robishaw

Anna Scaife

Jeroen Stil

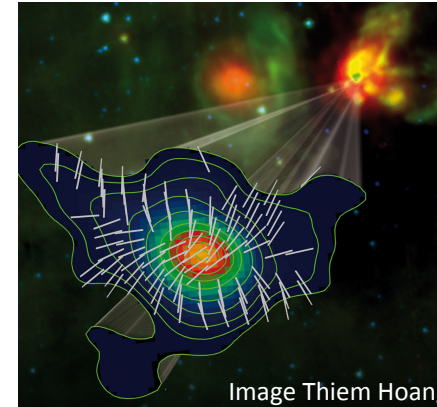
+ 29 associated members, among whom **Roberto Pizzo, Marta Alves**

19 magnetism chapters in the SKA Science book

Cosmic Magnetism is central to astrophysics on all scales:

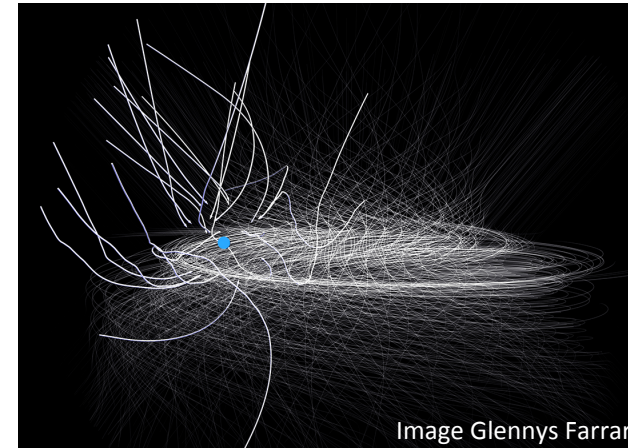
Stellar evolution

- pulsars and collapsed stellar objects
- Jovian planets
- cloud collapse & star formation
- stellar activity & outflows
- supernova remnants, planetary nebulae



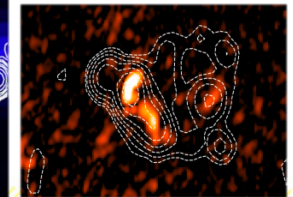
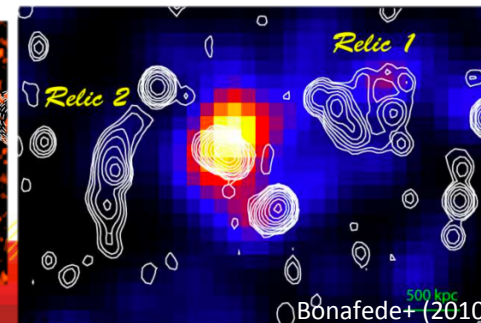
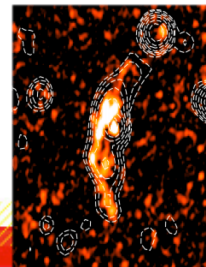
Galaxy evolution

- ISM turbulence and energy transport
- stability of galactic disks
- acceleration, propagation & confinement of cosmic rays



Inter-Galactic phenomena

- energy transport in clusters
- AGN and IGM feedback



Current concept of Cosmic Magnetism Key Science Projects

1. Origin and Evolution of Magnetic Fields in Large Scale Structures (Mpc scales)

- The magnetic field in clusters and filaments
- The magnetic cosmic web
- Probing the nature of Dark Matter and fundamental physics

2. Origin and Evolution of Magnetic fields in Galaxies (kpc - pc scales)

- Emergence and evolution of magnetic fields in galaxies
- AGN physics at all redshifts and luminosities
- Magnetic fields in nearby galaxies
- Multi-scale magnetism in the Milky Way

