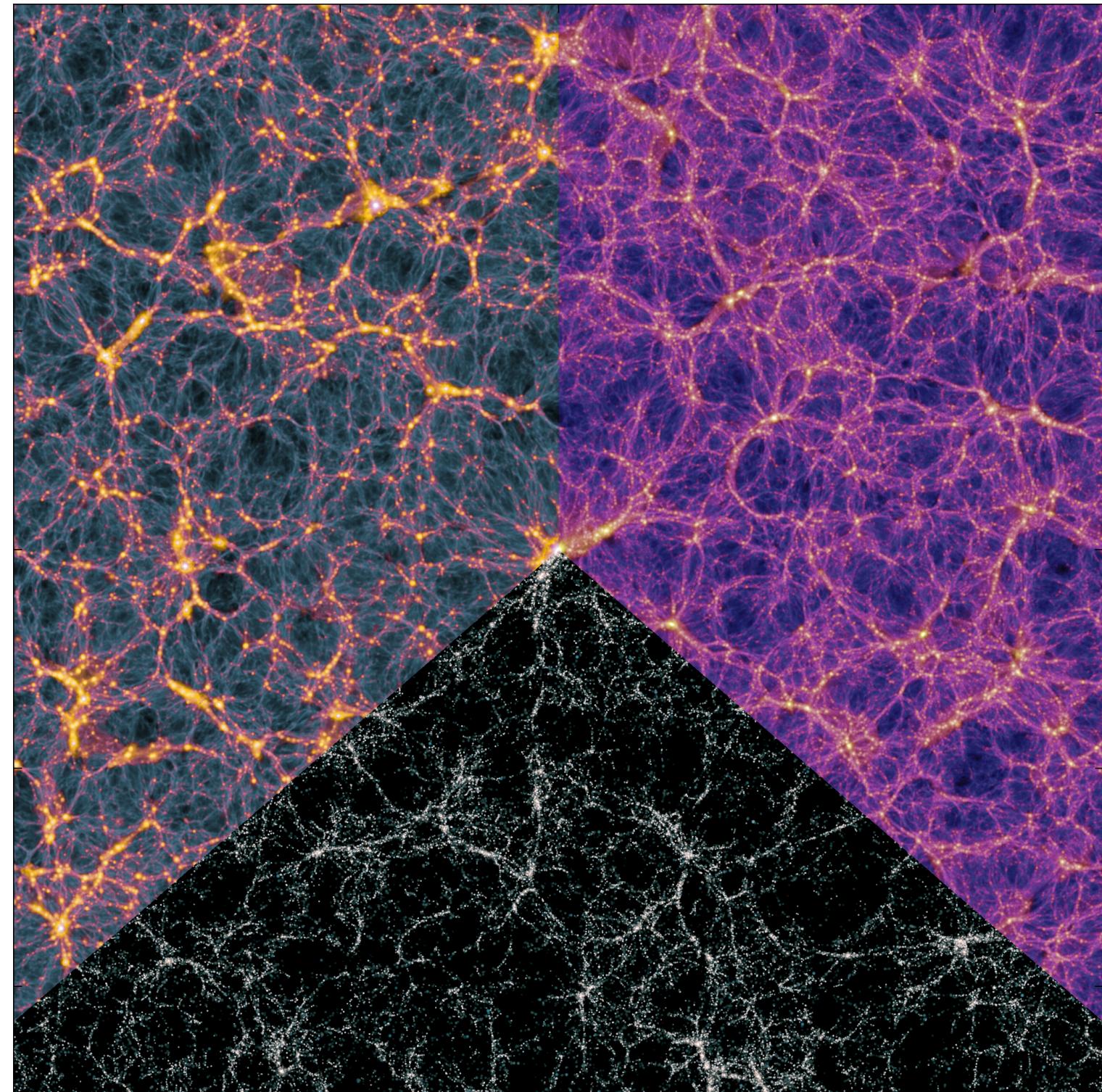


The origin of galactic magnetic fields

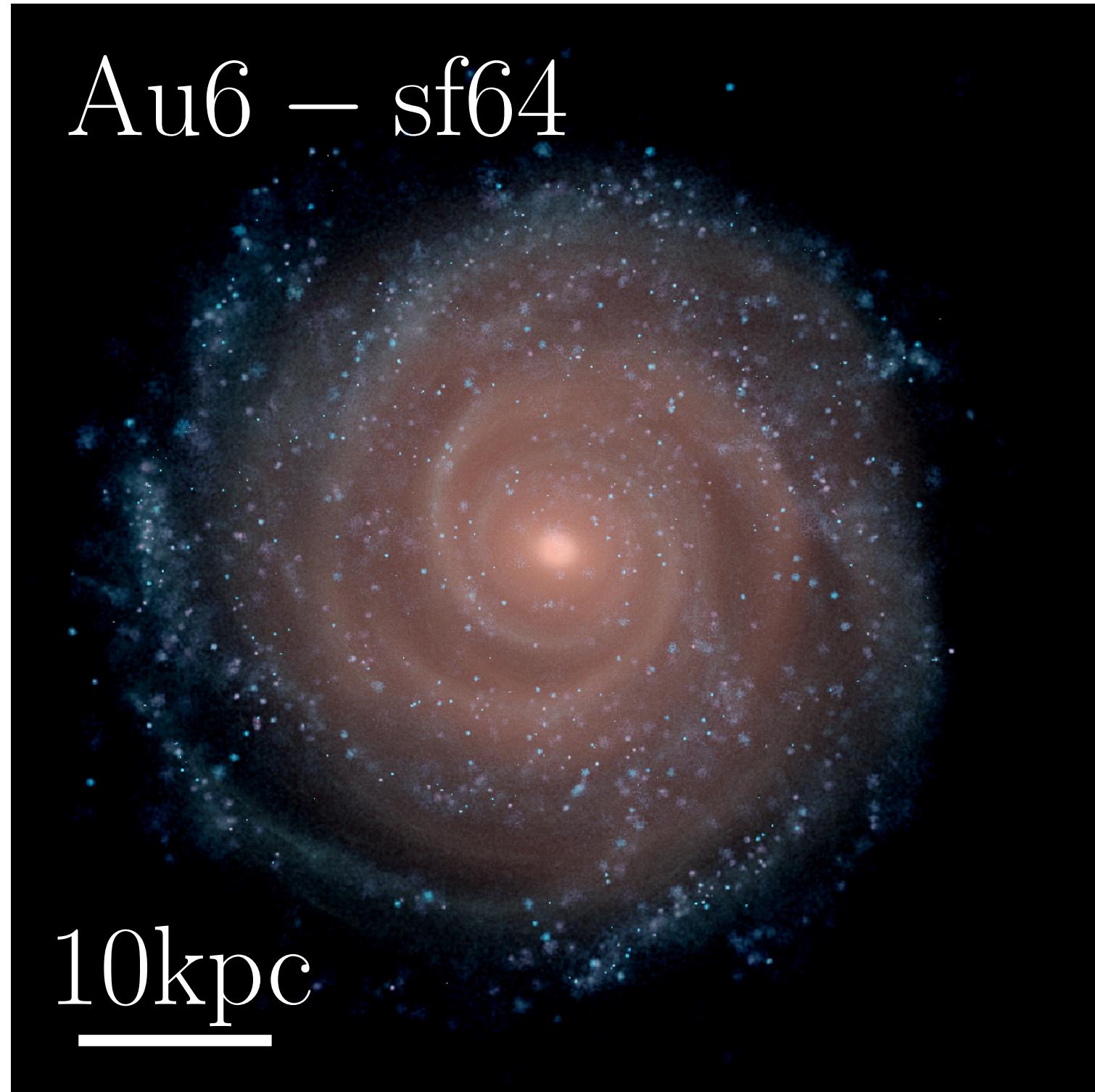
with **R. Bieri, F. van de Voort, M. Werhahn, A. Fattahi,**
T. Guillet, C. Pfrommer, V. Springel, R. Talbot

