

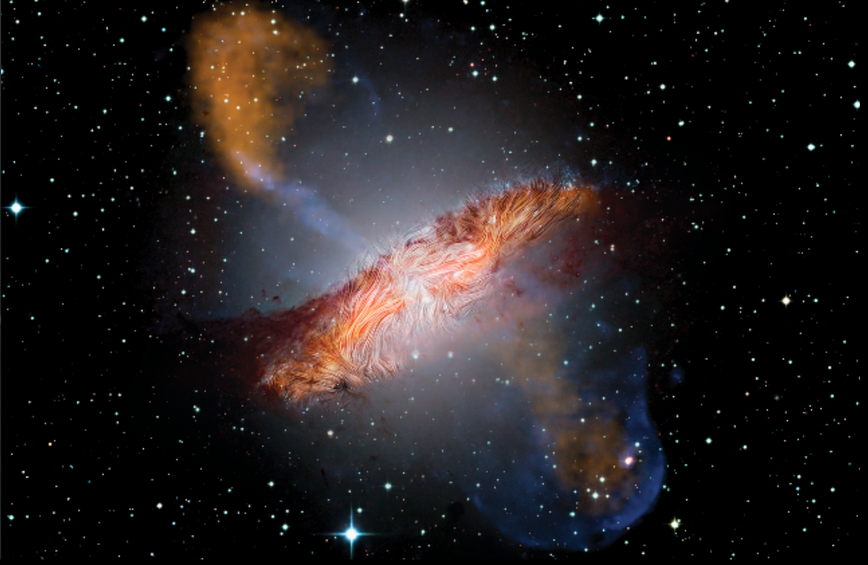

Extragalactic magnetism using far-infrared polarimetry with PRIMA

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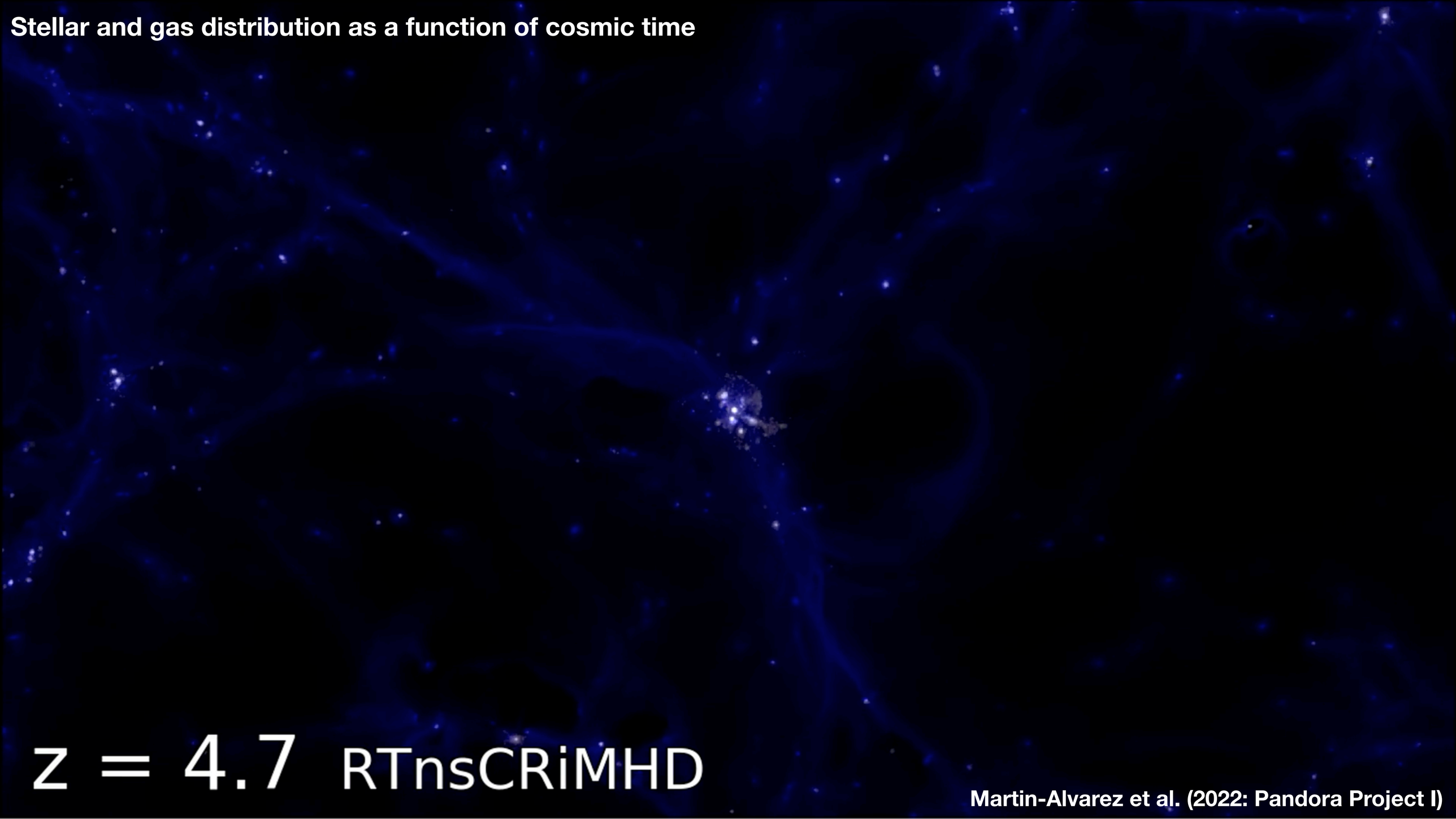
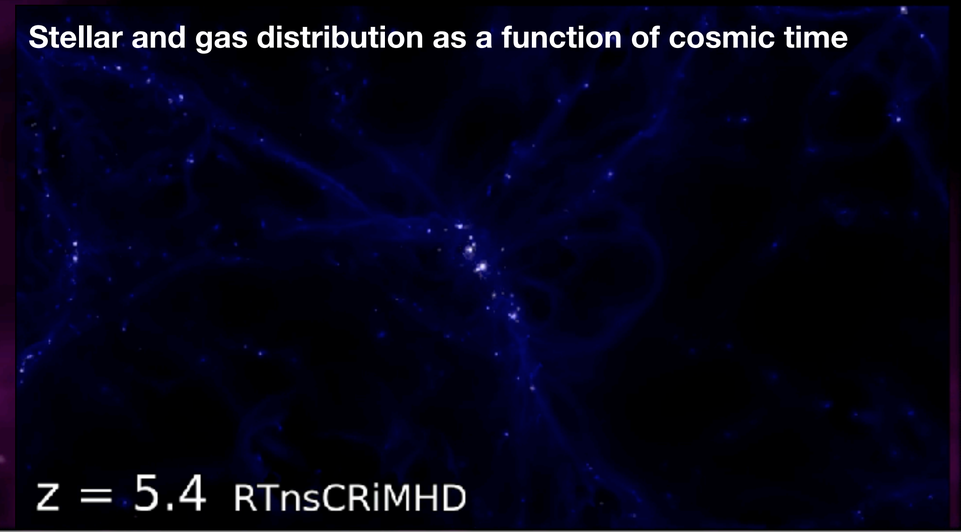

Stellar and gas distribution as a function of cosmic time
z = 4.7 RTnsCRiMHD
Martin-Alvarez et al. (2022: Pandora Project I)

Stellar and Magnetic Field distribution as a function of cosmic time

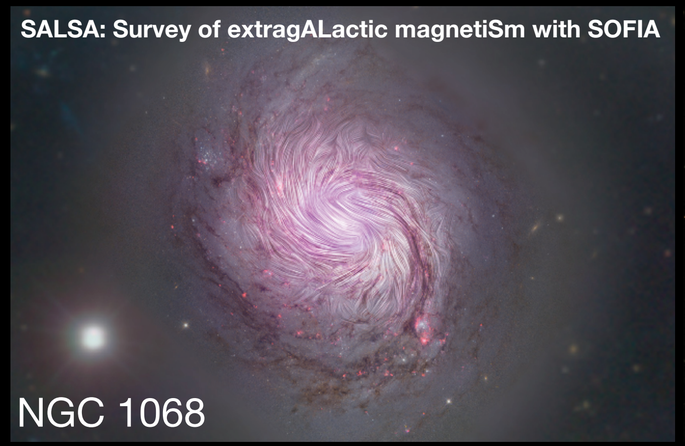
Martin-Alvarez et al. (2022: Pandora Project I)