3. Magnetic fields and stellar evolution (stellar scales)

- Role of magnetism in star formation, stellar evolution, exoplanets

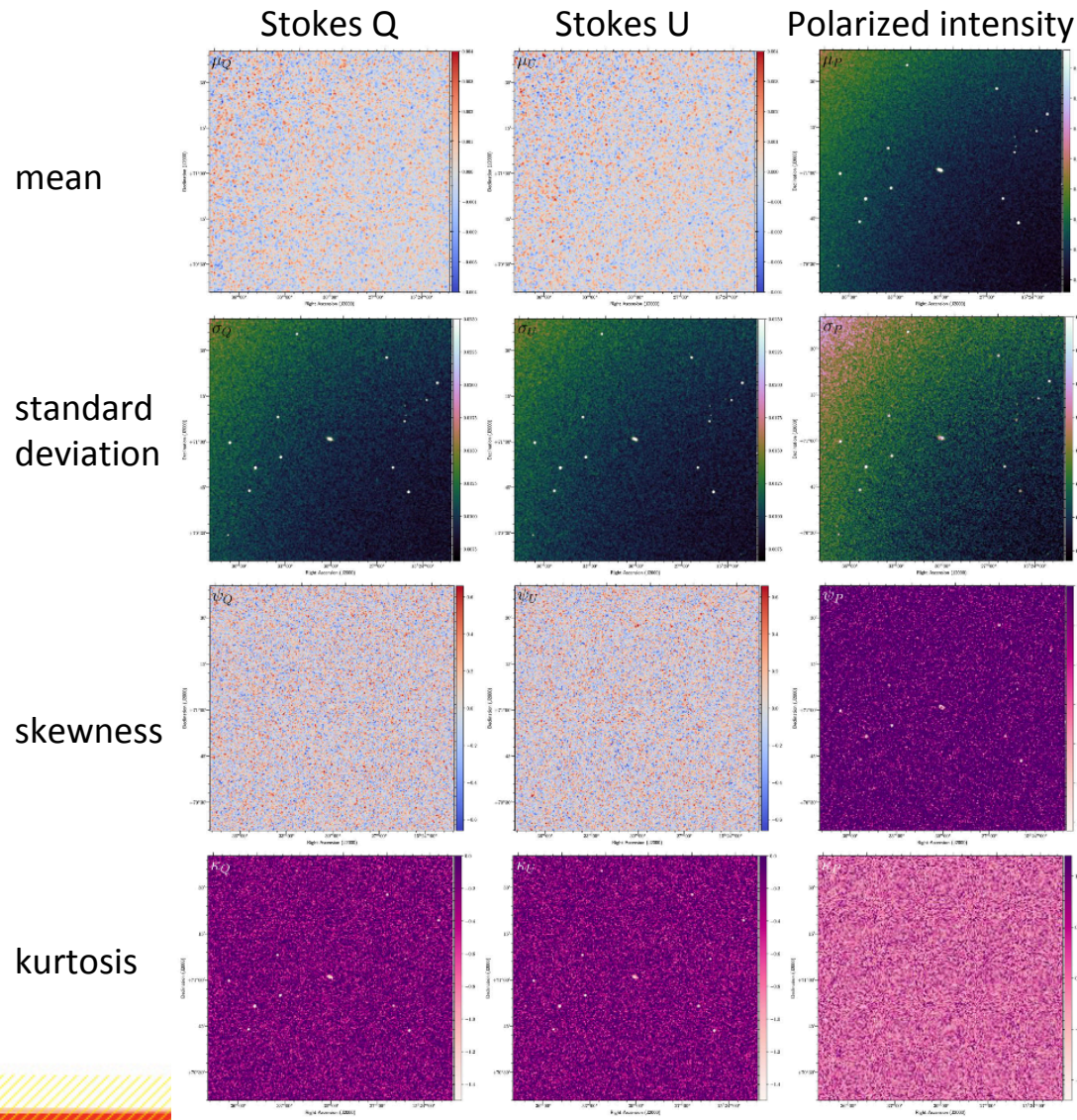
Main SKA observables for cosmic magnetic fields

1. **Synchrotron emission:** total intensity and polarization
2. **Faraday rotation:**
 - RM Grid from extragalactic background sources and pulsars
 - broad-band polarimetry gives Faraday depth spectra
3. **Zeeman splitting** (absorption and emission): in-situ measurements in neutral gas

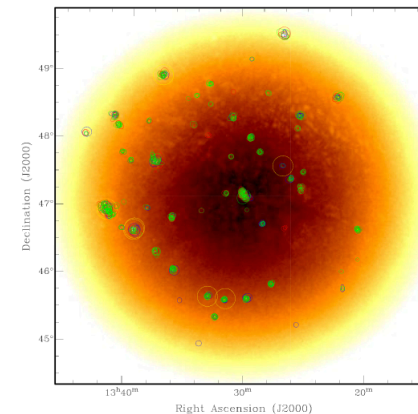
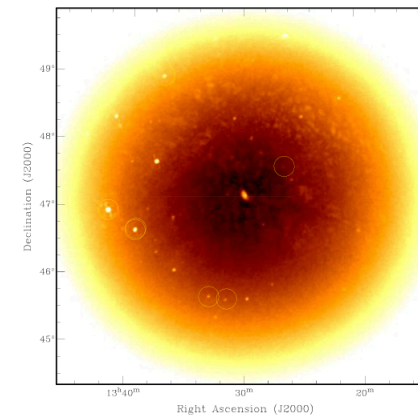
We require:

