Magnetic fields in prestellar cores
a new perspective from meter-wavelength radio data

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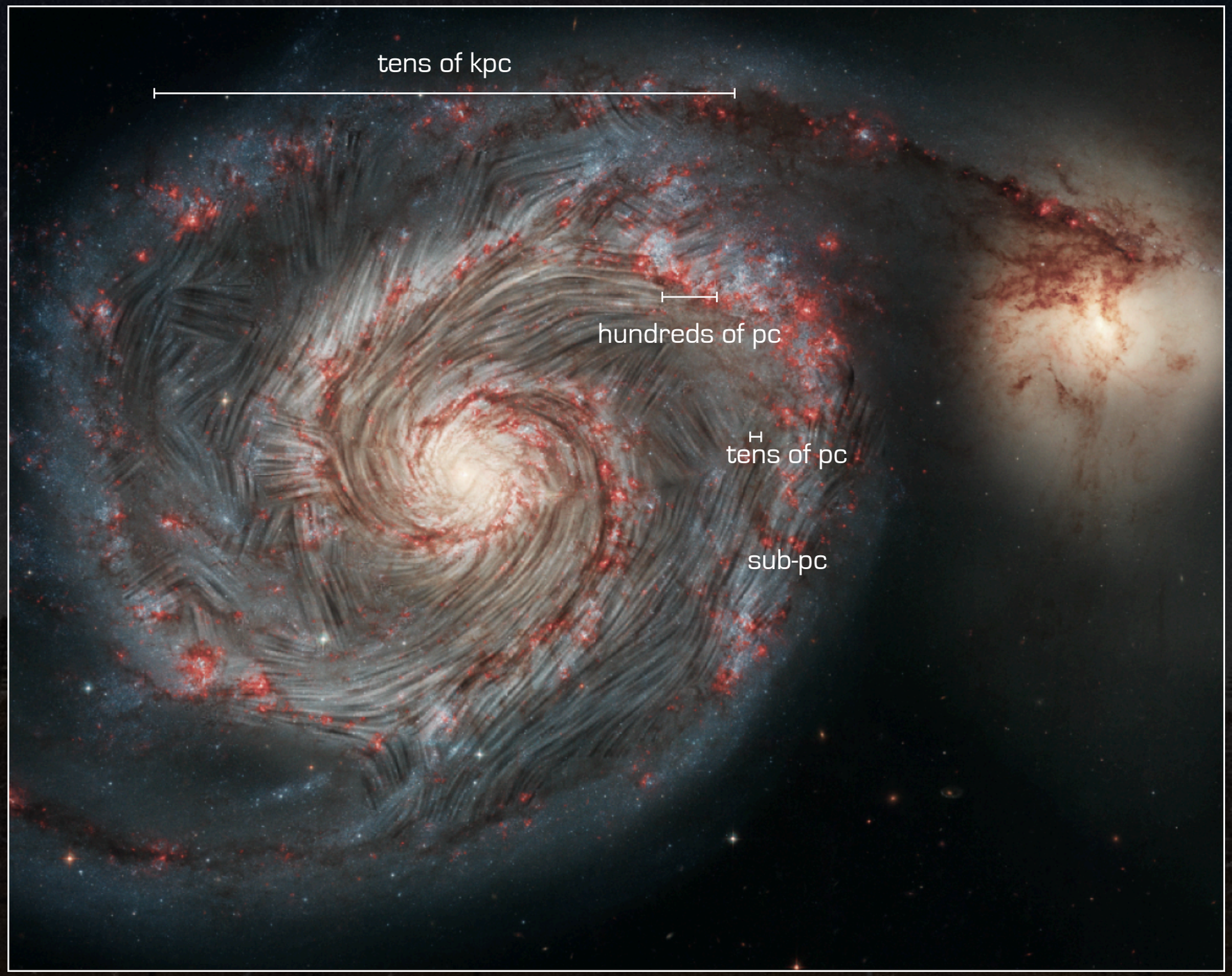
Magnetic fields in Galactic star-formation

Messier 51 (M51) galaxy - The Whirlpool galaxy - Hubble Space Telescope SOFIA 154um **(Borlaff+2021)**



Credits: NASA, ESA, S. Beckwith (STScI) and the Hubble Heritage Team (STScI/AURA)

- **Big problem:**
Milky-Way type of galaxies are inefficient in forming stars

- **Ingredients:**

MAGNETIC FIELD vs MATTER COUPLING

FEEDBACK & IONIZATION
(photons, shocks, cosmic rays)