Ruediger Pakmor, Vienna, 19th February 2024

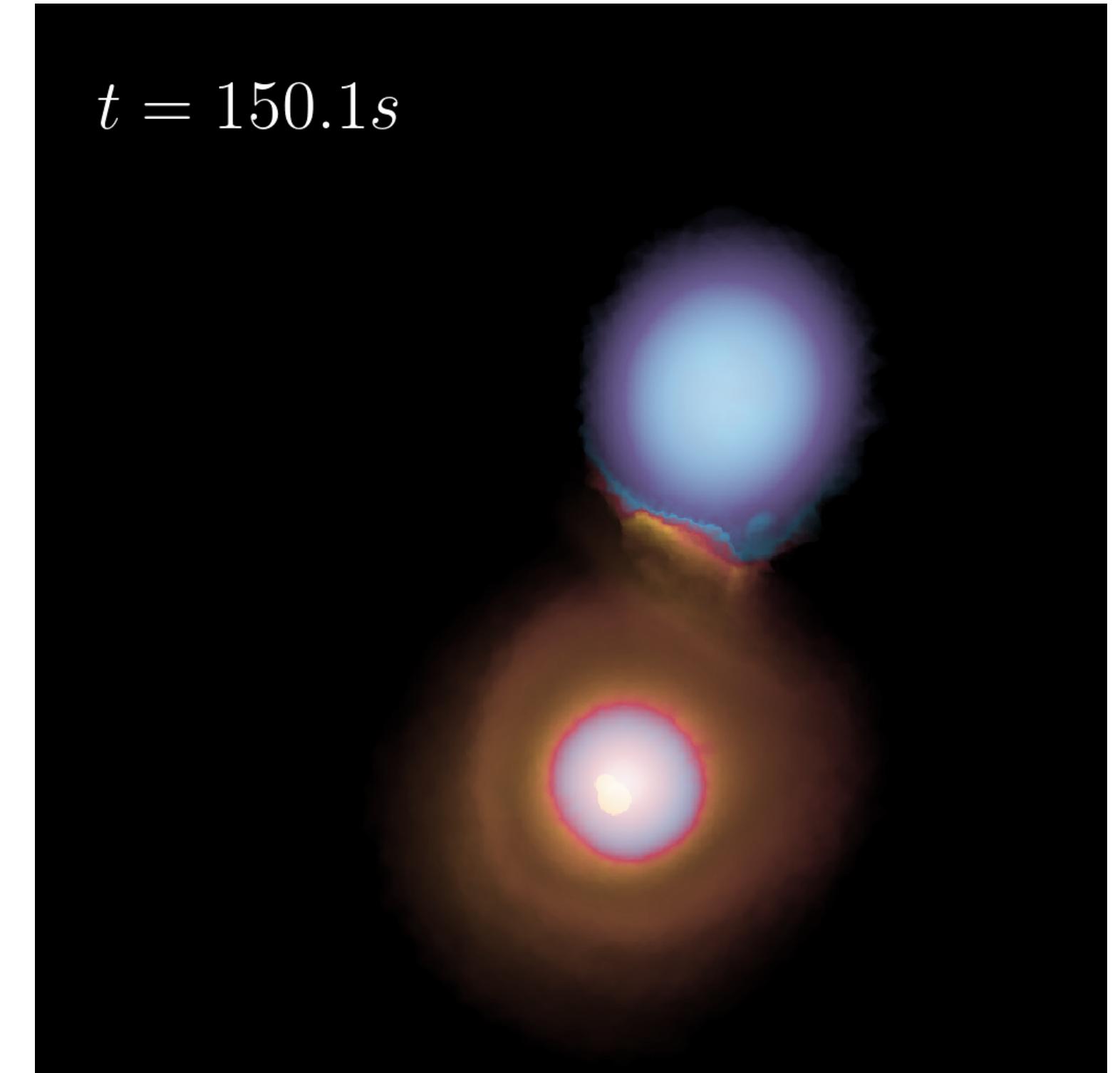
Other interests (talk with me)



MillenniumTNG: 500^3 Mpc/h
cosmological box 3×10^7 Msun
baryonic mass resolution



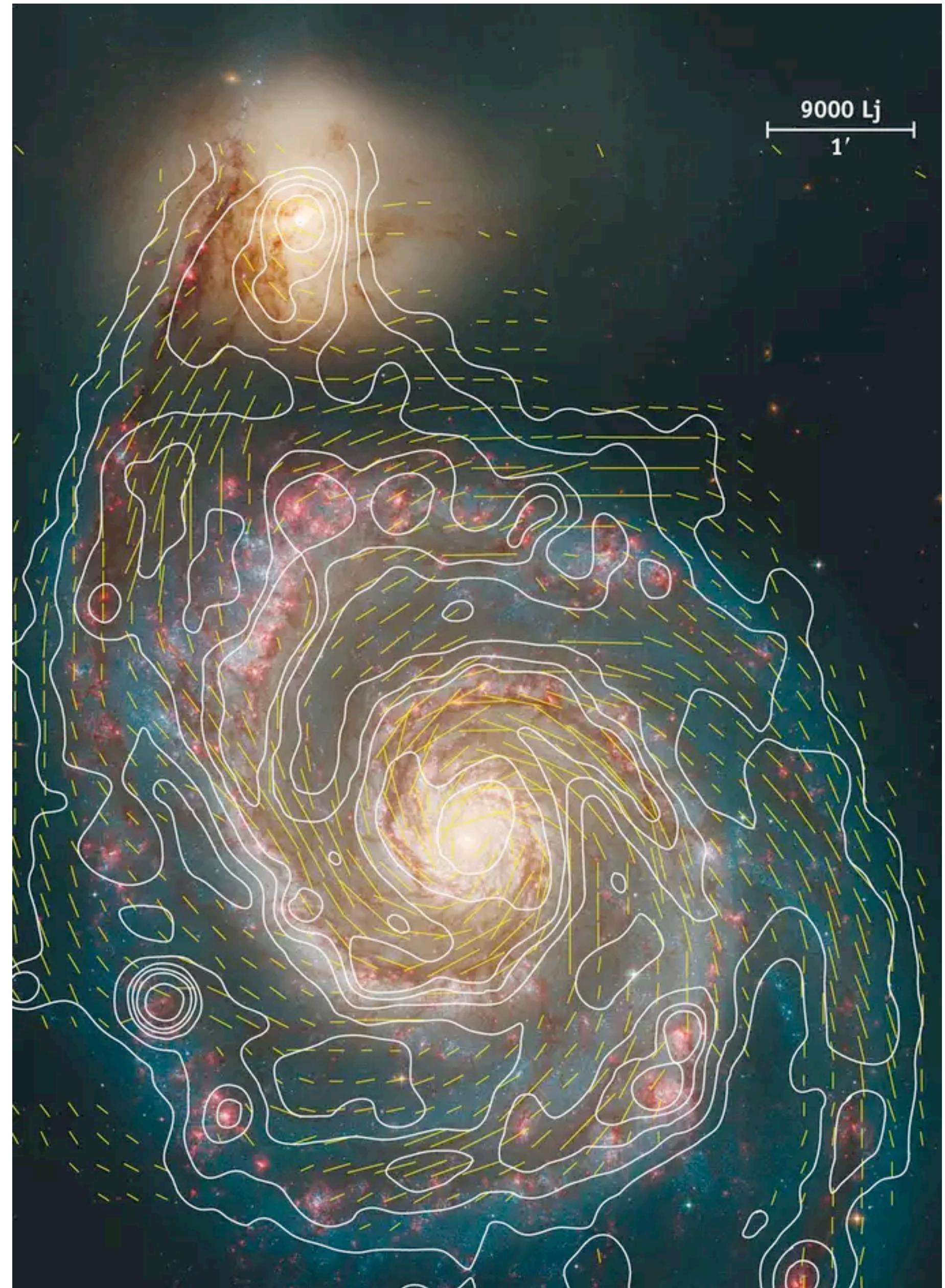
Auriga Superstars: Cosmological
Wilky Ways with 10^8 star particles



Type Ia Supernovae: Explosion
simulations of white dwarf mergers

Magnetic fields in disc galaxies

- Spiral galaxies today have large scale ordered magnetic fields
- Field strength hard to measure precisely, typical values of $10\mu\text{G}$
- Typical seed fields only 10^{-20}G
- Efficient dynamo needed!