- wide wavelength-squared coverage with fine spectral resolution
- excellent polarization calibration

Recent technical highlights: polarized source finding through 'Faraday moments'

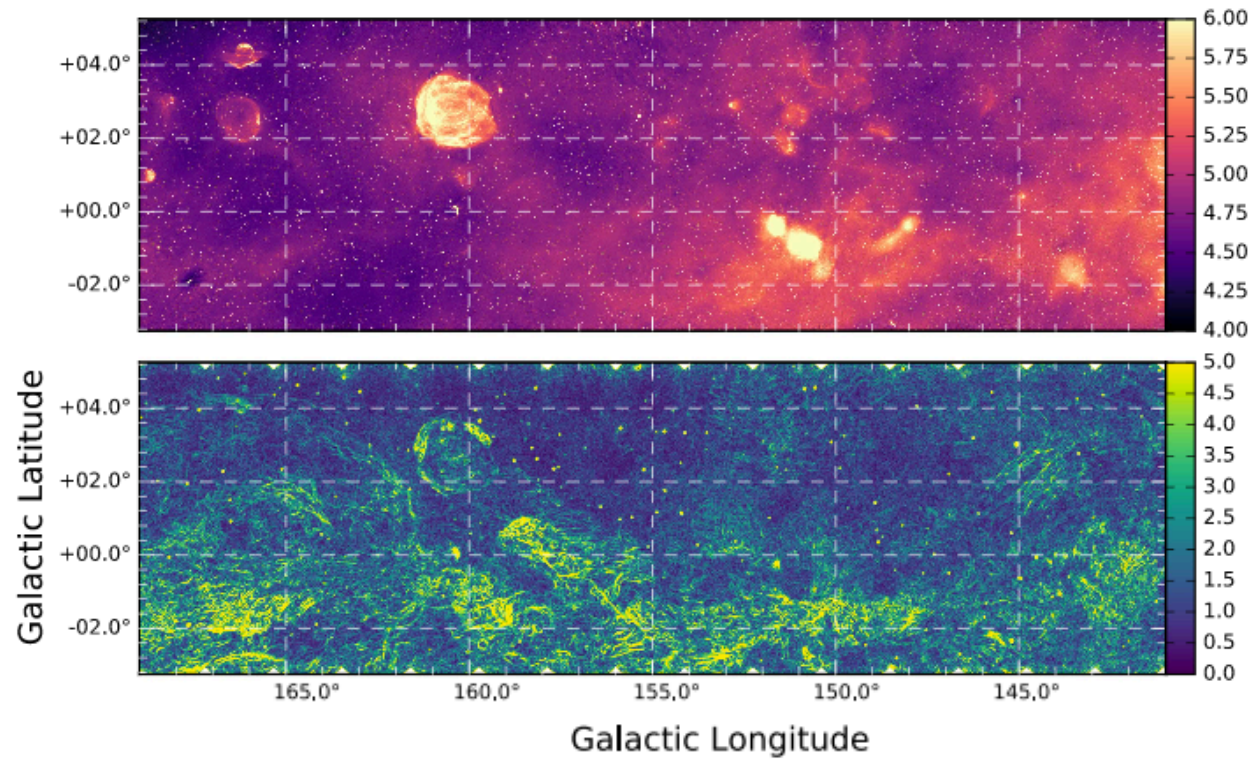


LOFAR observations of the M51 field