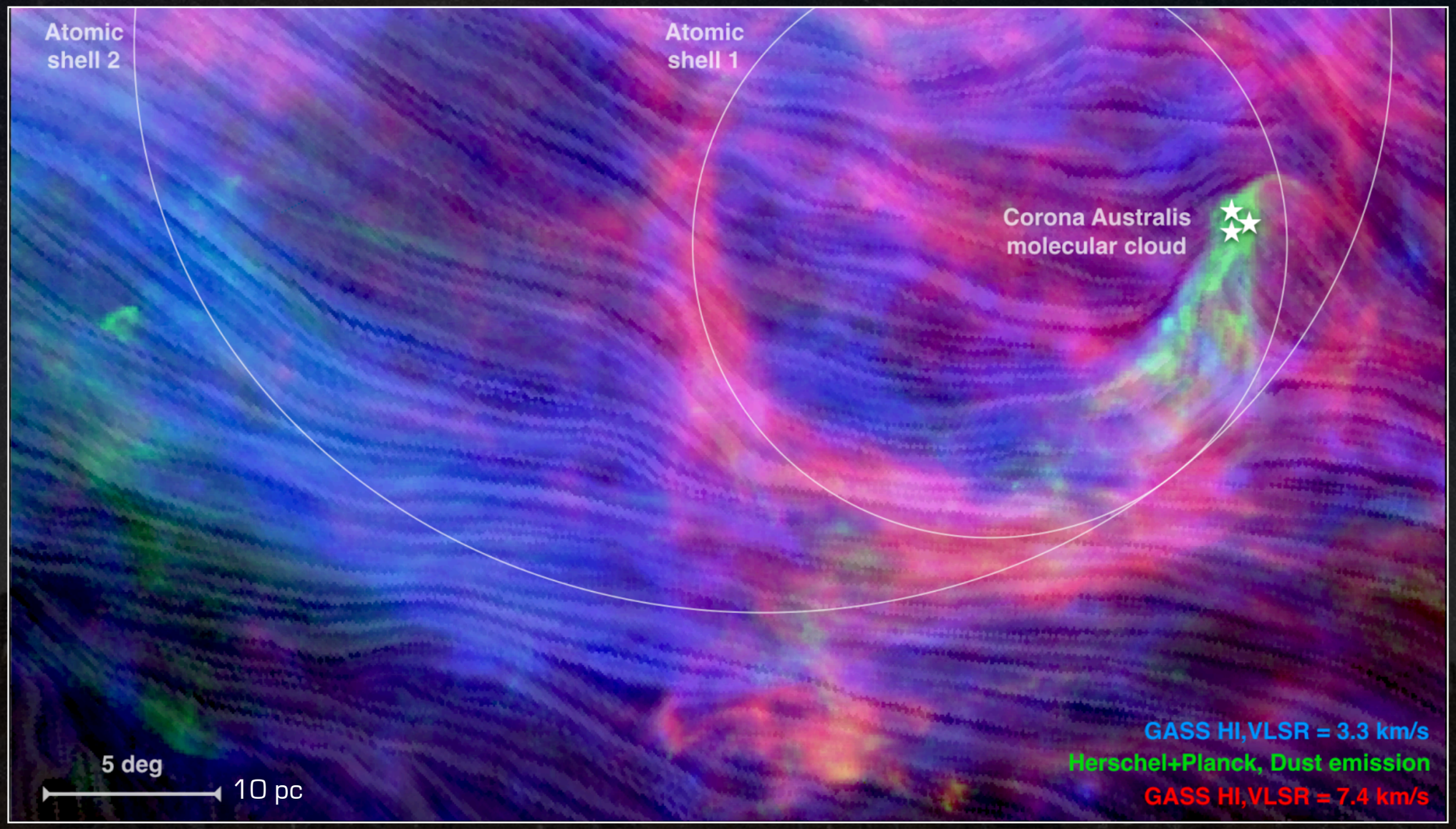
TURBULENT and MULTIPHASE
interstellar medium (ISM)