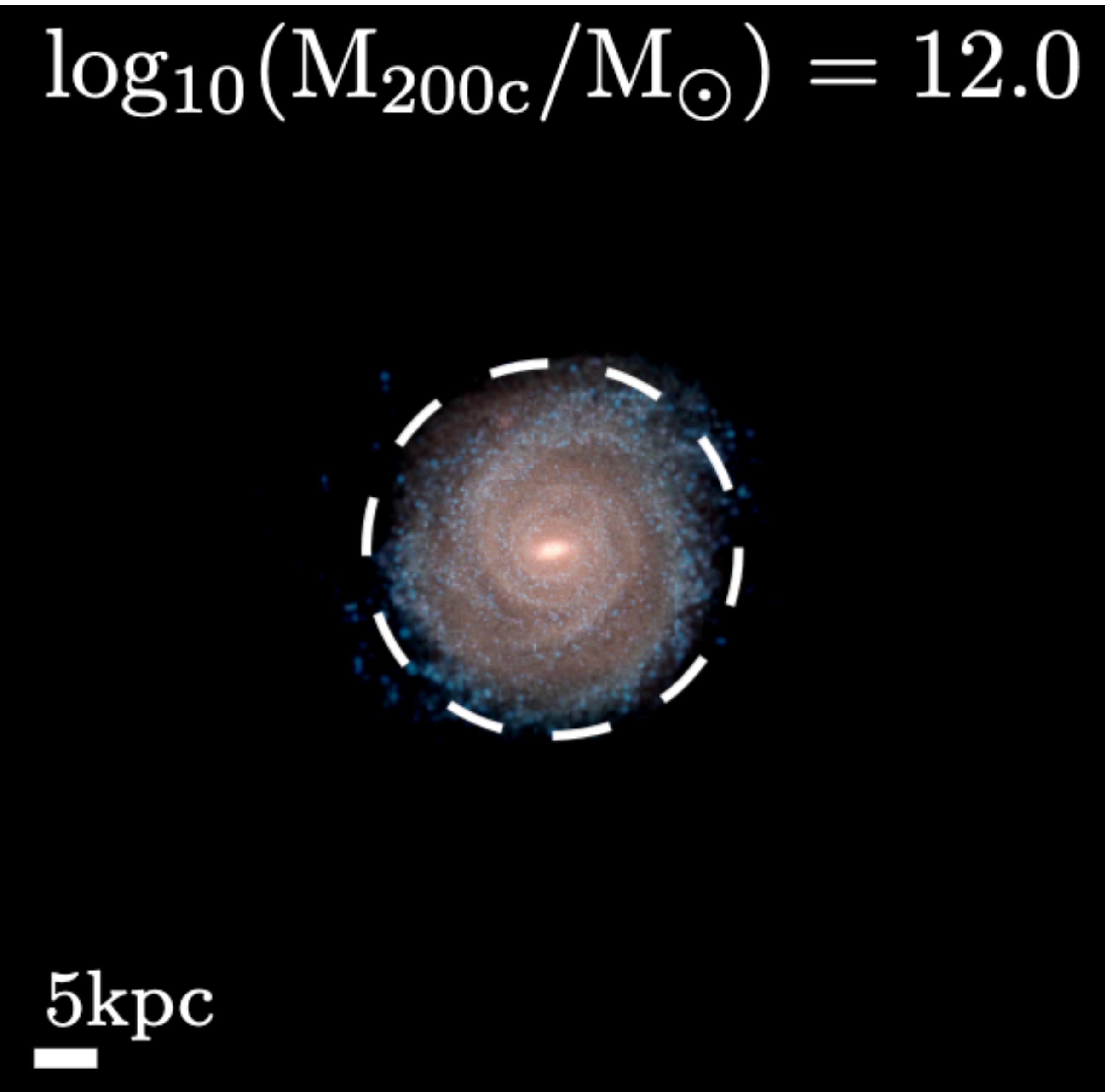


Magnetic field lines in M51 and contours of total emission at 6 cm (MPIfR, R. Beck)