$z = 5.4$ RTnsCRiMHD

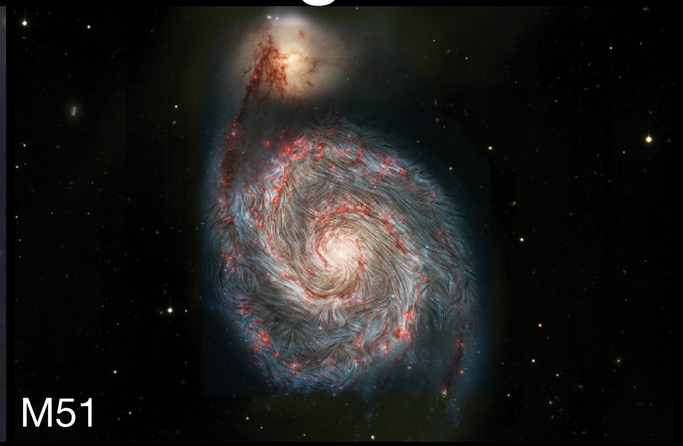


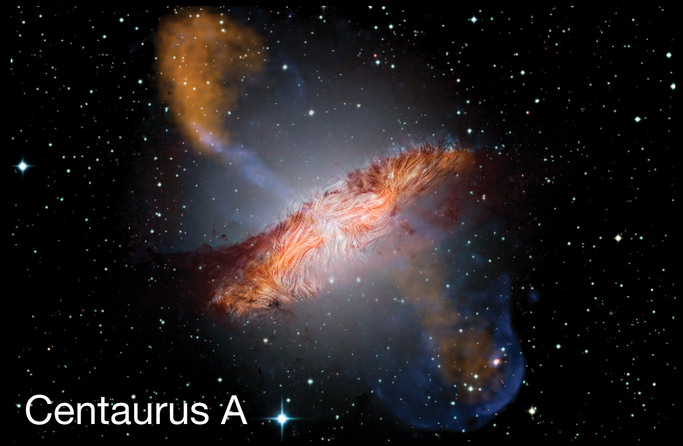
Magnetic fields permeate the interstellar and intergalactic medium

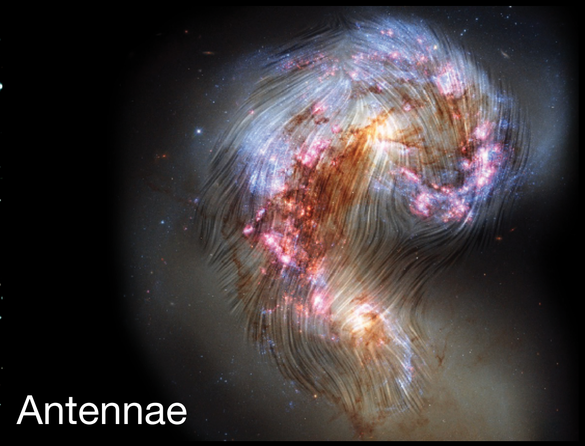

M82



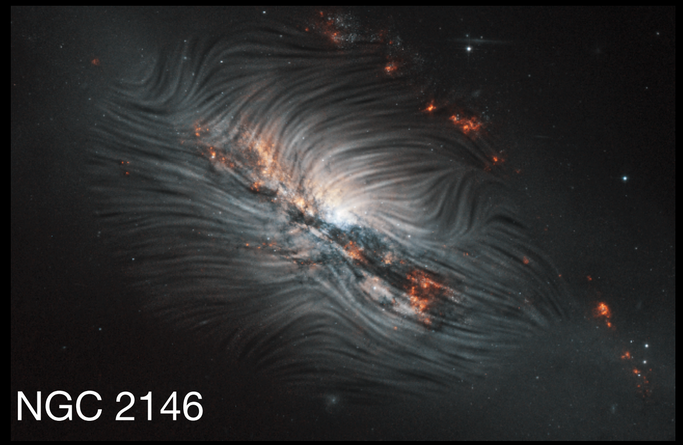
NGC 1068


M51


Centaurus A


Antennae


NGC 3627

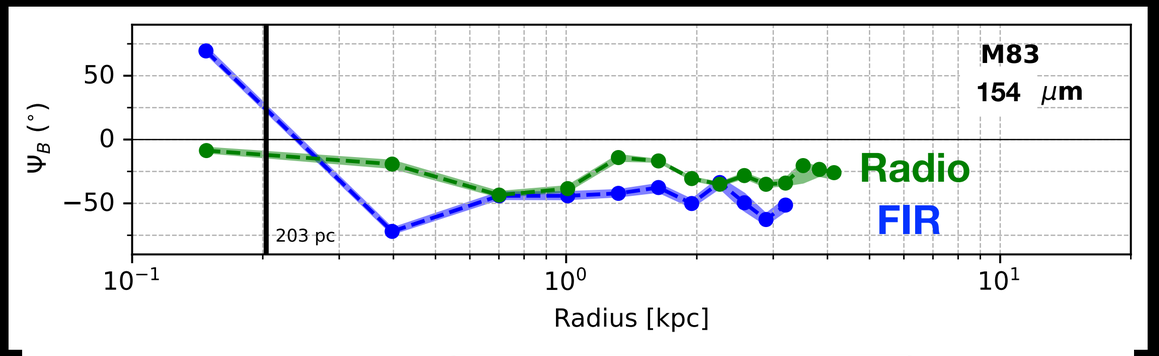

NGC 2146

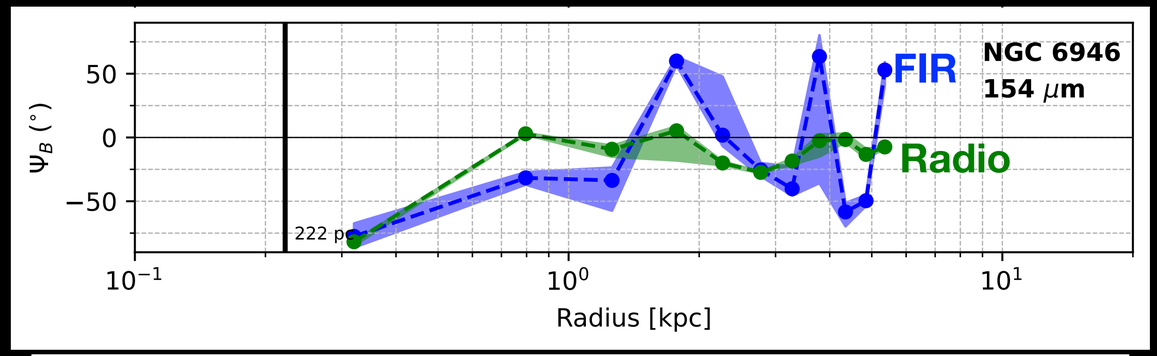

M83

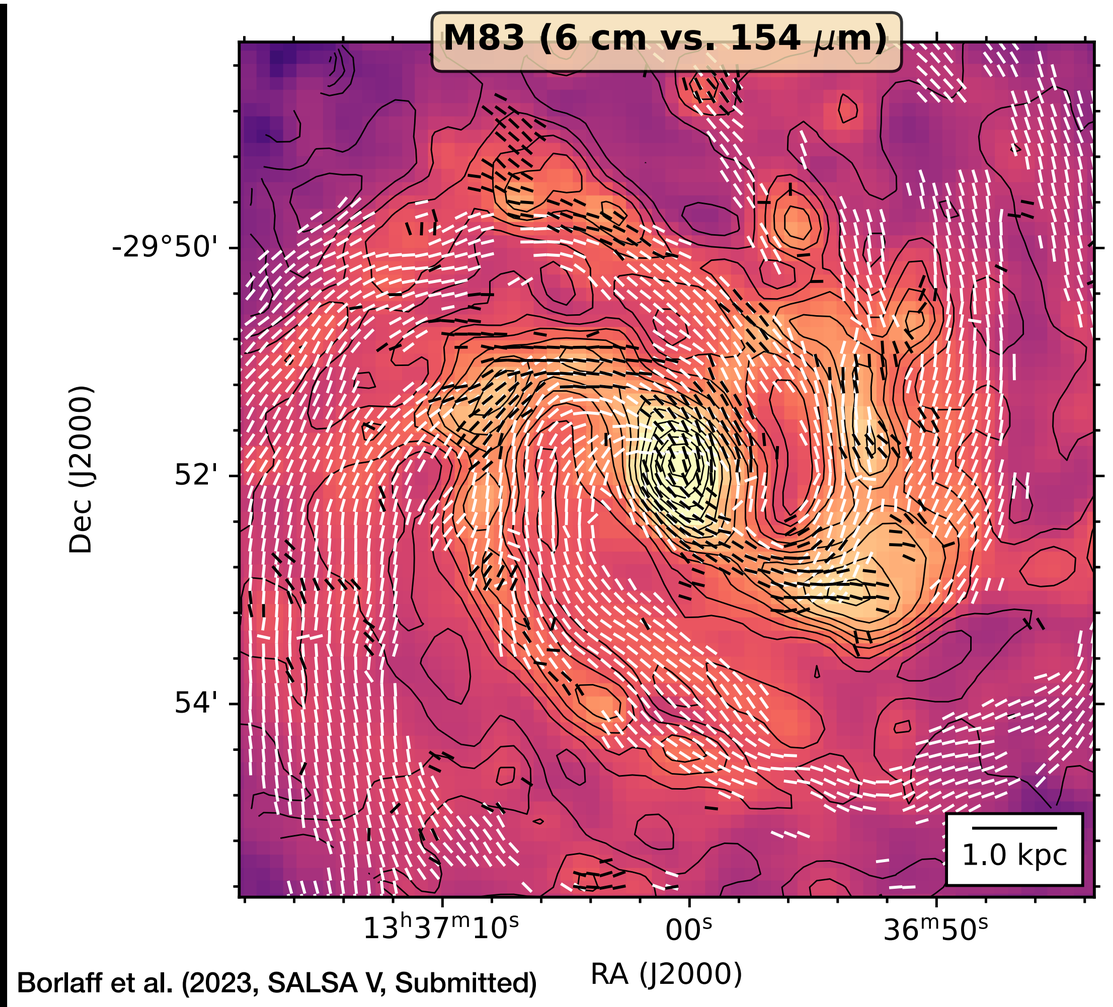

NGC 7331

Borlaff etal. (2021)
Lopez-Rodriguez (2020, 2021a,b, 2022b,2023a)