MULTISCALE

GALACTIC LABORATORY

Magnetic fields in Galactic star-formation

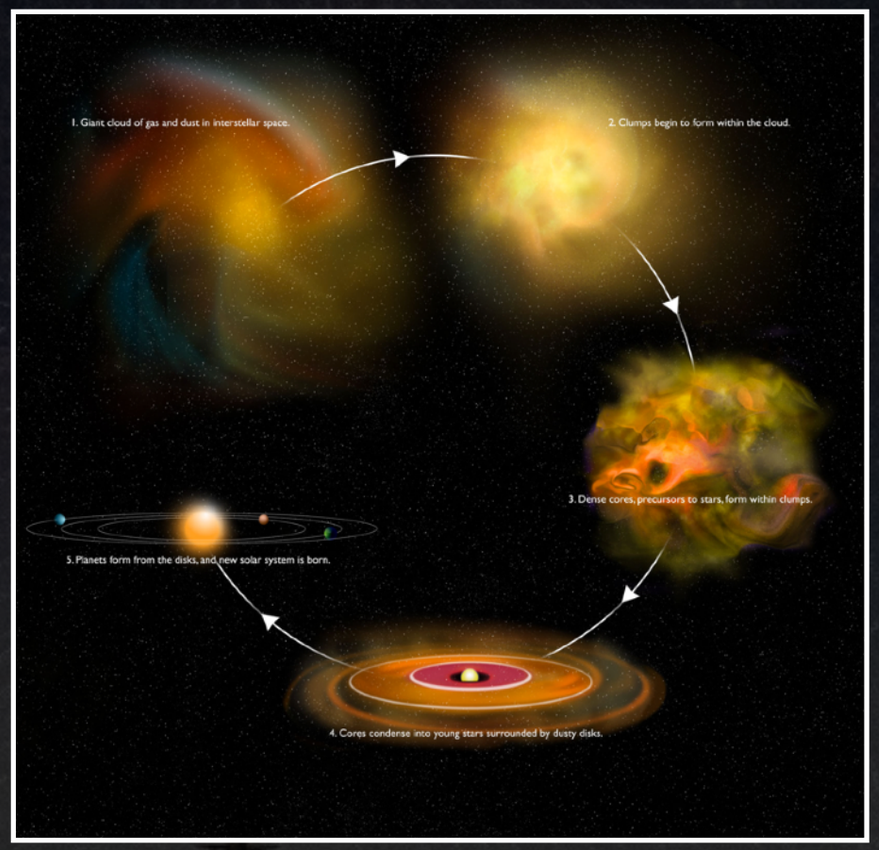
Star forming regions are anchored to the Galactic magnetic field that influences their dynamics: density structures parallel to perpendicular wrt the magnetic field orientation



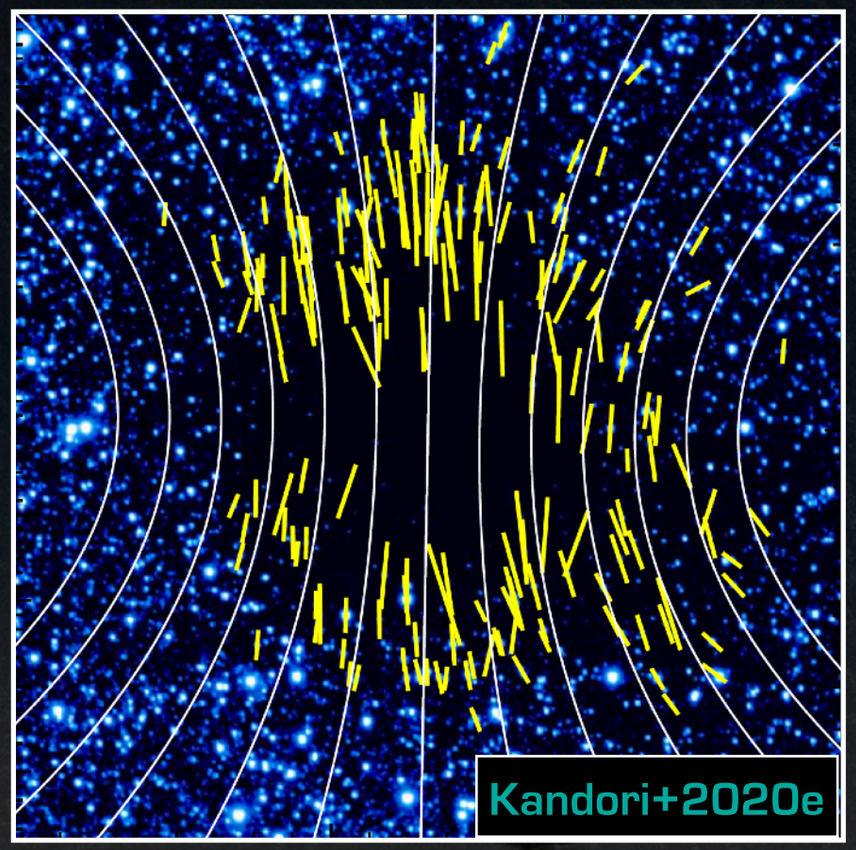
Corona Australis MC (150 pc, **Bracco+2020c)**