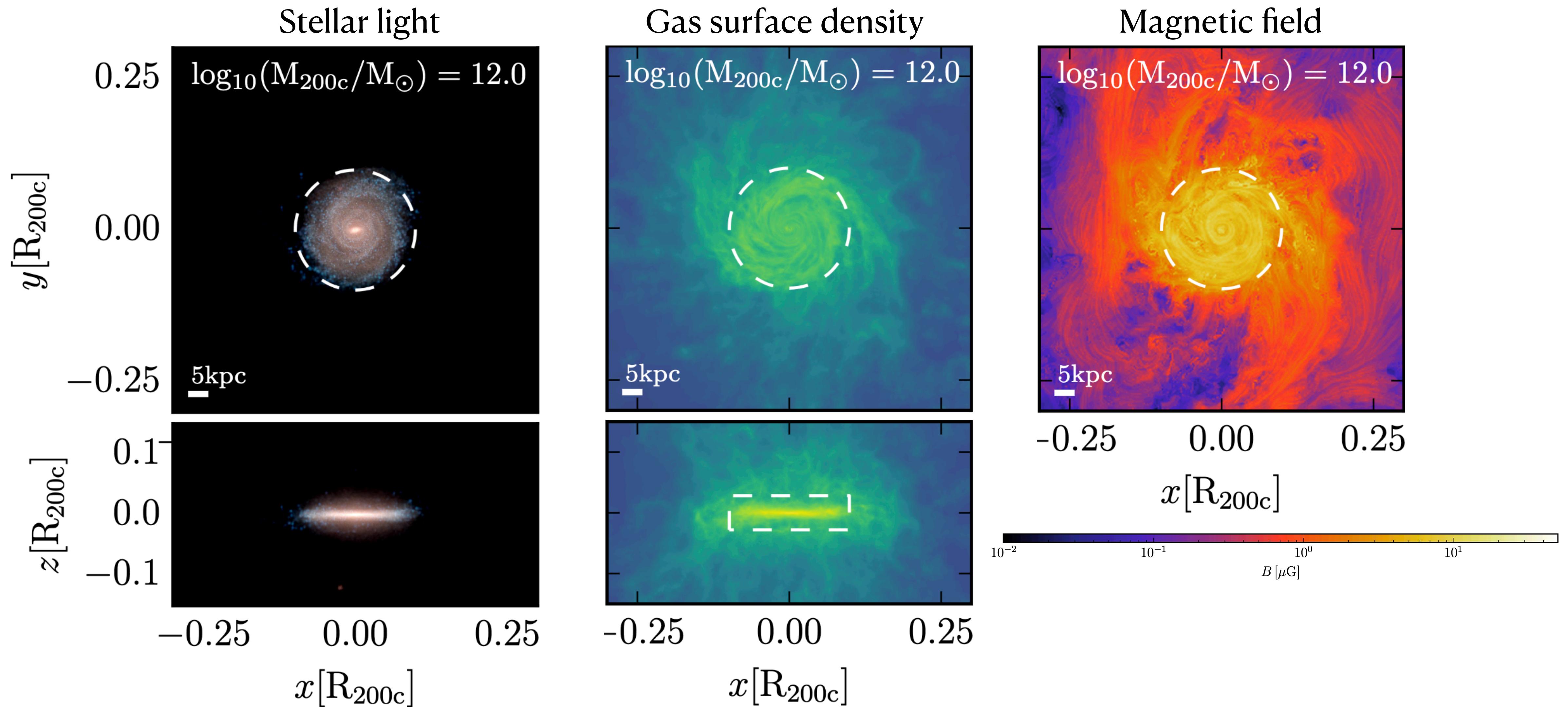
Auriga

cosmological zoom simulations

- Using moving-mesh MHD code Arepo (<https://arepo-code.org/>)
- Cosmological zoom initial conditions
- Well tested model for galaxy formation (Auriga, IllustrisTNG) including gas, stars, BHs, DM
- Ideal MHD, small uniform seedfield
- Resolution in ISM ~100pc (no molecular clouds!), effective model for star-forming ISM and galactic winds, BH accretion and feedback