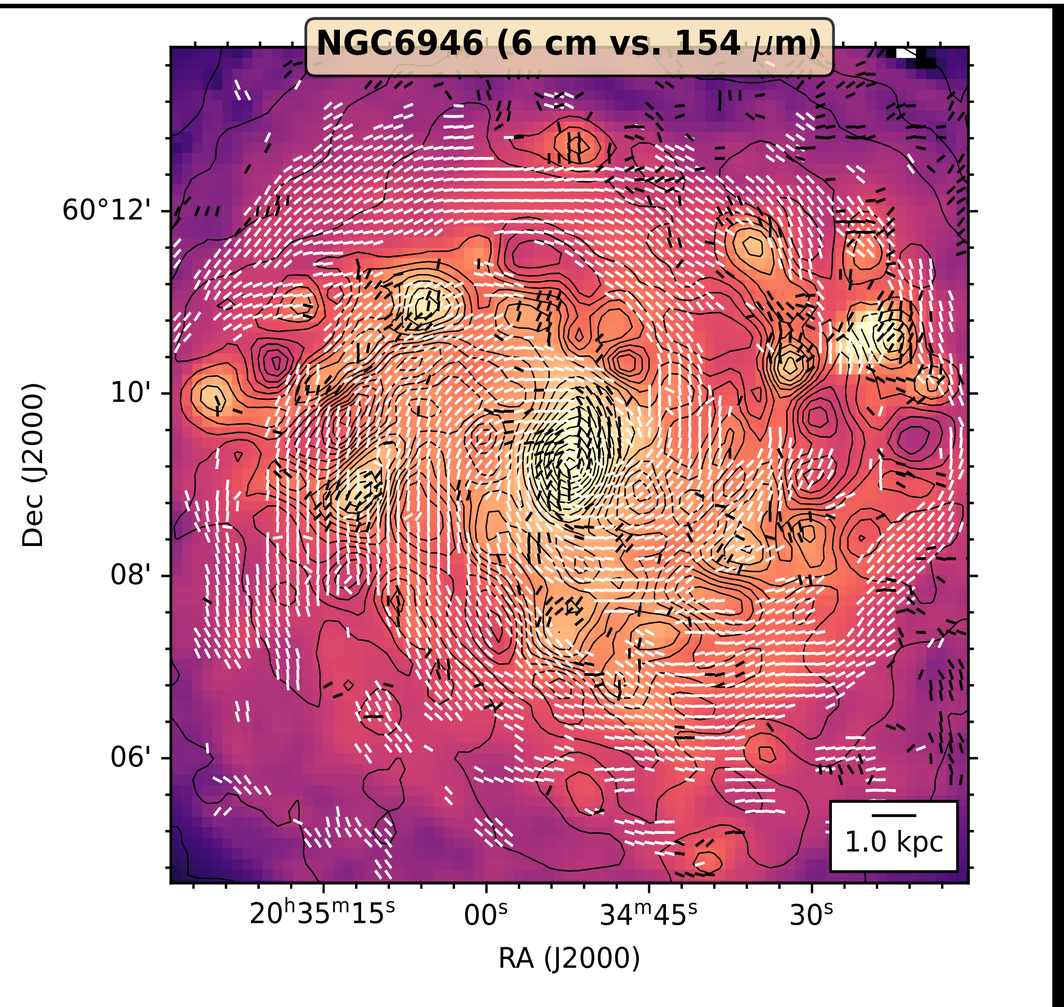
FIR B-field is more turbulent than the Radio B-field







Borlaff et al. (2023, SALSA V, Submitted)



Turbulent B-field is located in the dense and cold ISM associated with SF regions

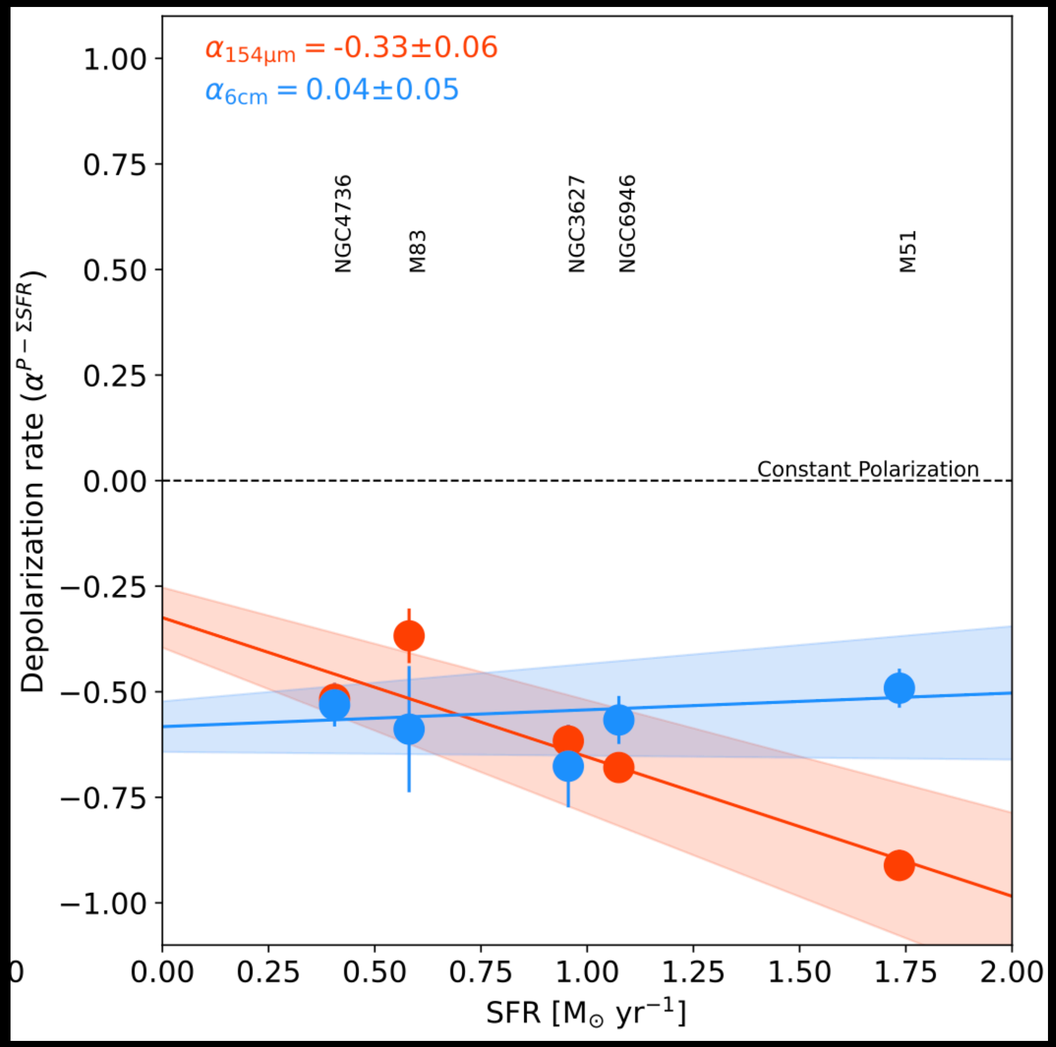
Radio - P consistent with constant across SFR.