See also **Planck int. results XXXII, XXXIII, XXXV 2016, Soler 2019, Pineda+2023**

From clouds to stars: the role of prestellar dense cores

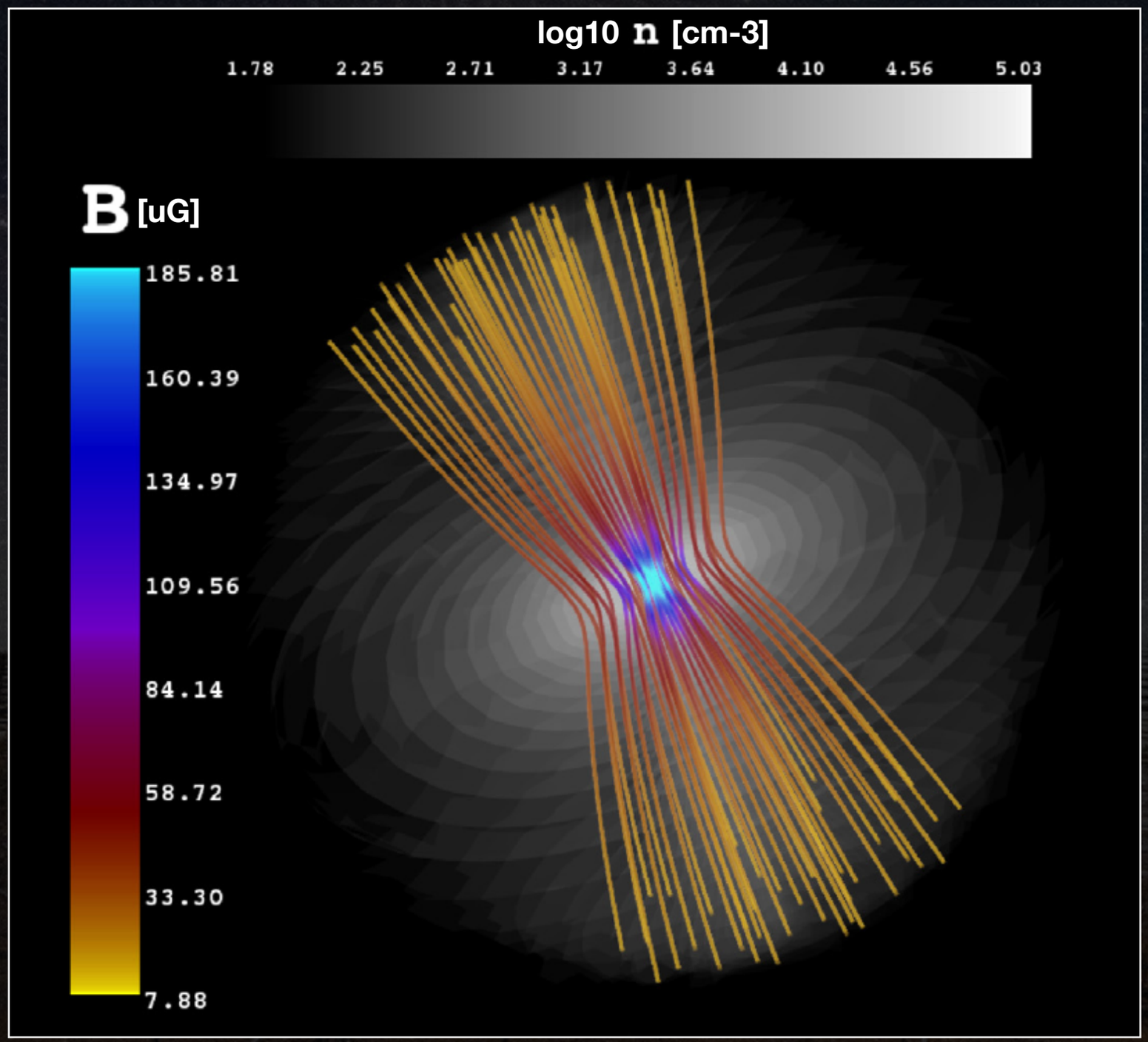


FeSt 1-457 in the Pipe Nebula, NIR data with SIRPOL



- First self-gravitating objects that undergo gravitational collapse in young stellar objects
- Dense, cold over-densities with low amount ionization, mostly from low energy cosmic rays (<1 GeV, **Padovani+2009, 2011**)
- Question: is magnetic pressure strong enough to inhibit gravitational collapse?
- Measurements: Zeeman + dust polarization (NIR - mm) suggest field strengths spanning **from tens of uG to mG** (see reviews by **Pineda+2023** and **Pattle+2023**)