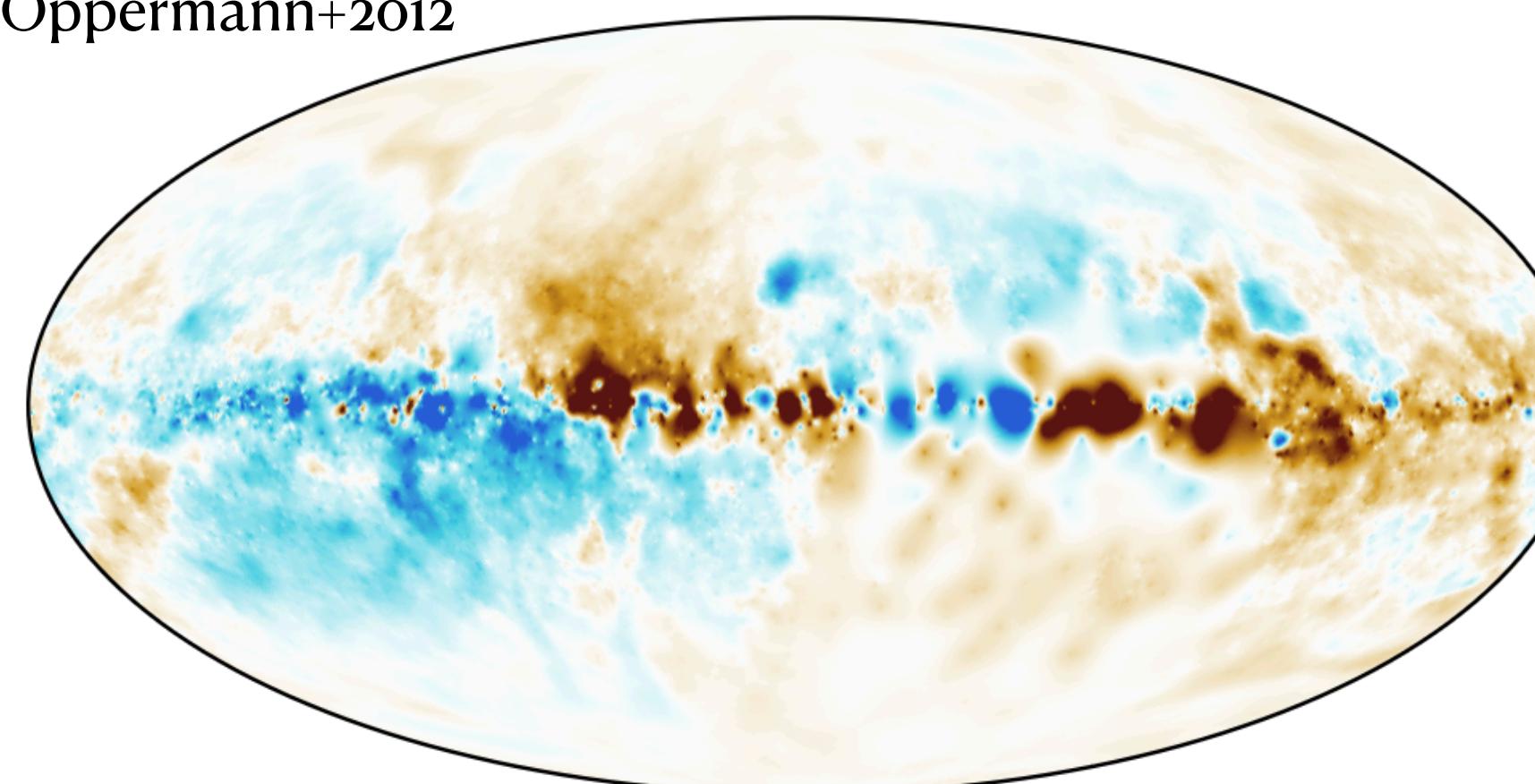
A cosmological Milky Way



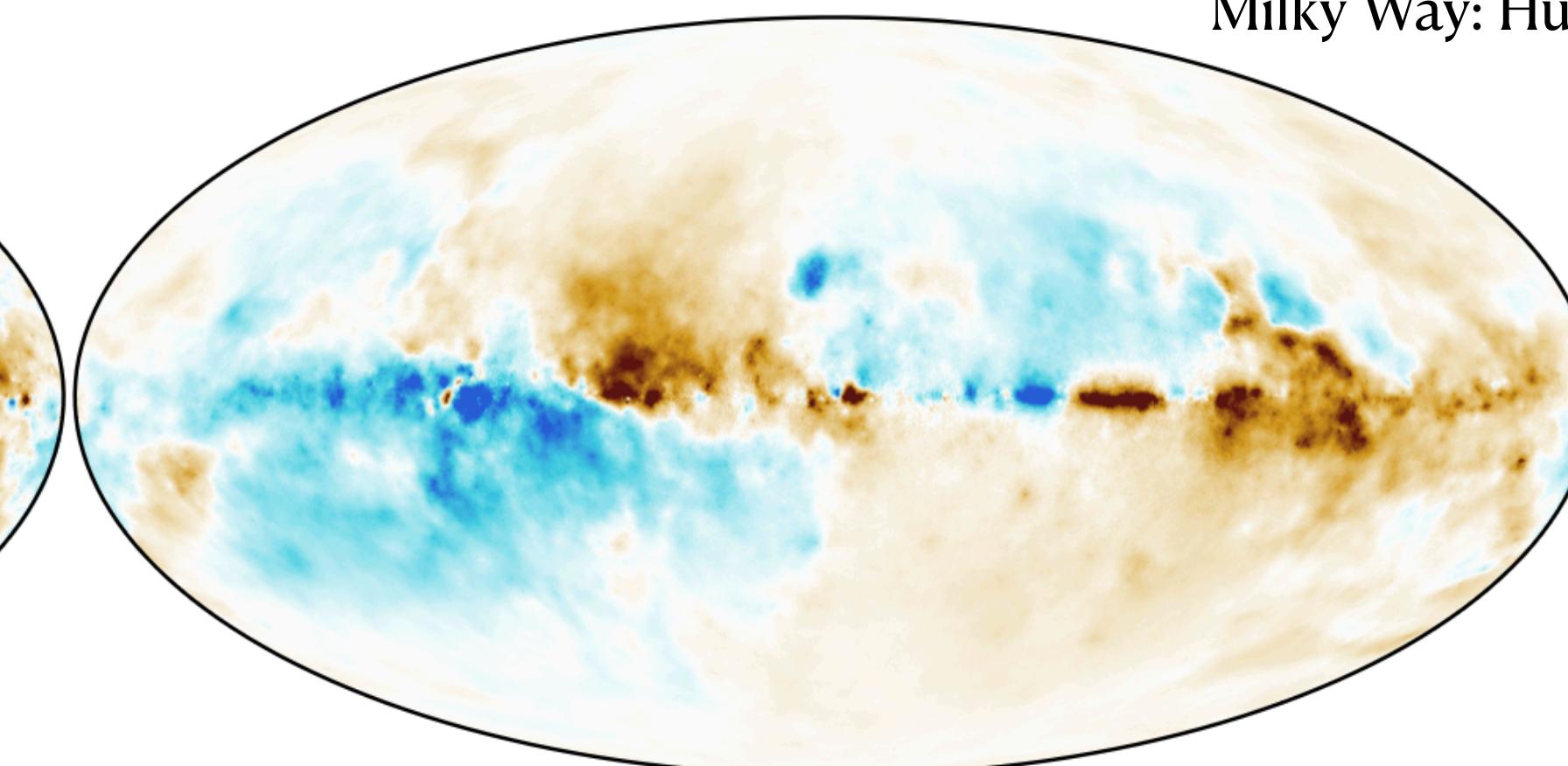
Allsky Faraday map

$$RM = \frac{1}{2\pi} \frac{e^2}{m_e^2 c^4} \int_0^{s_{\text{obs}}} n_{\text{th}}(s) B_{||}(s) ds$$