FIR
- P decreases due to an increment of the turbulent B-field
- Tighter depolarization rate with SFR

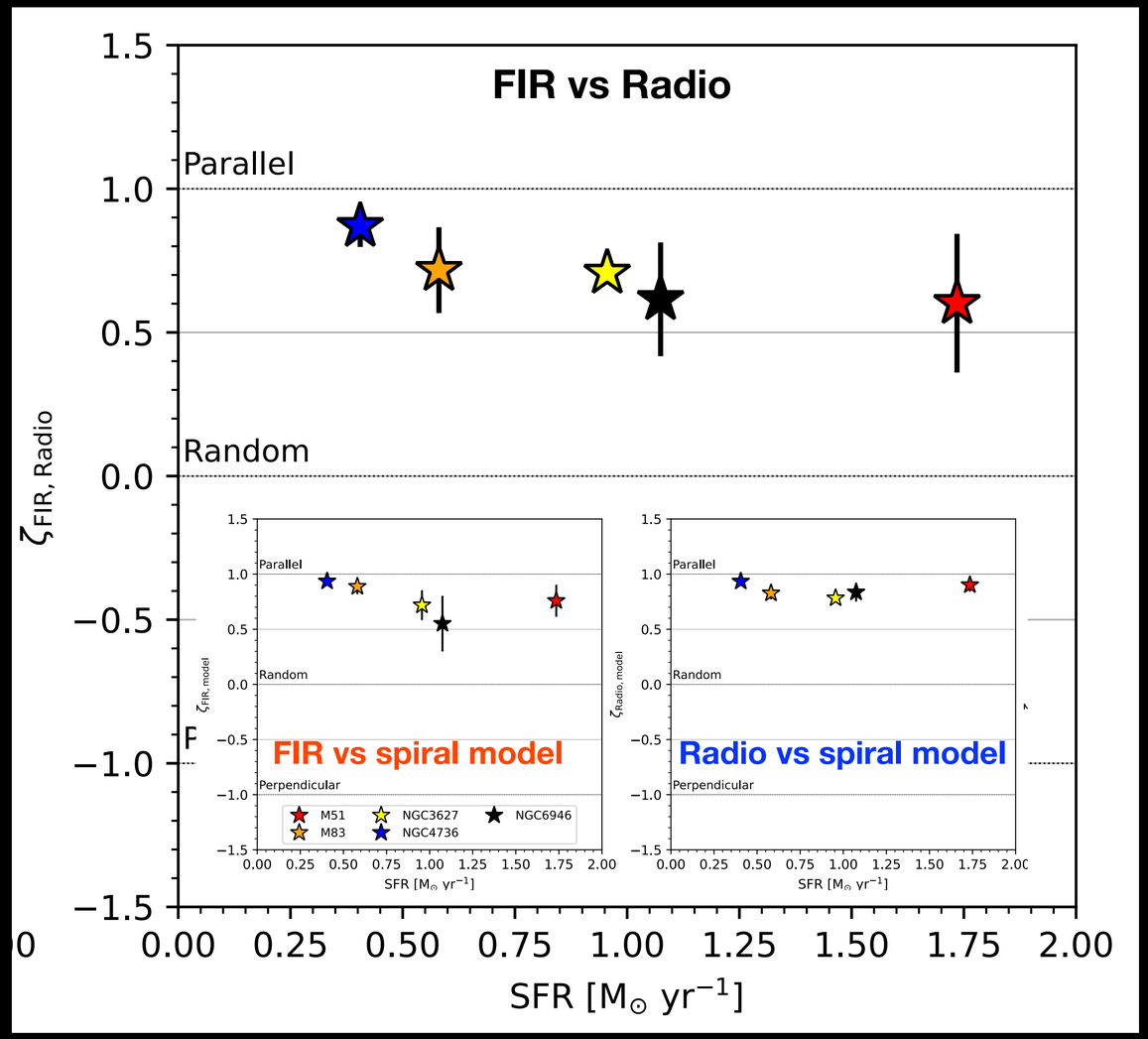
- ζ decreases due to an increase of turbulent B-fields driven by the SF regions.

- FIR polarimetry is more sensitive to the turbulent B-field driven by SF regions than Radio polarimetric obs.

Depolarization rate vs SFR of the galaxy



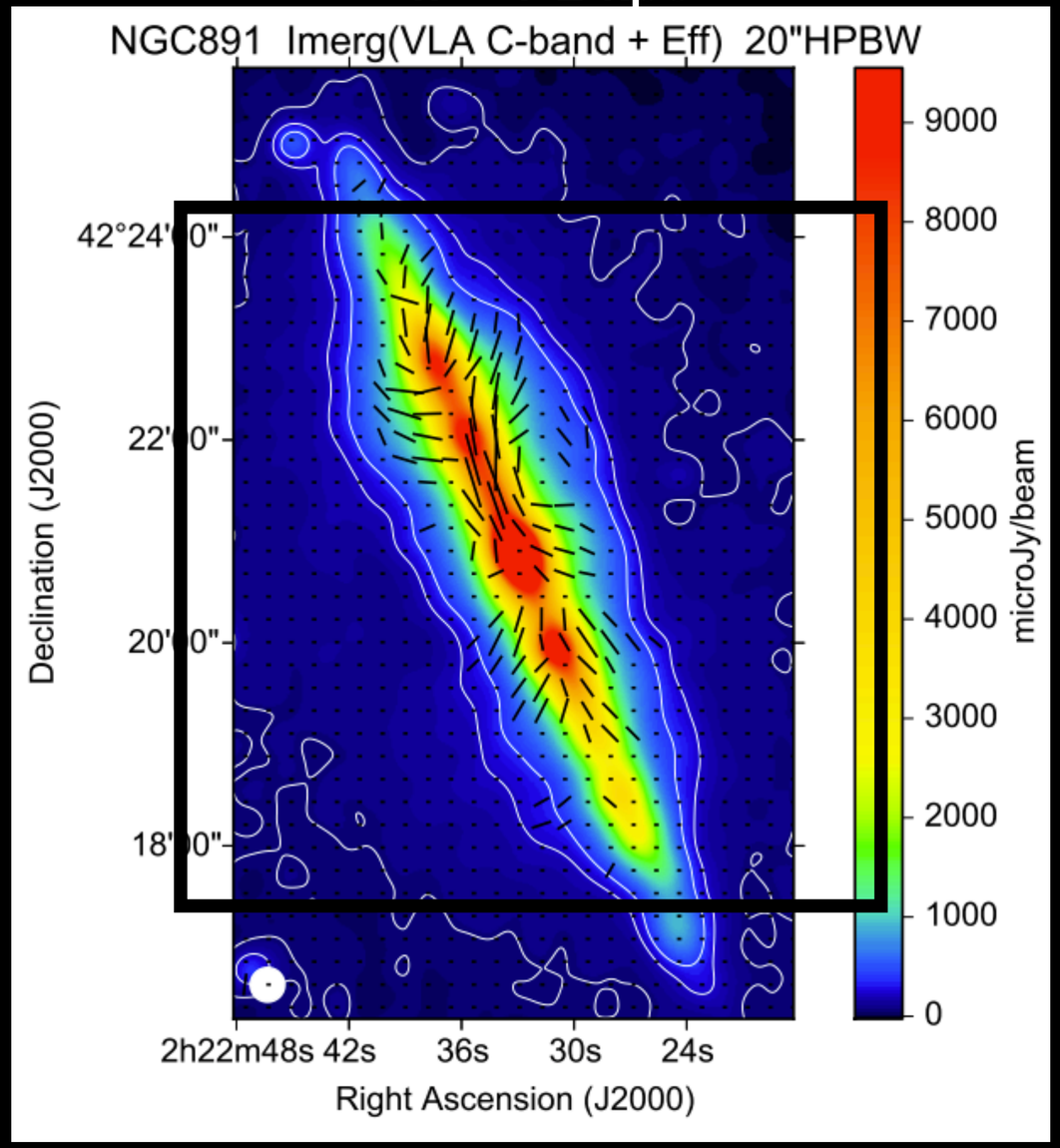
FIR vs Radio B-field alignment



3D structure of the B-field using radio and FIR

Radio: warm and diffuse ISM

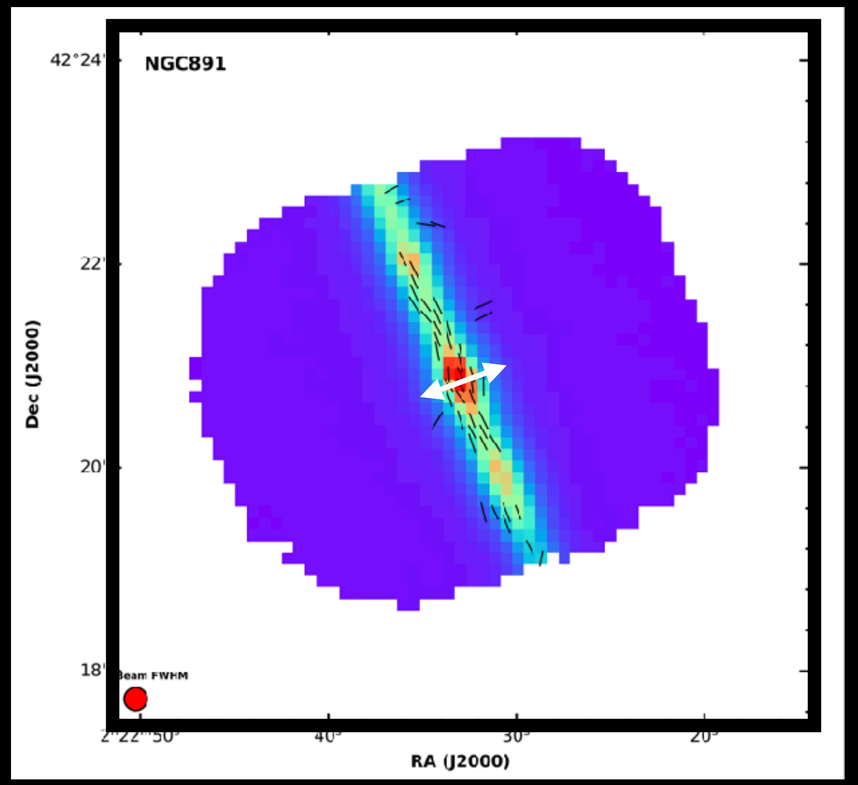
h ~ 1-2 kpc



Krause et al. (2018,2020)

FIR: cold and dense ISM

h < 0.5 kpc



Jones et al. (2020) **FWHM (HAWC+): 13.6″**

How do galactic B-fields influence the assembly of GMCs and star formation rate in galaxies?