The radio window on magnetized prestellar cores



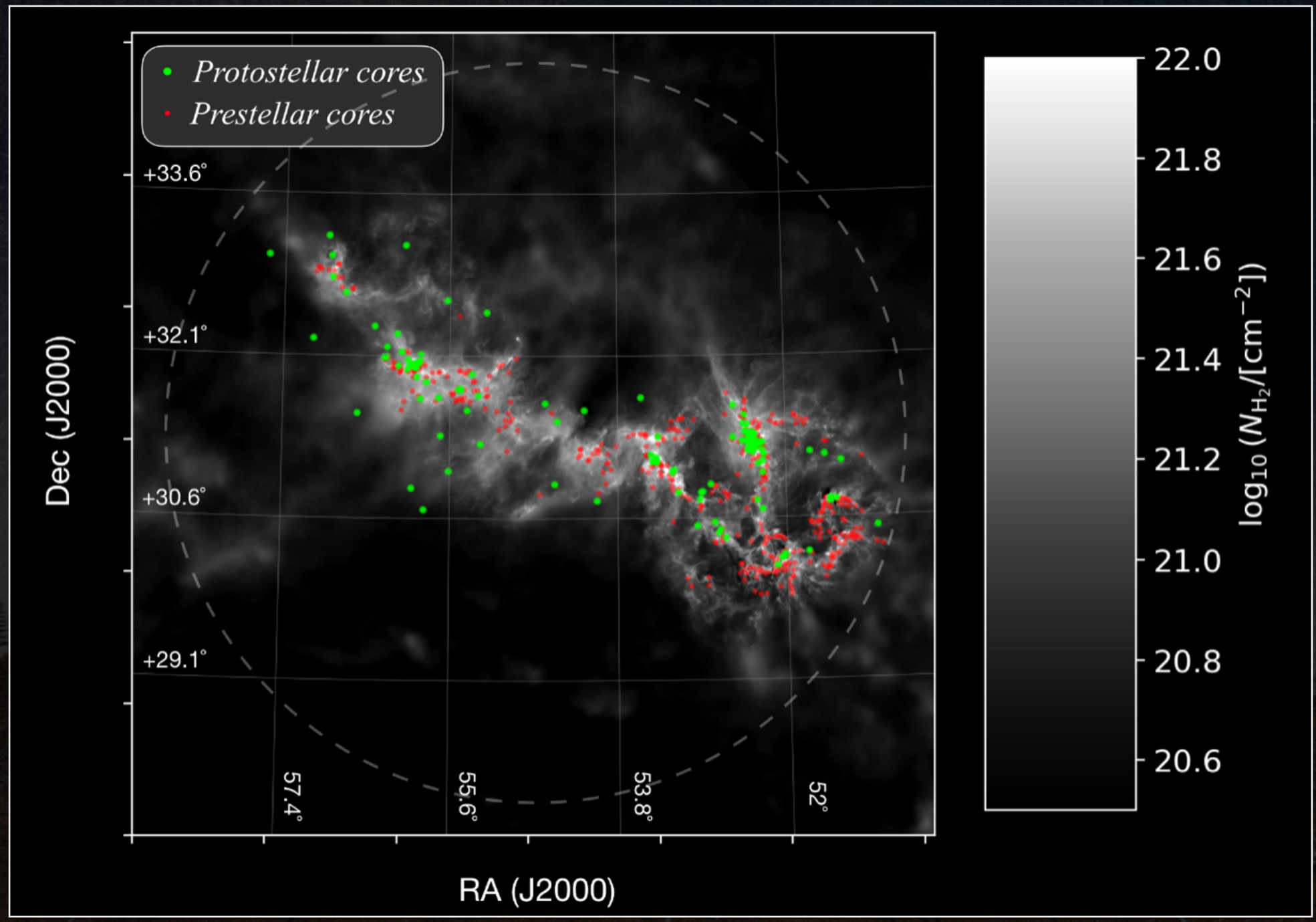
Padovani+2013

- Analytical models of dense cores **(Li & Shu 1996, Galli+1999)**
- Cosmic ray electrons (CRe) suffer energy losses only at $N_{\rm H} > 10^{25}\,{\rm cm}^{-2}$ **(Padovani+2018)**
- Given the Galactic CRe flux (e.g. **Bracco+2024a**) and the magnetic-field strengths (**here ideal MHD applies**), we expect non-thermal synchrotron radiation.
- This synchrotron emission is detectable at radio wavelength...at least statistically!