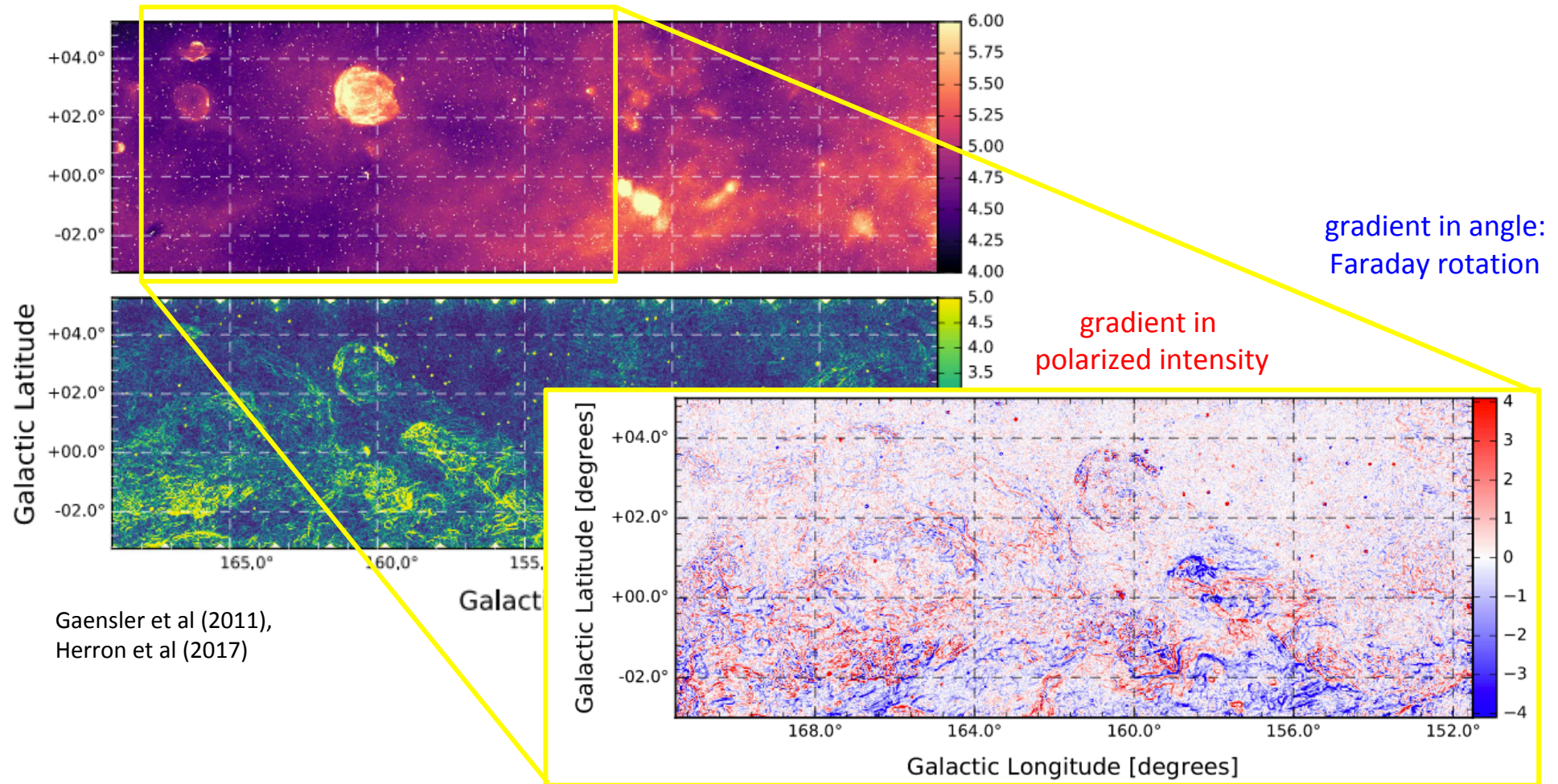
Farnes et al (2018)

Recent technical/science highlights: polarization gradients probe Galactic magnetic fields



Herron et al (2017)

Recent technical/science highlights: polarization gradients probe Galactic magnetic fields