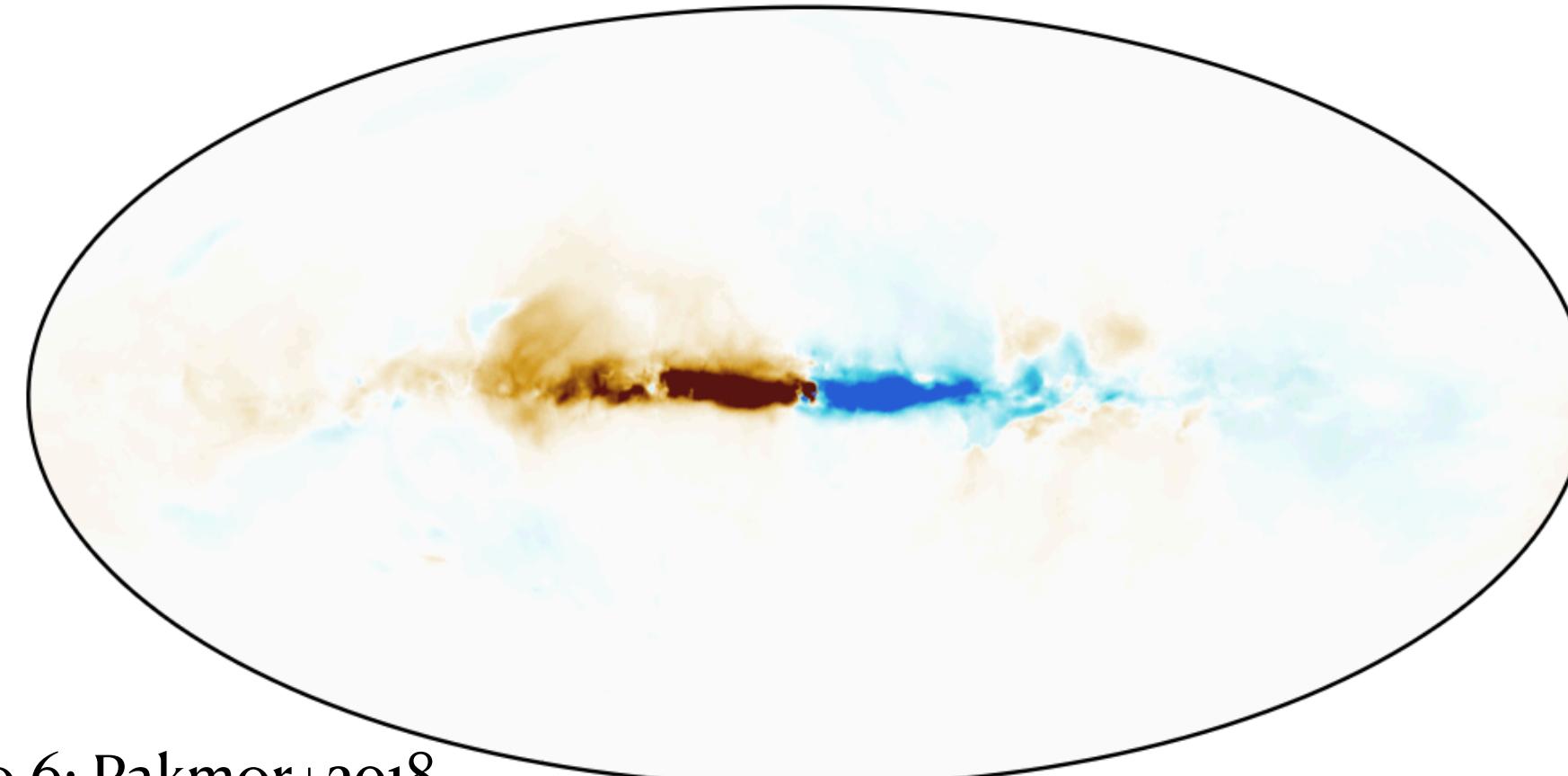
Milky Way: Oppermann+2012



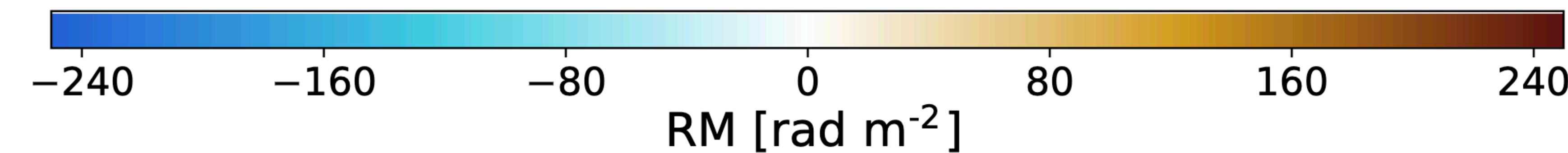
Milky Way: Huschenreuter+2022



Auriga Halo 6: Pakmor+2018

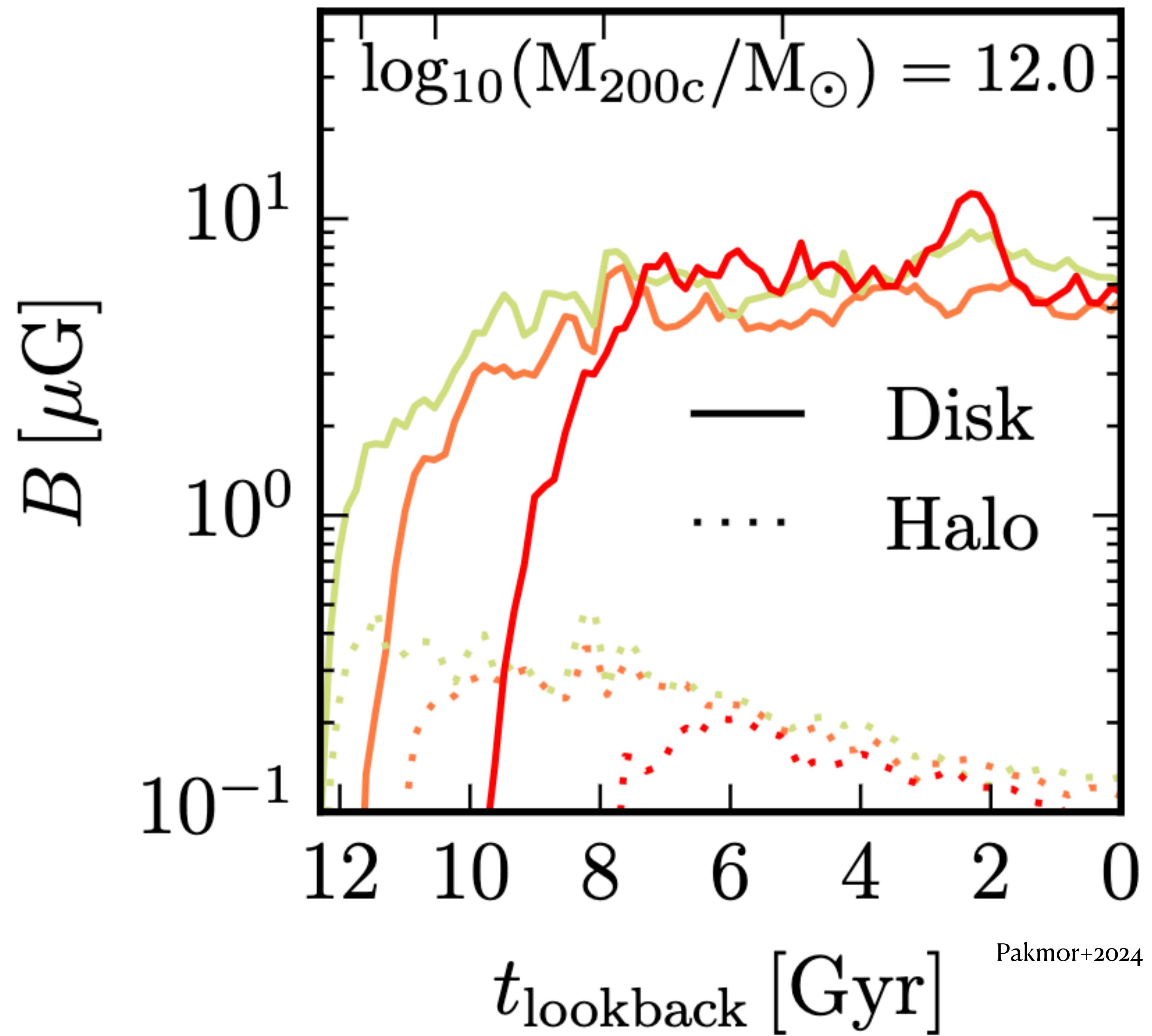


Auriga Halo 6 + WARPFIELD: Reissl+2023



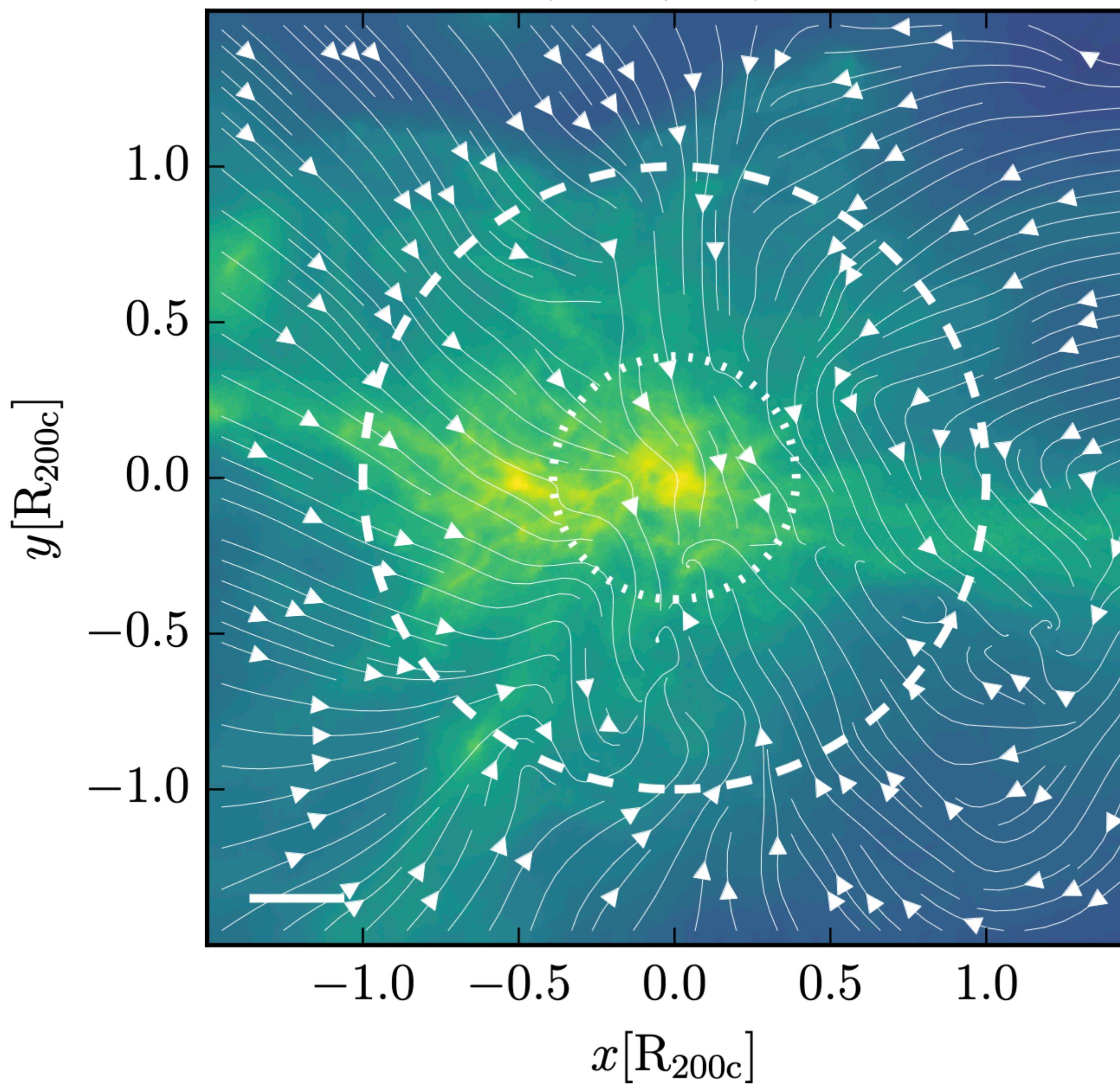
Magnetic field amplification

- $M_{\text{gas}} = 5 \times 10^4 M_{\odot}$
- $M_{\text{gas}} = 4 \times 10^5 M_{\odot}$
- $M_{\text{gas}} = 3 \times 10^6 M_{\odot}$