  Padovani & Galli 2018

Synchrotron emission from dense cores in Perseus in LoTSS DR3

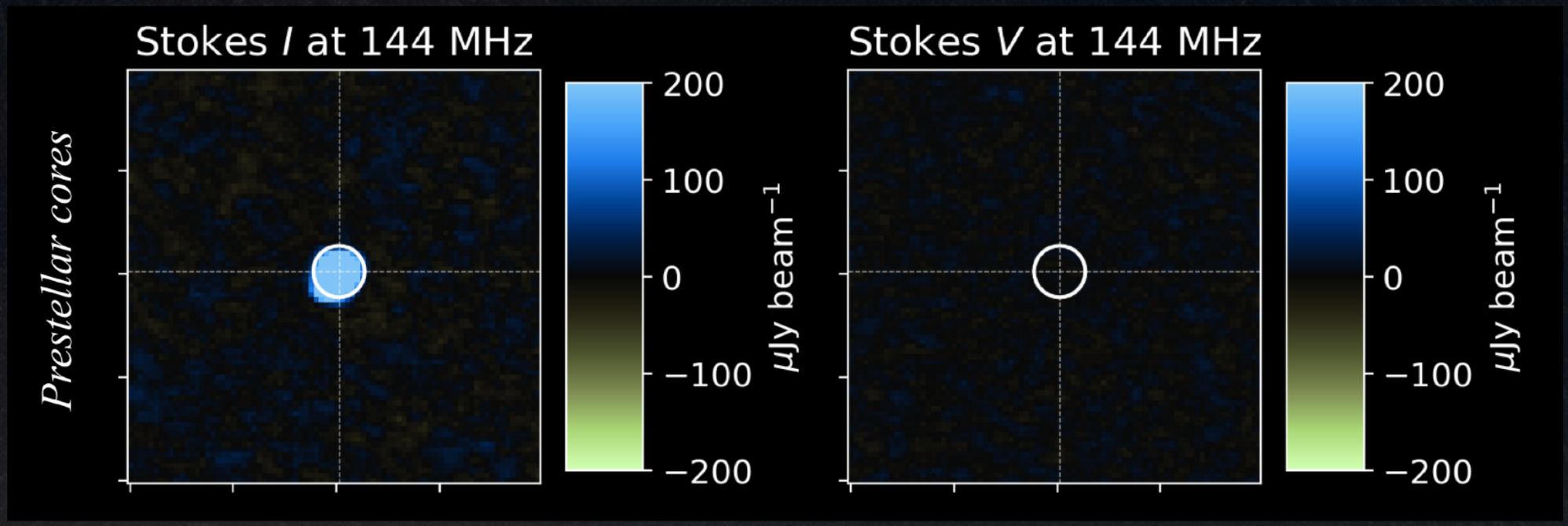
Dust thermal emission of Perseus (300 pc), Herschel and Planck combined **(Bracco+2020b)**