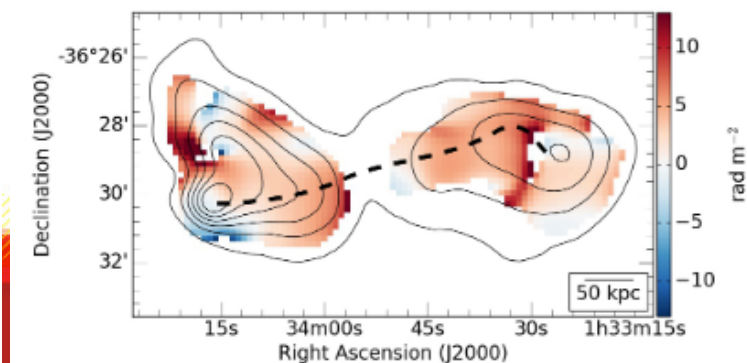
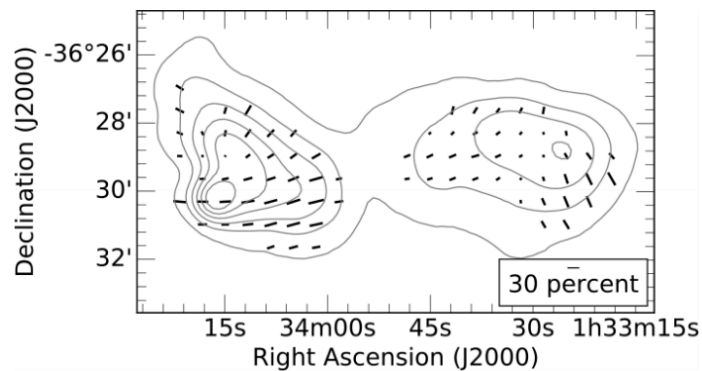
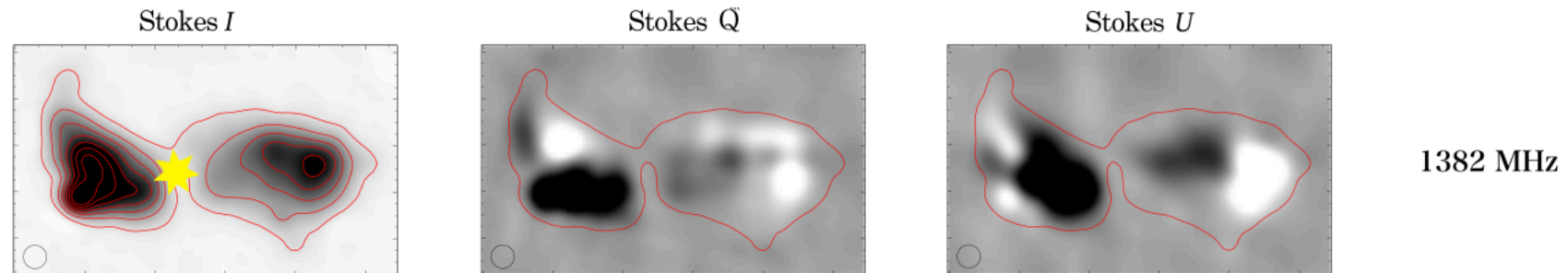


Gaensler et al (2011),
Herron et al (2017)

Herron et al (2018)

Recent science highlights: Faraday depth structure of radio galaxy NGC 612

1.3 – 3.1 GHz ATCA



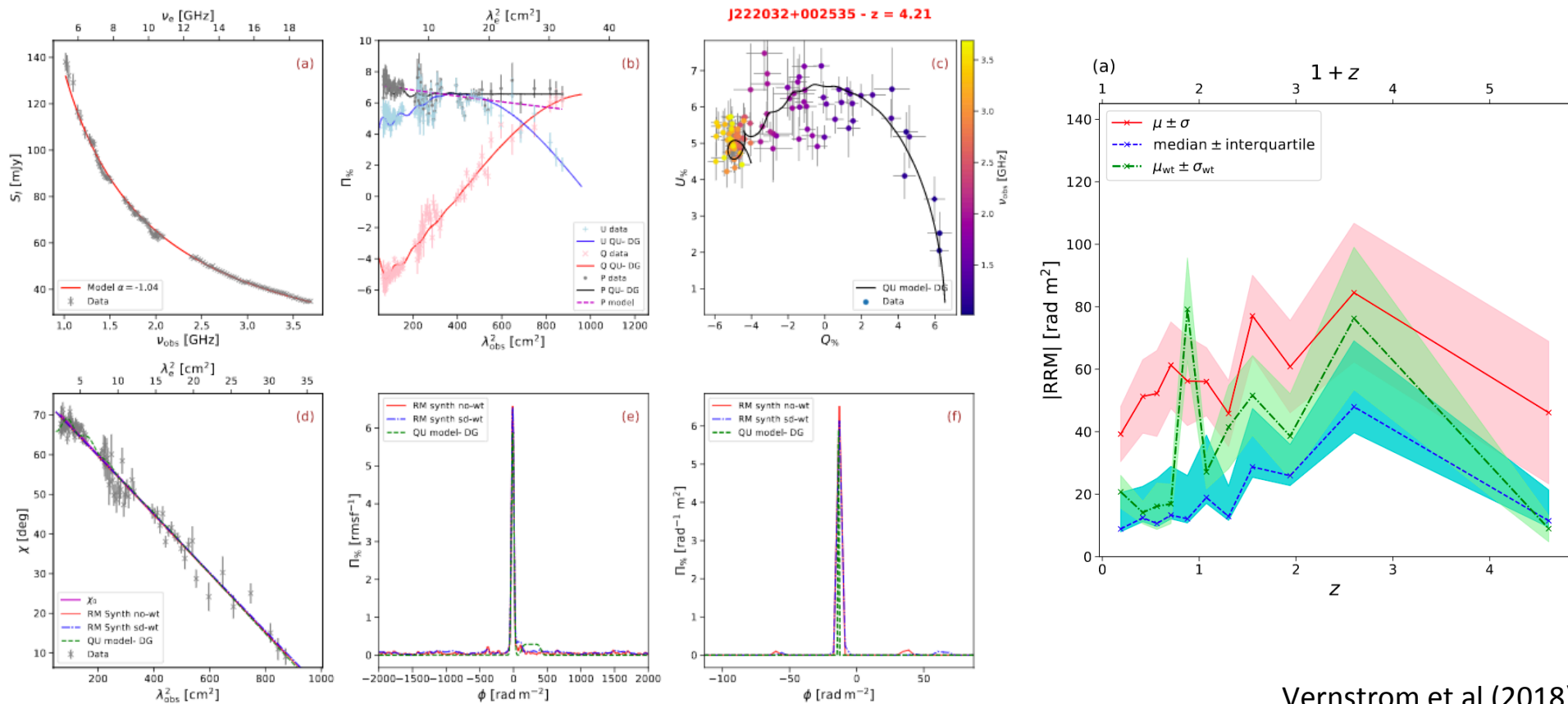
Modeling polarization indicates that Faraday rotation is external to synchrotron emission