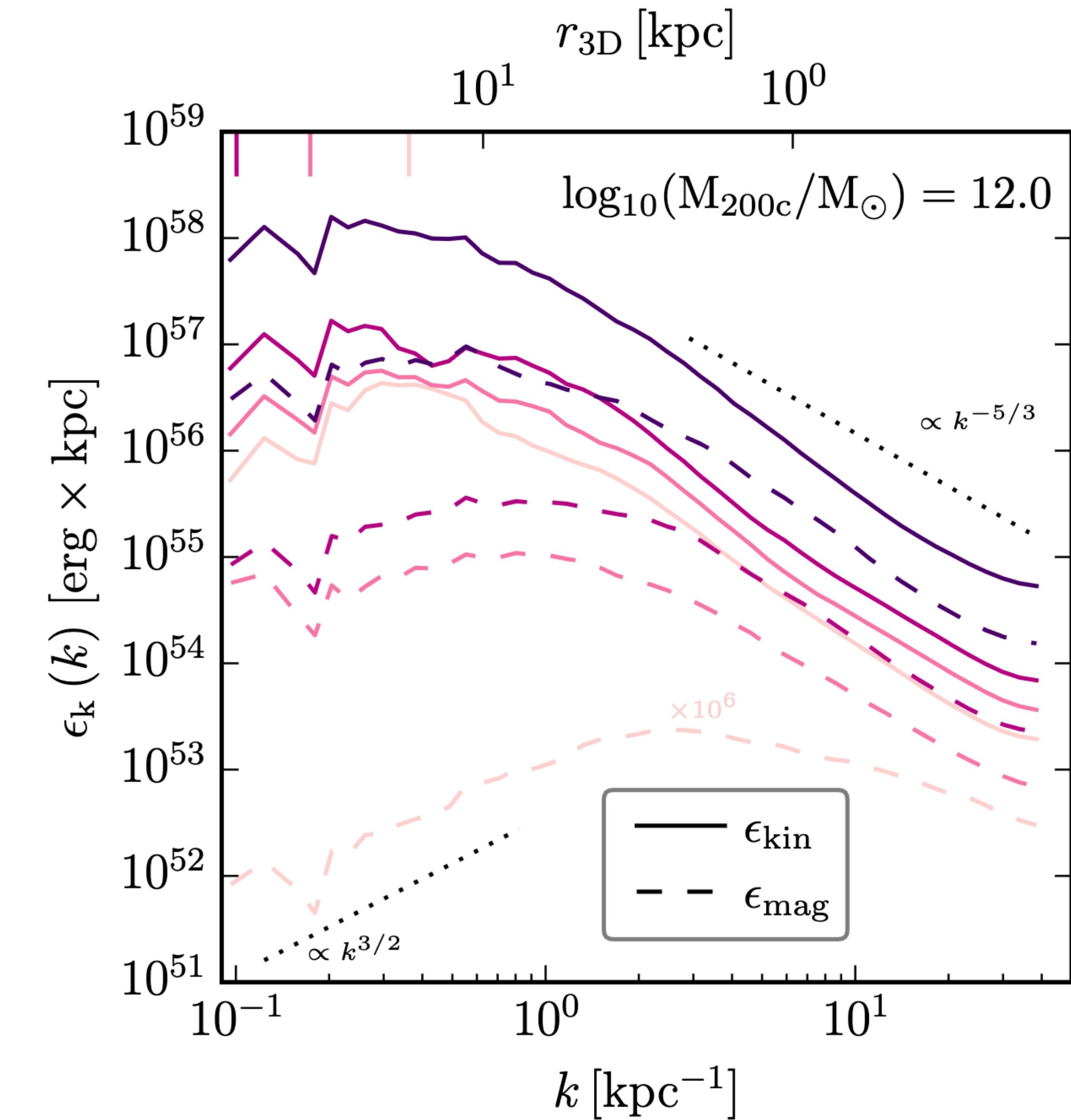


The turbulent dynamo

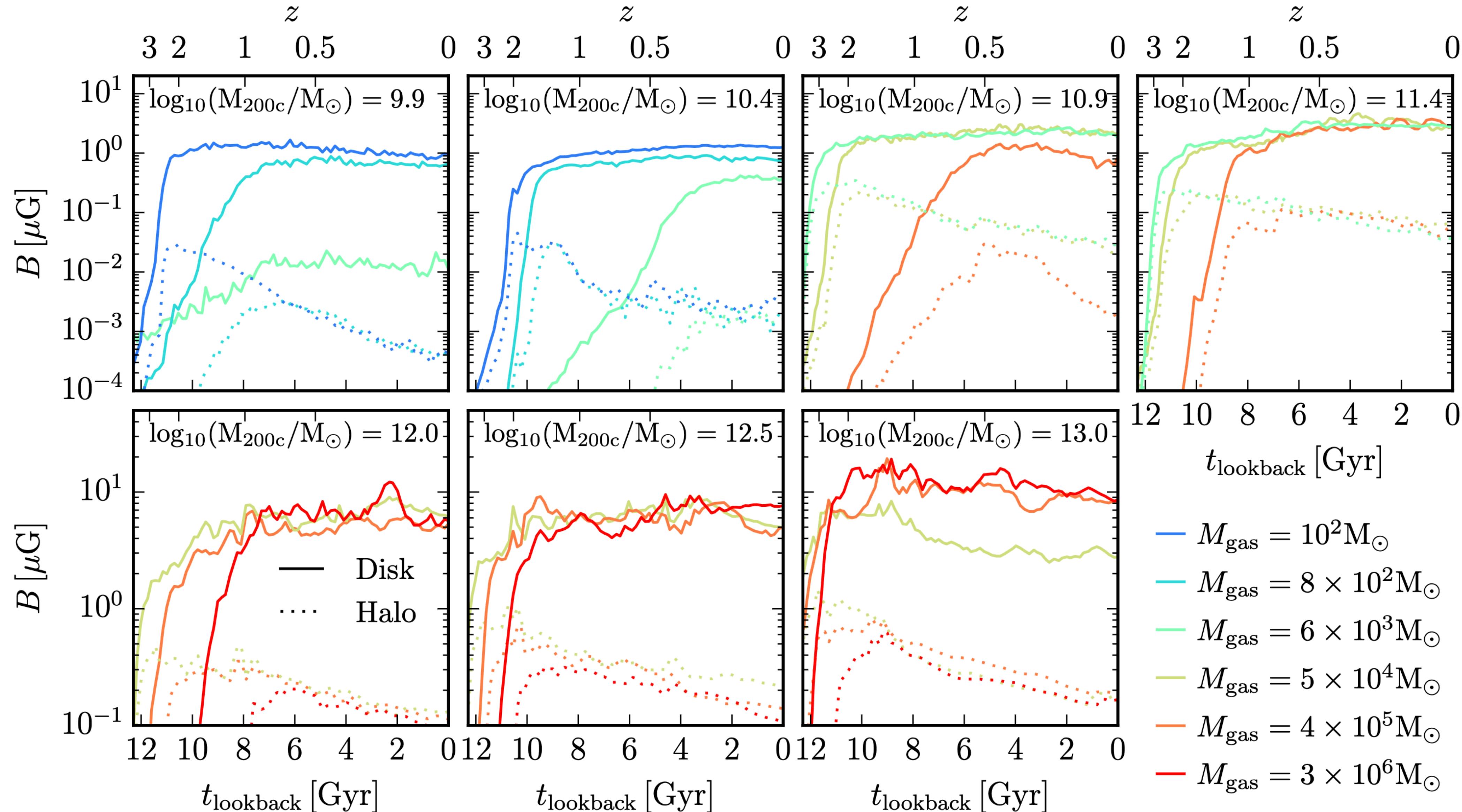
Gas surface density + velocity field



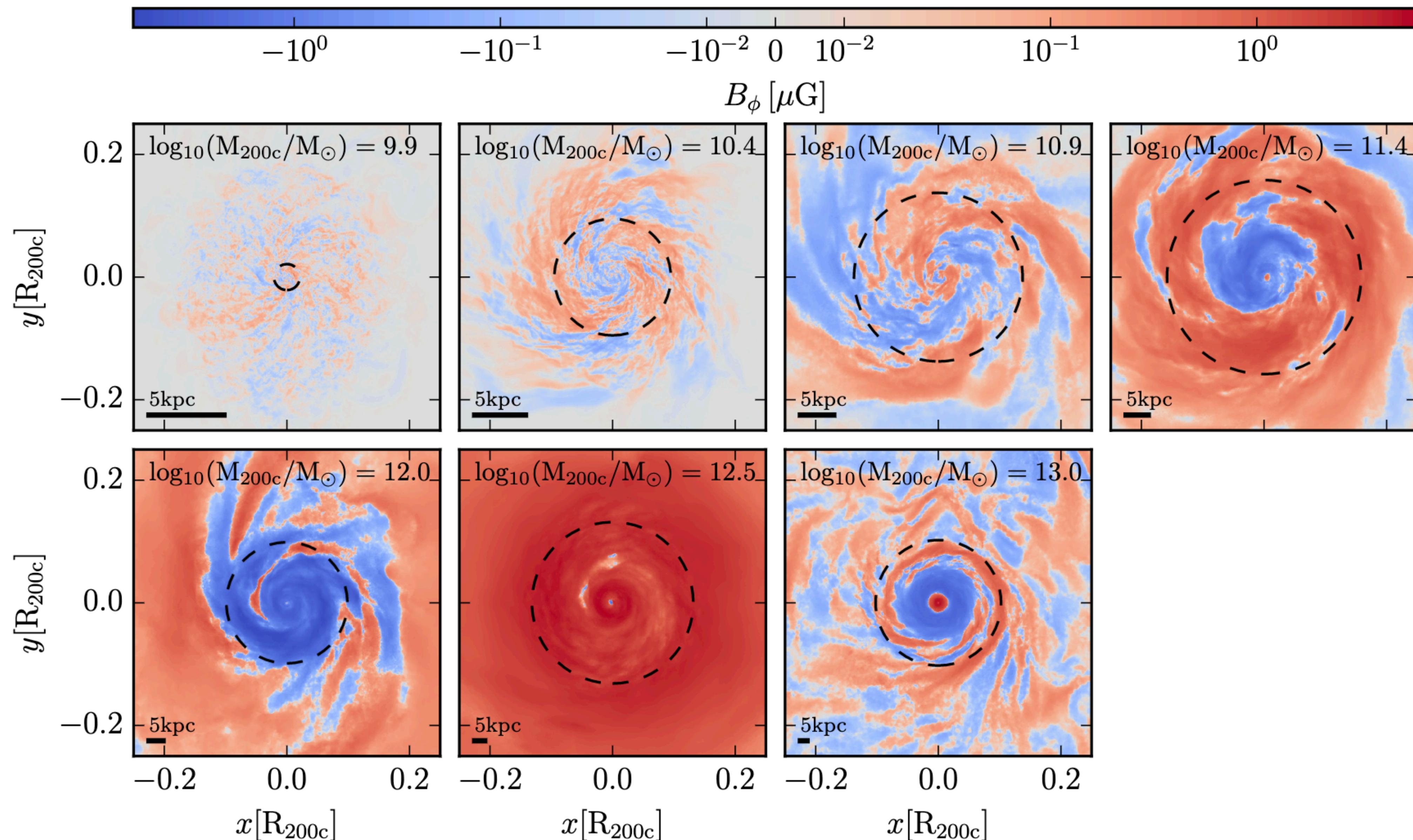
Kinetic and magnetic power spectra



Magnetic fields form dwarf galaxies to groups

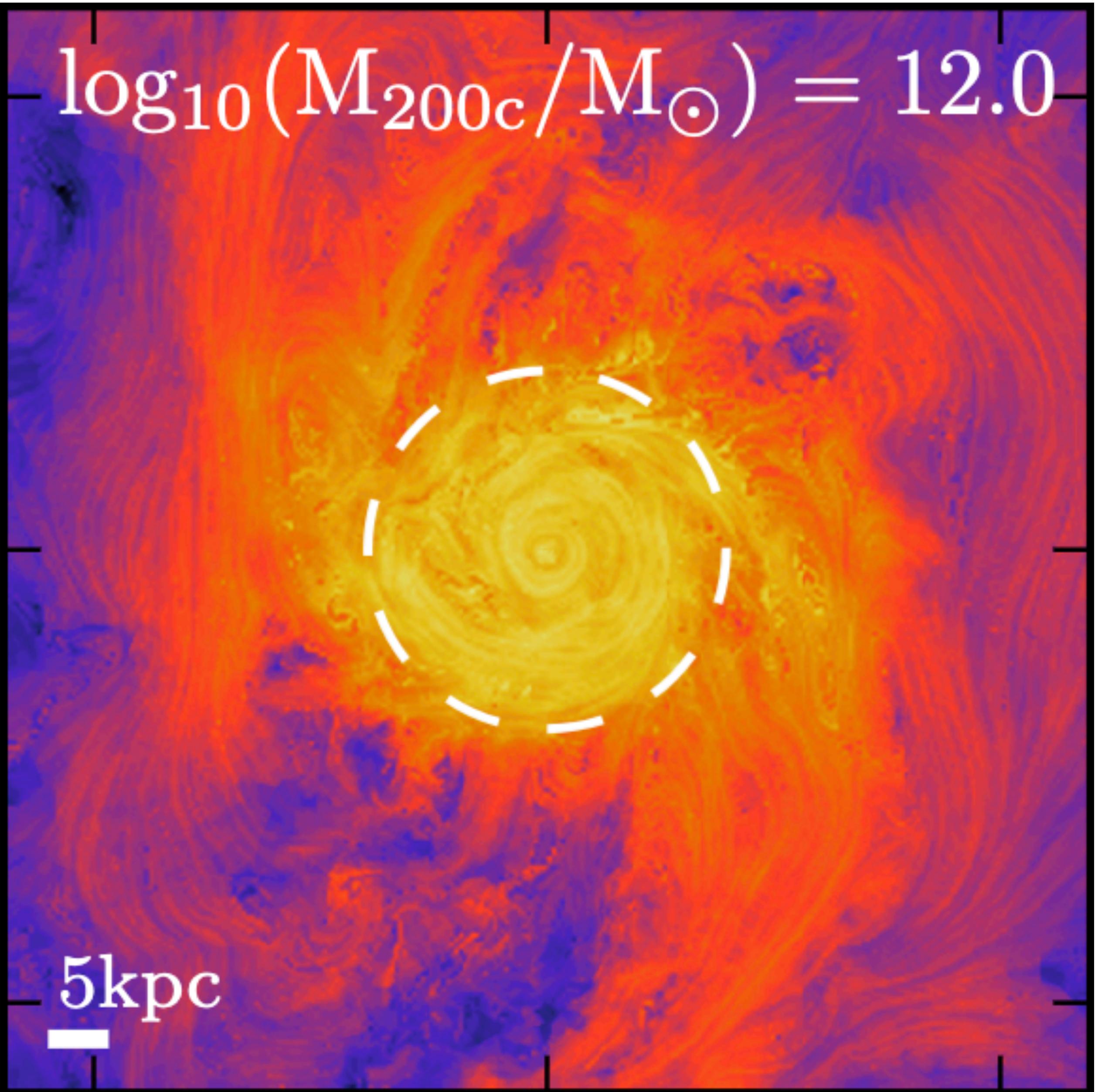


Magnetic fields form dwarf galaxies to groups



Summary

- Cosmological galaxy simulations can produce realistic magnetic field strengths for all halo masses
- High redshift turbulent dynamo amplifies to $\sim 10\%$ of equipartition
- Rotating disc orders and amplifies to equipartition
- Reliable magnetic fields crucial diagnostic and basis for various transport processes (CRs, thermal conduction)



Stability of the magnetic field structure