PRIMA can distinguish between magnetically vs gravitationally dominated molecular cloud.

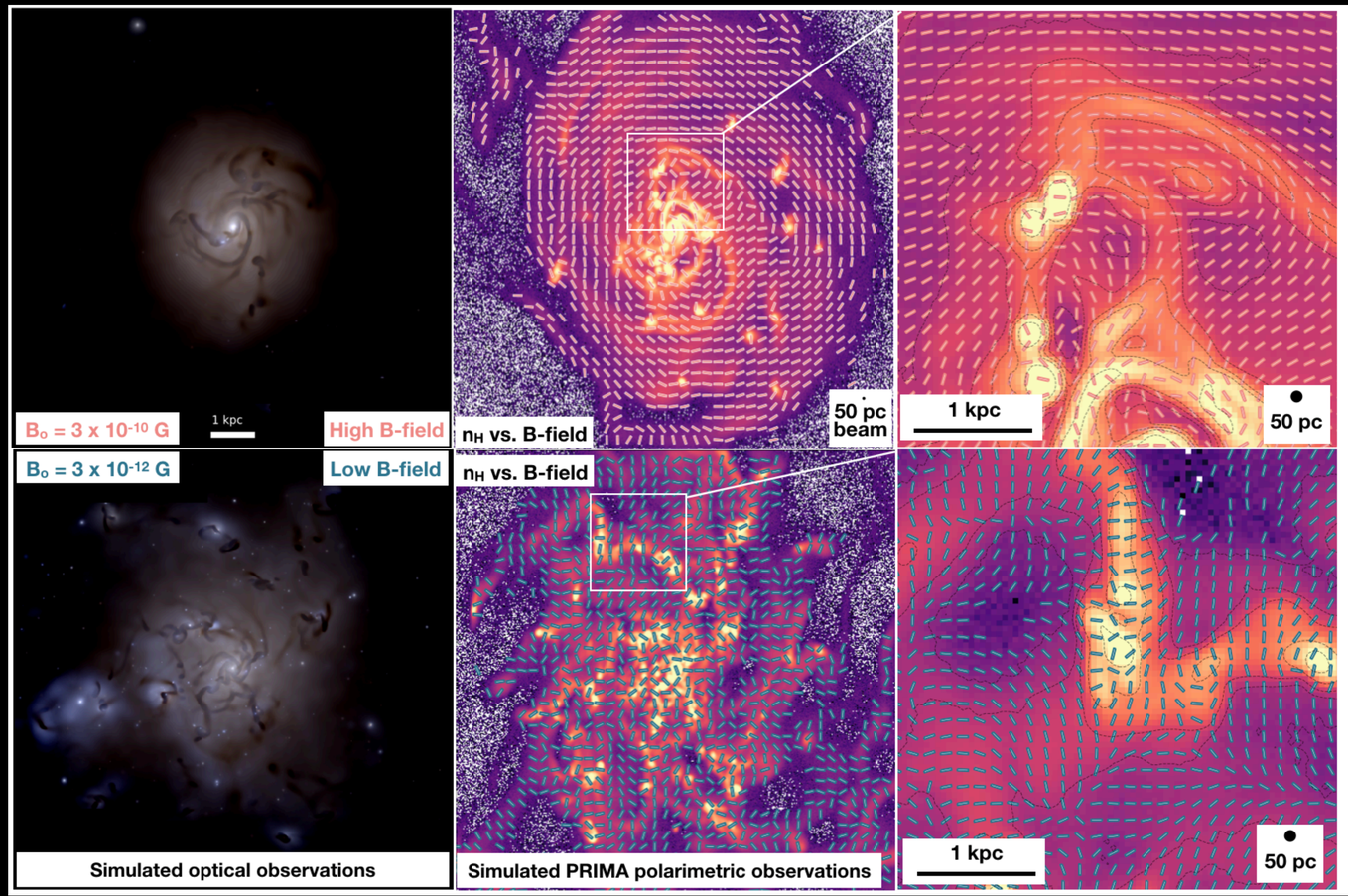
Mock FIR polarimetric observations with PRIMA