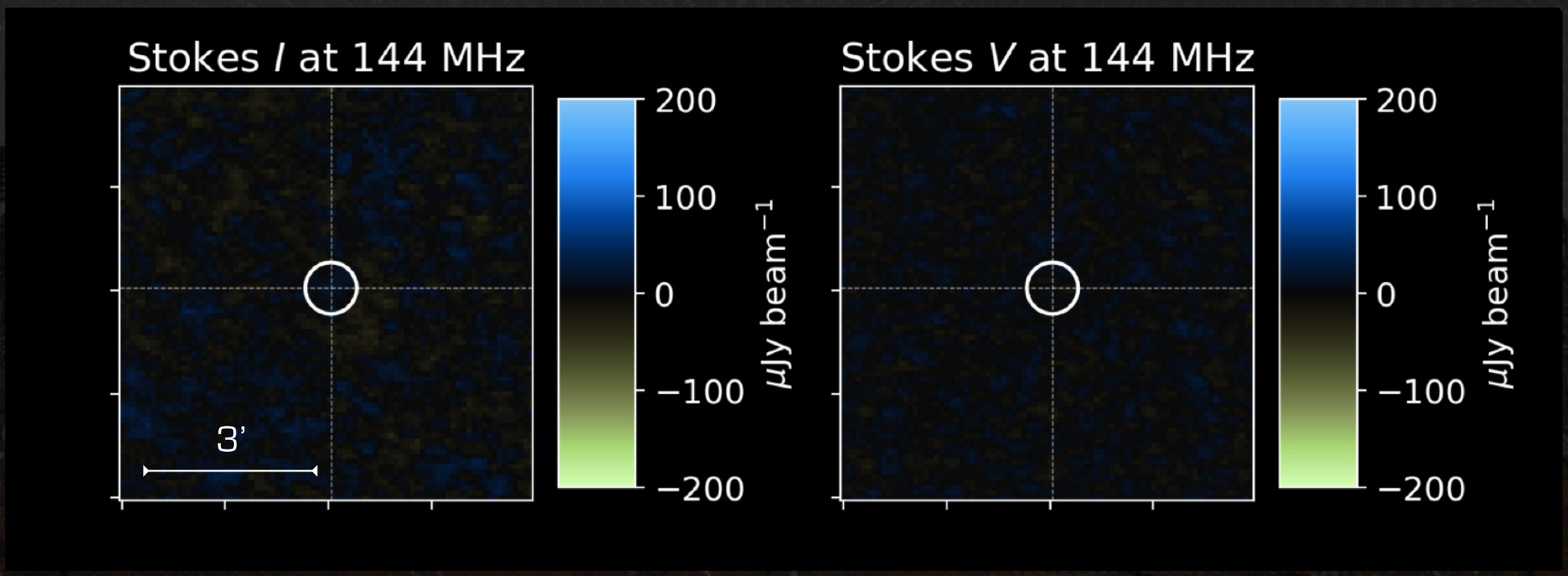
Bracco+2025, Pezzuto+2021: 353 prestellar, Herschel FWHM around 20”

Synchrotron emission from dense cores in Perseus in LoTSS DR3

Median stacking



Removing 2% of cores considered of extragalactic contamination



Bracco+2025

*No detection at a level of 5 uJy/beam (20”)

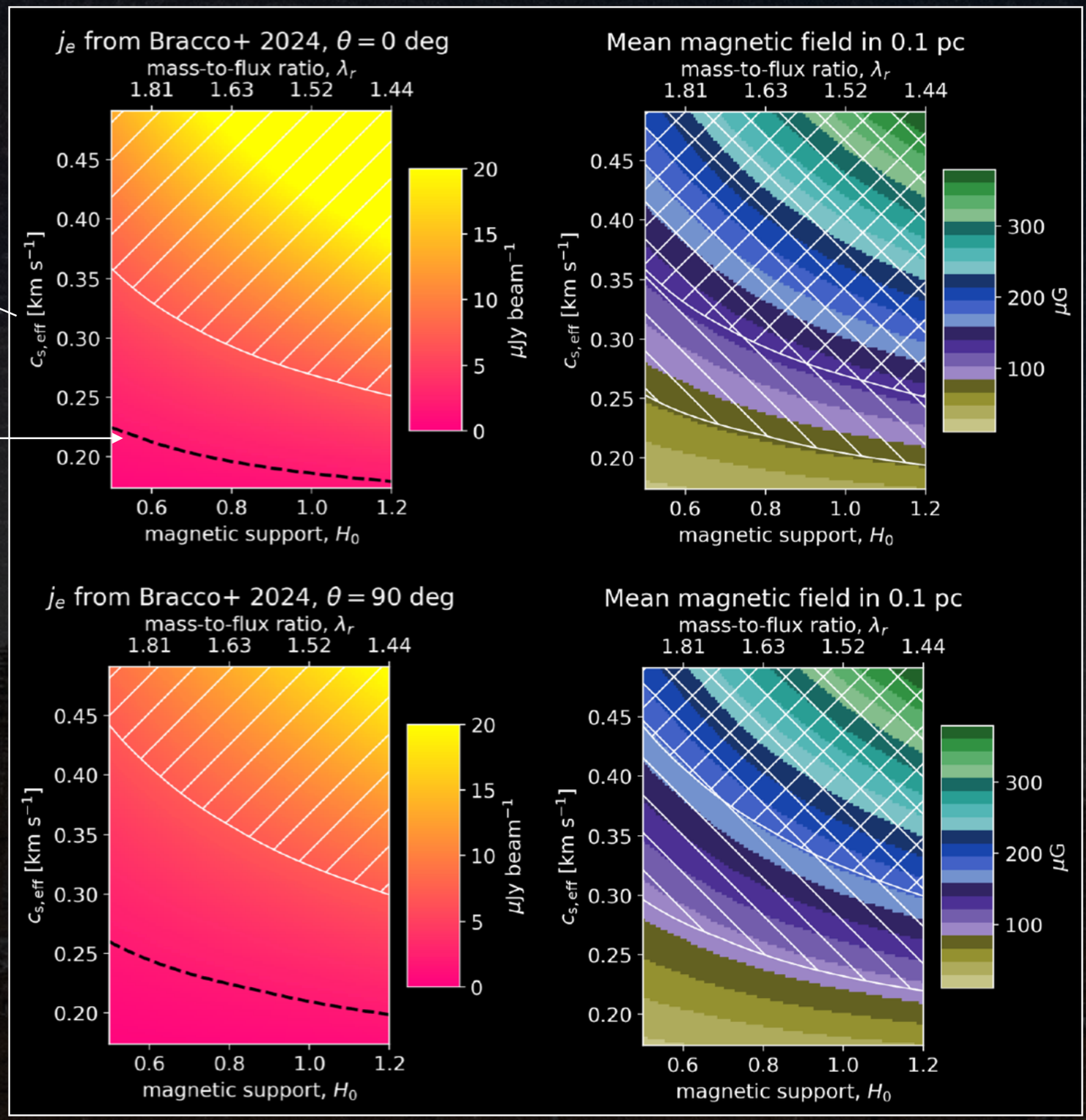
Synchrotron emission from dense cores in Perseus: a statistical approach, median stacking