→ thermal material in thin sheet around the synchrotron lobe

Kaczmarek et al (2018)

Recent science highlights: Magnetization of high-redshift galaxies

2-4 GHz JVLA data of high- z ($z > 3$) and low- z polarized sources: no relation between rotation measure and redshift found.



Vernstrom et al (2018)

Future highlights: upcoming conferences

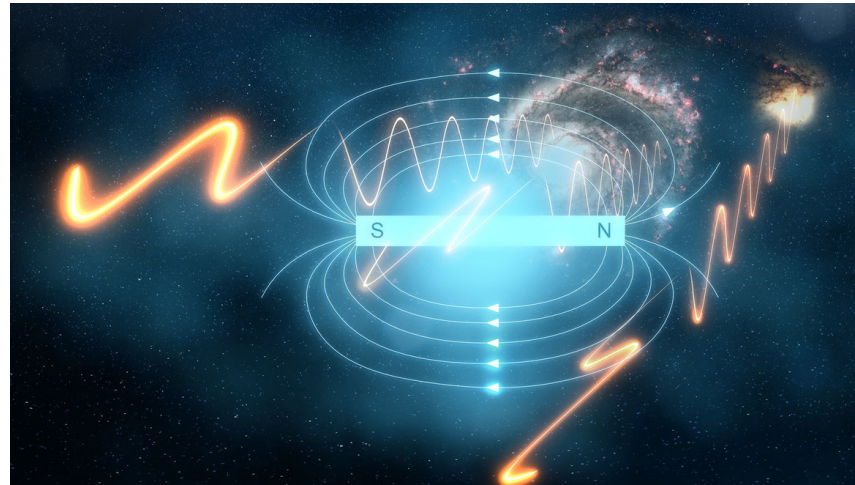
- The Power of Faraday Tomography (Japan, May 2018)
- IAU General Assembly Focus Meeting 8: *New Insights in Extragalactic Magnetic Fields* (Vienna, Aug 2018)
- IAU General Assembly Focus Meeting 4: *Magnetic fields along the star-formation sequence* (Vienna, Aug 2018)
- *LOFAR Magnetism Key Science Project annual meeting* (Krakow, Sep 2018)

Current status of the Cosmic Magnetism SWG:

- fairly sizeable community
- preparing for SKA with pathfinders/precursors in various ways

BUT the SWG is very disjoint and divided into separate groups.

SKA1 polarization surveys



First priority:

an all-sky SKA1-MID Band 2 polarimetric imaging survey

- across the entire 950 – 1760 MHz band
- to $\sim 4 \mu\text{Jy}/\text{beam}$ sensitivity
- at 2 arcsec resolution

In addition: a series of smaller, deeper surveys at various wavelengths