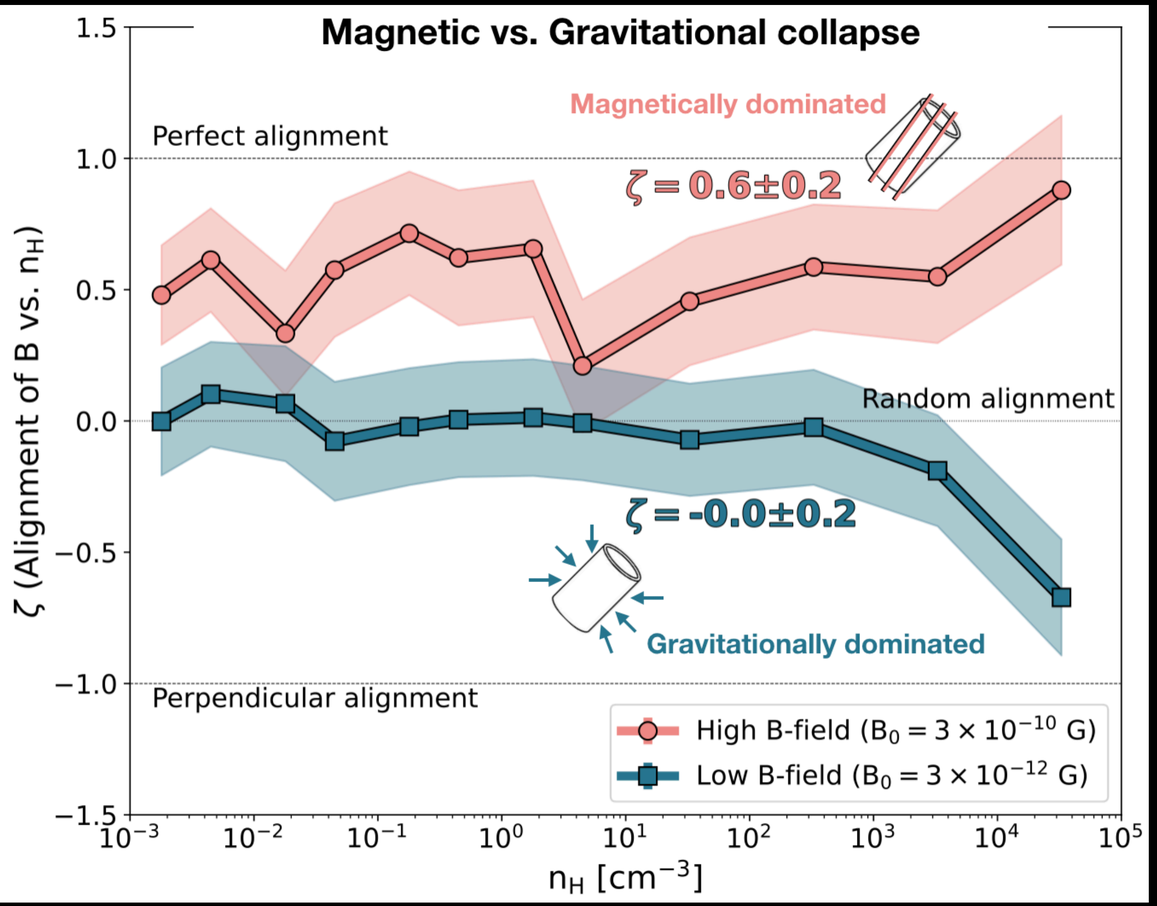
Simulated Optical Observations

Simulated PRIMA polarimetric observations at 100 um

Zoom-in of the dust emission and B-field orientation at 20 pc resolution

Alignment between the B-field orientation and the density structure

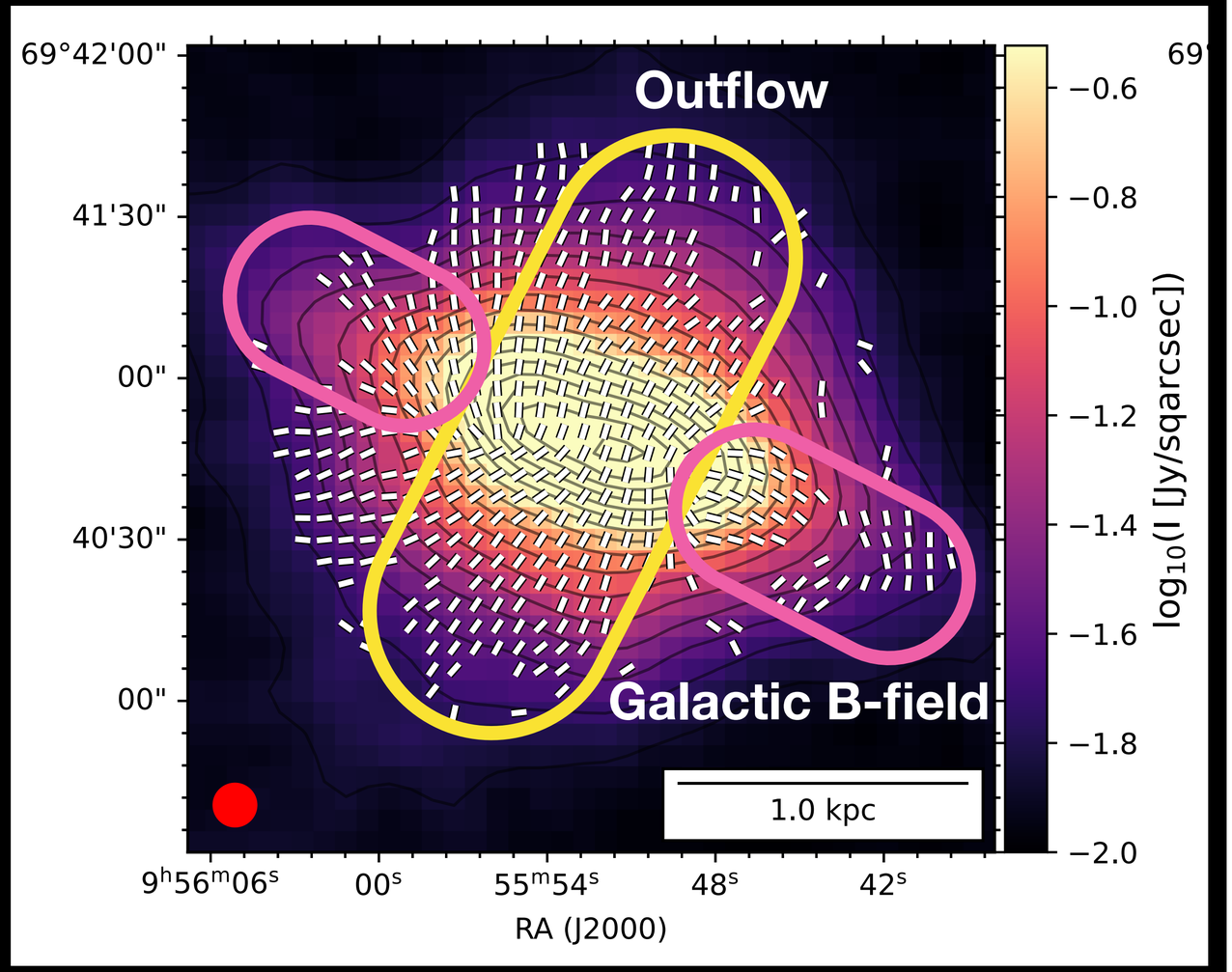




Simulations from Martin-Alvarez et al. (2022: Pandora Project I)

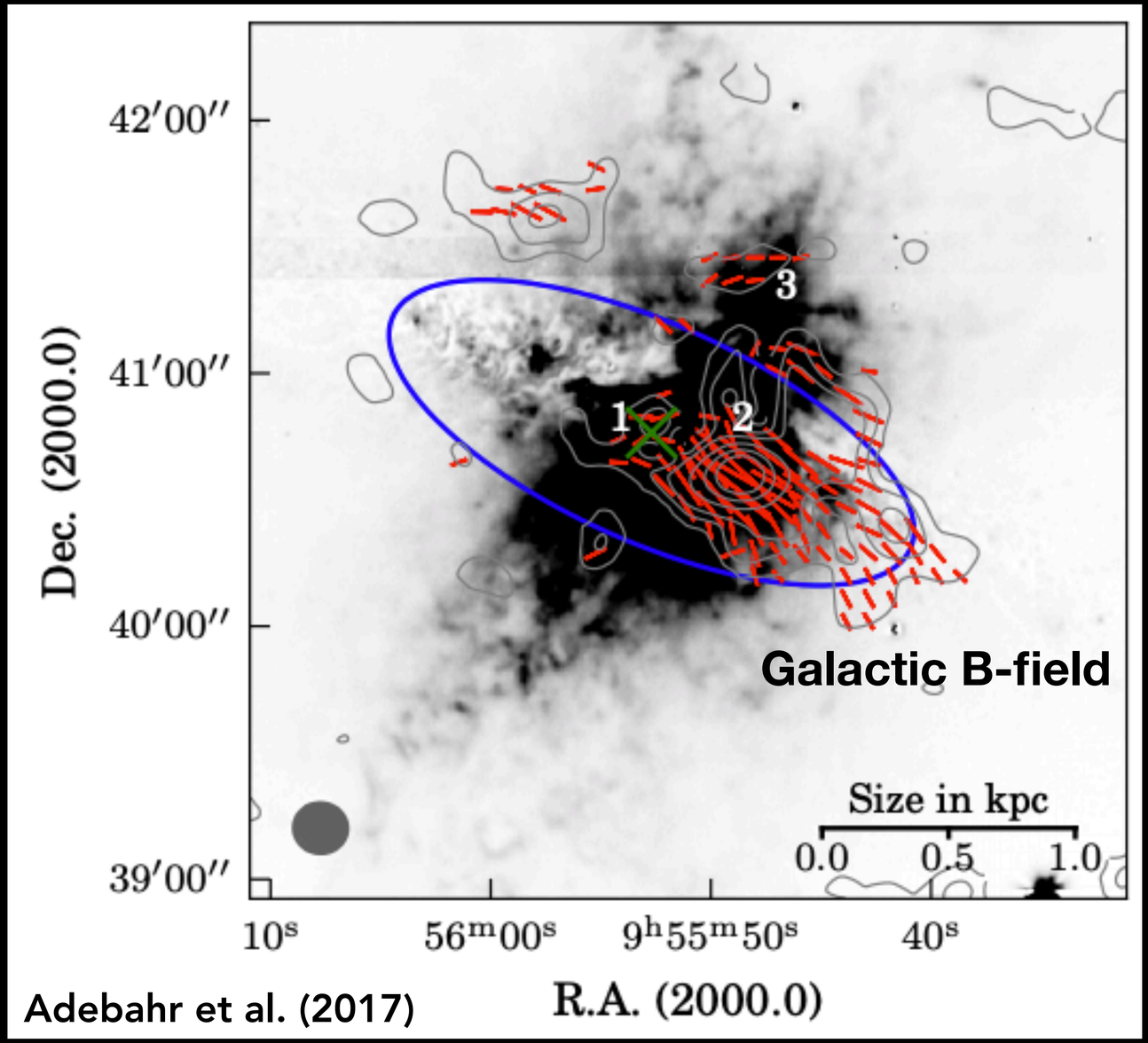
FIR polarization traces the B-field along galactic outflows

FIR (89 um)



Lopez-Rodriguez et al. (2021, 2022b: SALSA IV)

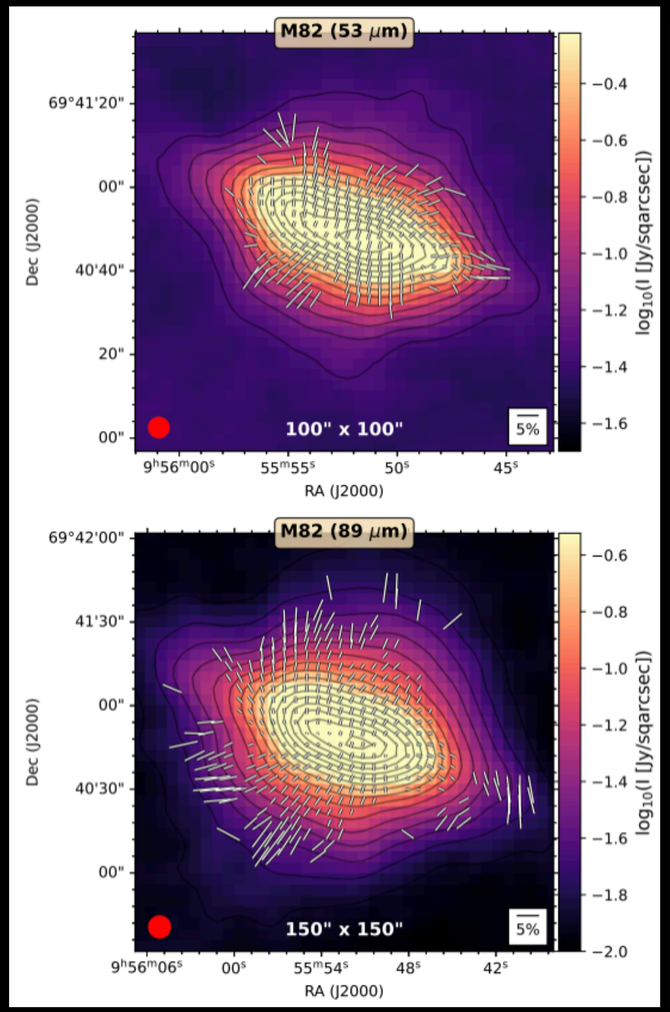
Radio (18 and 22 cm)