Turbulent+T
hermal

SKA-Low

2 uJy/beam
9 hours with AA*
4 hours with AA4

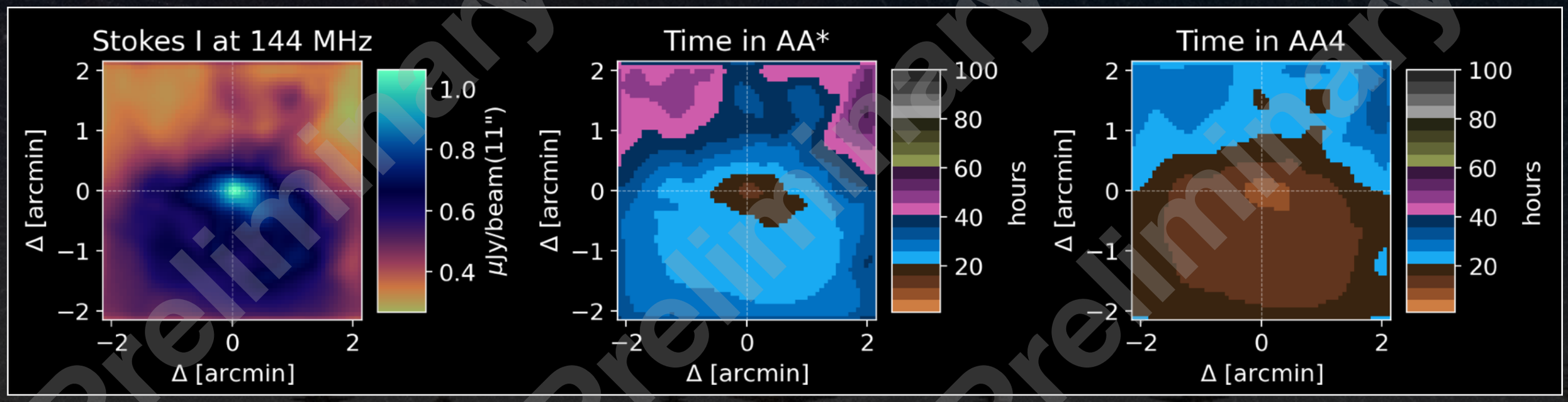
Sokolowski+2022



Bracco+2025

Synchrotron emission from dense cores, what's next?

SKA-Low forecasts using MHD numerical simulations of embedded cores in one Orion-like cloud at 400 pc in single dense cores **(Kuffmeier+2023)**



Bracco+ in prep. for the SKA science book 2025

* Thanks to the large FoV (several-degree wide) statistical analysis will be possible.

Summary

- The importance of bridging high and low frequencies for studying the magnetized ISM in star formation
- The radio perspective can help put constraints on the magnetic-field strength in molecular clouds and refine our understanding of the formation of solar-type stars
- Prestellar-core magnetic fields on the order < 100 uG in the Perseus MC (Bracco+2025)
- Bright future with more sensitive radio telescopes coming online!

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