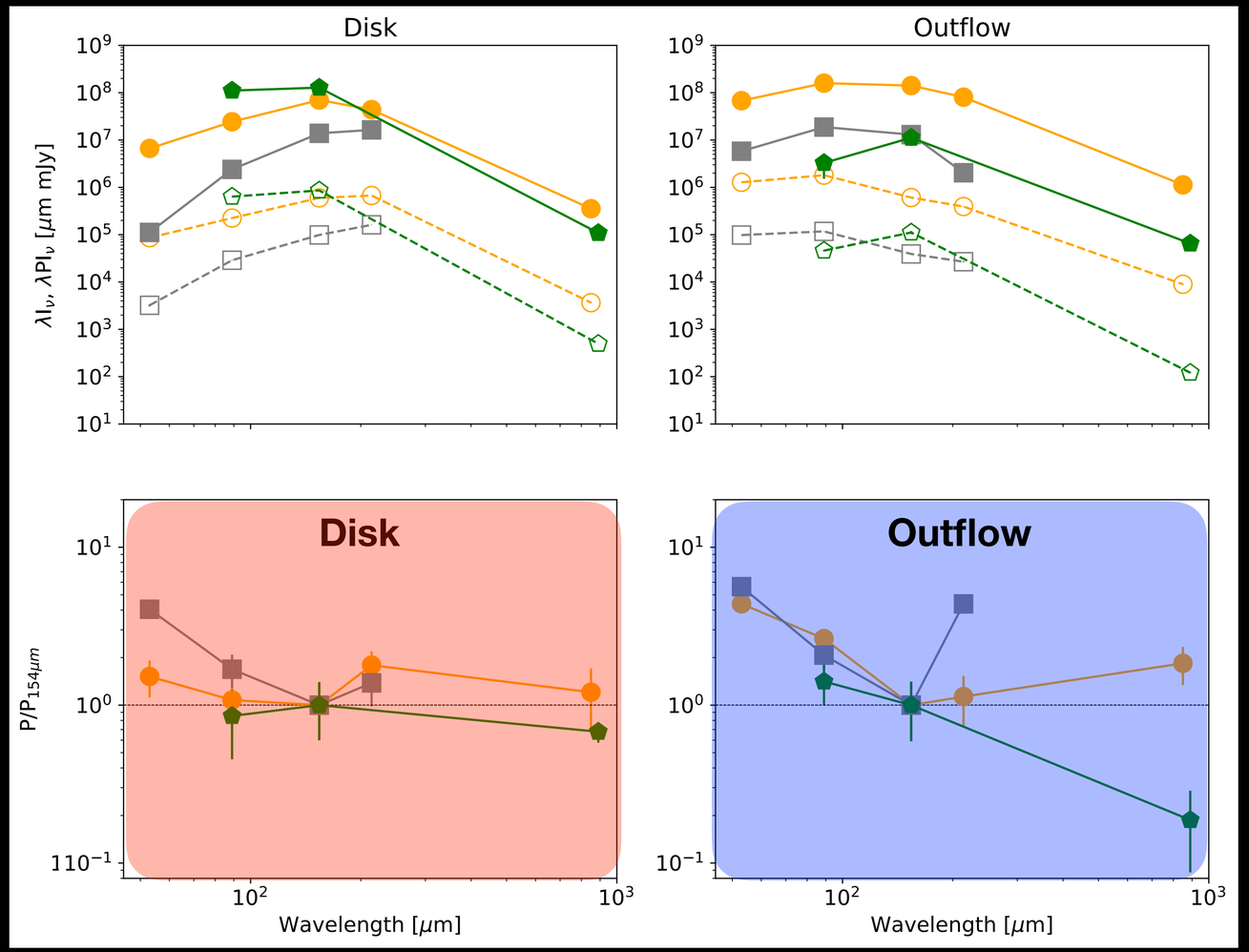


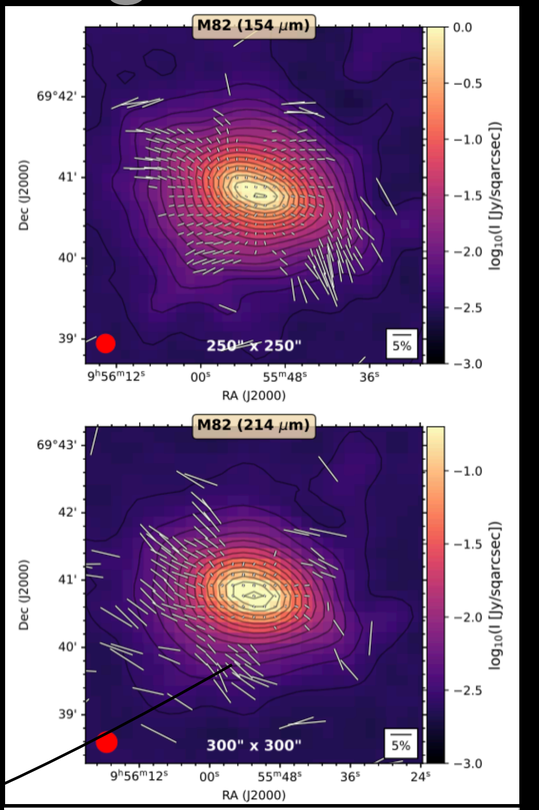
Adebahr et al. (2017)

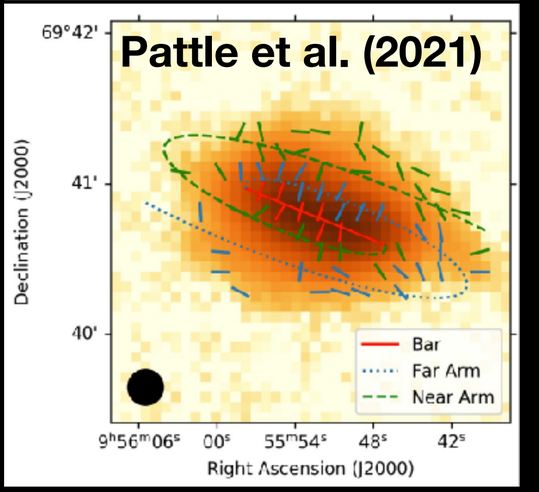
Dust properties: FIR polarized spectrum of Starburst galaxies

At least two dust components are required to explain the polarized SED of starbursts









P constant due to a single dust component and optically thin dust

P may decrease due to dust temperature gradients along the LOS in the outflow

Lopez-Rodriguez et al. (2022b, SALSA IV)

THE COSMIC HISTORY OF THE B-FIELDS IN GALAXY EVOLUTION USING FIR/SUB-MM POLARIMETRY

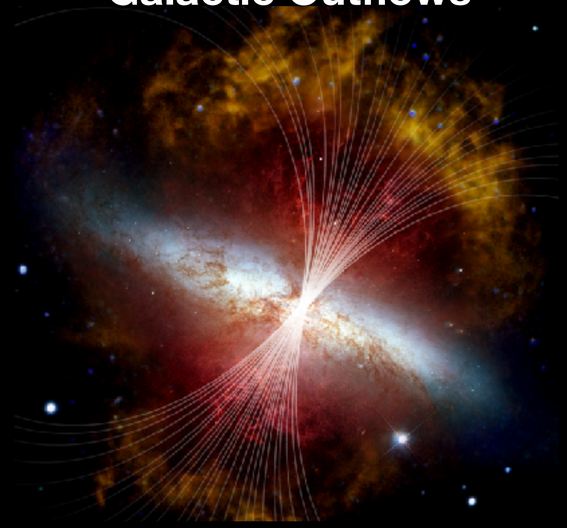
Mergers

Turbulent dynamo
B-field amplification

Active galaxies

Turbulent dynamo
B-field amplification

Galactic Outflows

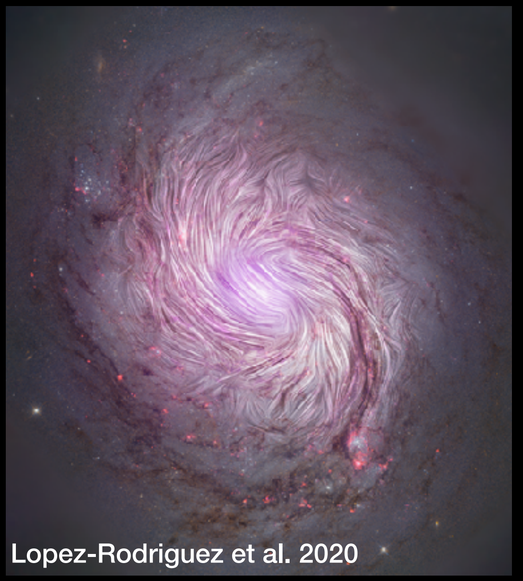


Turbulent dynamo
Permeate IGM with B-fields

Interaction, Star formation, galactic dynamo

Turbulent + Mean-field dynamo
SF disturbs/amplify mean-field

AGN, Star formation, galactic dynamo



Mean-field dynamo
Saturated B-field close equipartition with turbulent kinetic energy in the ISM

- **How did the evolution of galaxies in mergers affect magnetic fields?**
- **Is the circumgalactic medium magnetized?**
- **How has the magnetic field been amplified by interaction/SF in galaxies?**
- **What is the structure of the magnetic field around an active nucleus?**

The turbulent kinetic and magnetic energy are in equipartition in the outflow

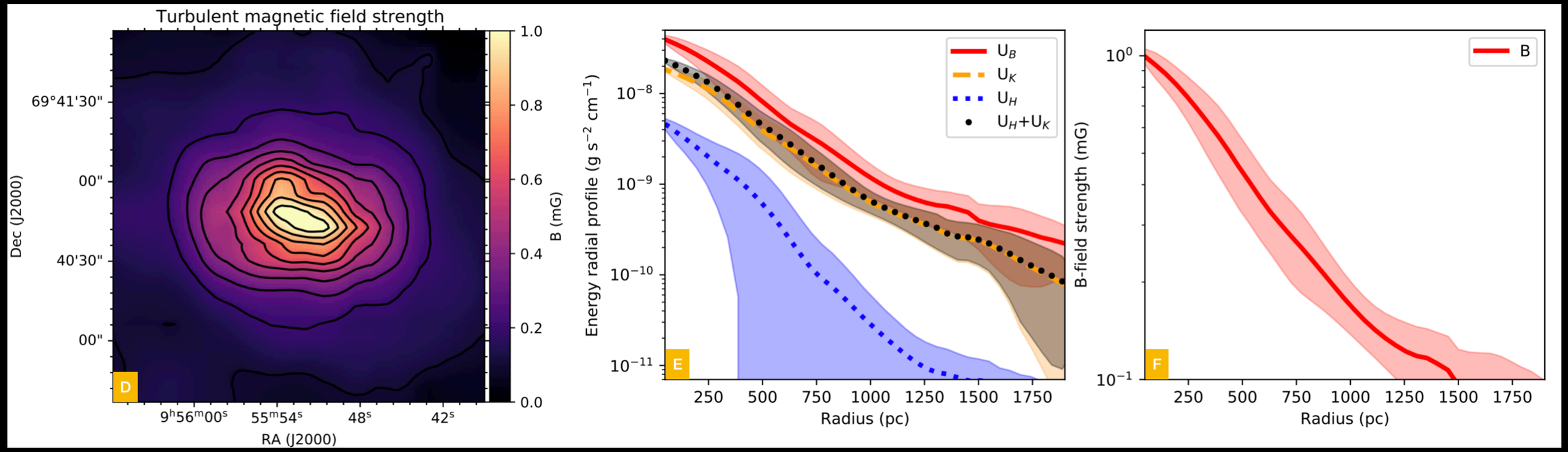
Energy budget:

- The entrainment between kinetic, thermal, and magnetic energies are defined by the beta parameter: $\beta' = \frac{U_K + U_H}{U_B}$

This method assumes:

- Corrected DCF method provides the mean B-field strength within the starburst mask.
- The energy map should satisfy that the beta parameter within the mask $\beta' = 0.56 \pm 0.23$

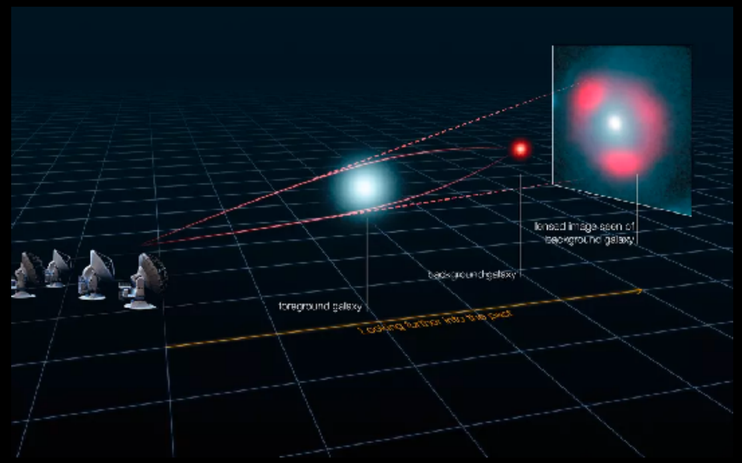
Galactic outflows permeate the CGM and IGM with astrophysical B-fields



Lopez-Rodriguez et al. (2021)

B-fields at high redshift using sub-mm polarimetry

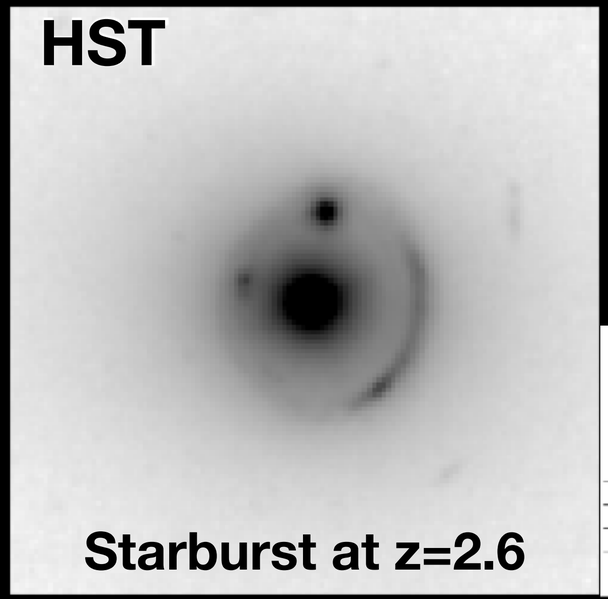
Gravitationally lensed galaxies at high-redshift

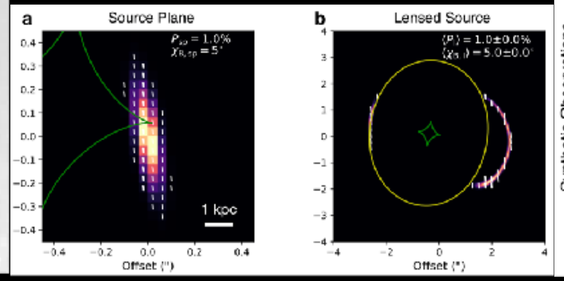


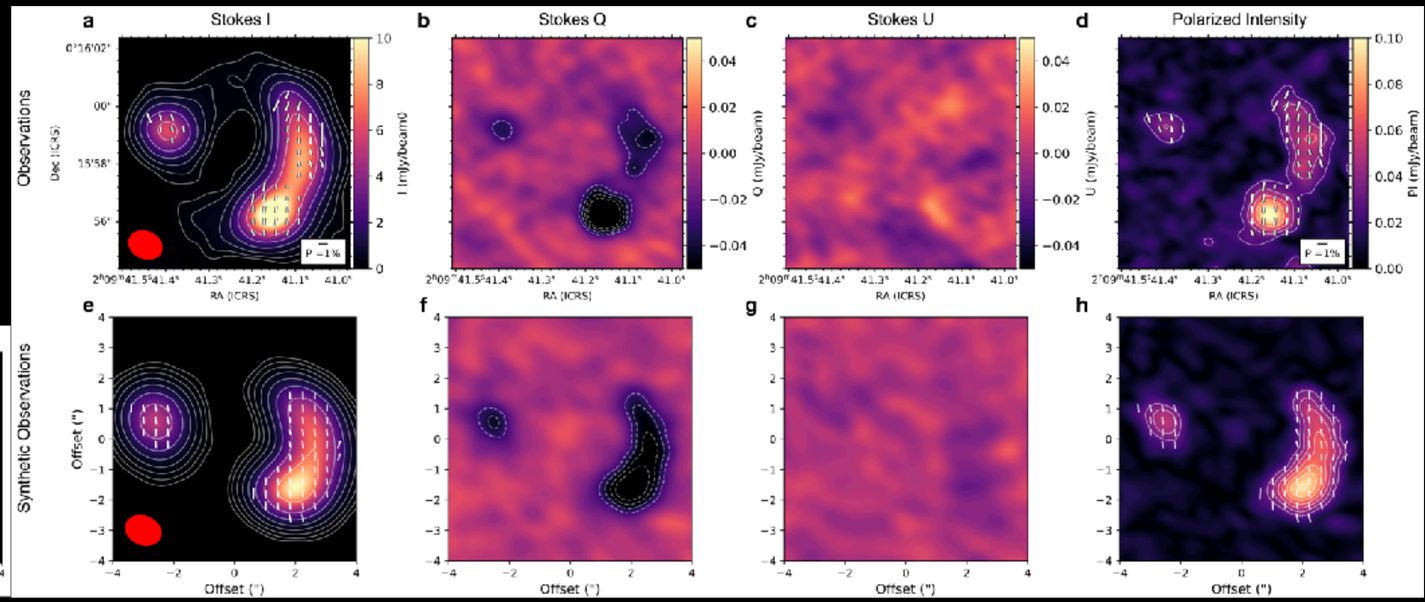
2 kpc-scale ordered B-field parallel to a fast rotating disk in a starburst at 3Gyr after Big Bang.

ALMA polarimetric observations

860 um (dust continuum polarization) at 0.5” resolution







Geach, Lopez-rodriguez et al. (submitted to Nature)

Gravitational lensing polarimetric model