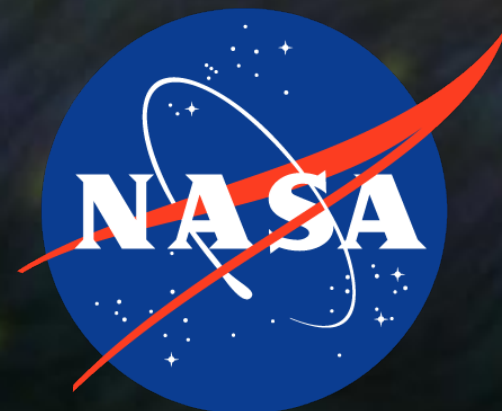


Galactic Astrophysics with a Full-Sky CMB Polarization Survey

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A mm-wave Survey

- Full-sky survey of total and polarized emission between ~ 20 and ~ 800 GHz in ~ 20 bands, e.g., PICO concept (Hanany et al. 2019)
- Angular resolution sub-arcminute at highest frequencies
- PICO designed to have **10,000x** the polarization sensitivity of Planck
- Frequency coverage picks up near where a FIR concept like PRIMA leaves off

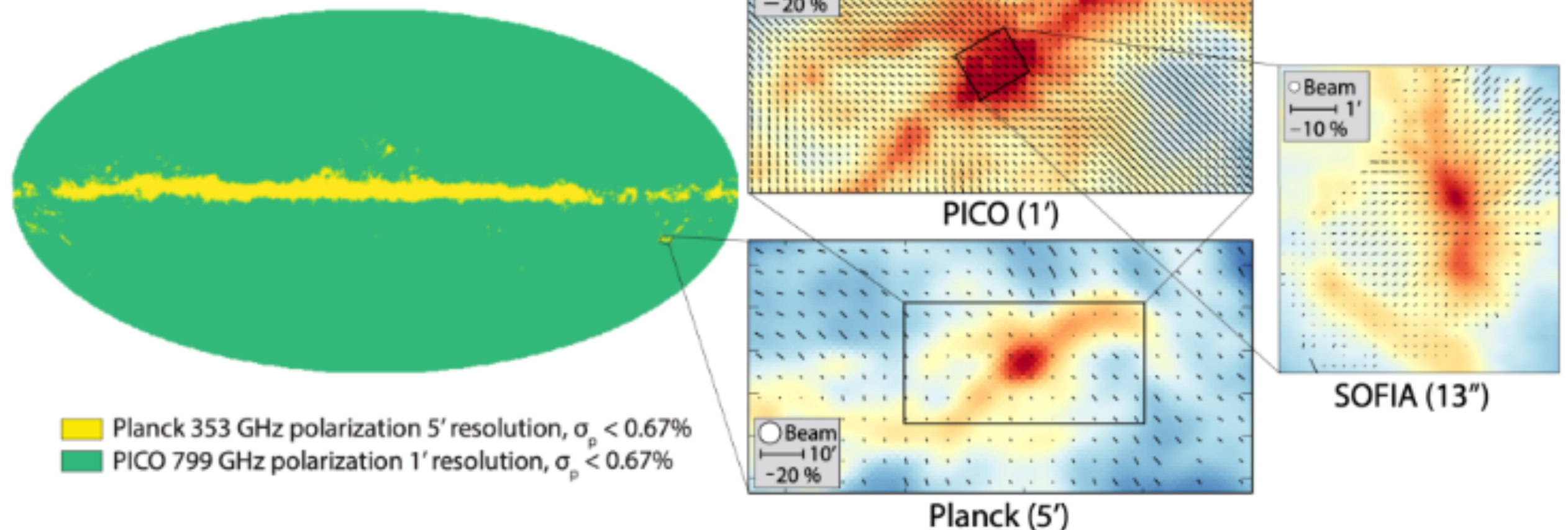
Science Beyond CMB

- Astro 2020 endorsement of CMB-S4: “The Survey is also excited by the **breadth of science**, including time-domain and transient studies, and the potential engagement of a community **well beyond traditional CMB cosmologists.**”
- The data products will “open[] up discovery space and provid[e] scientific data that will **engage a broad swath of the astronomical community.**”
- The Planck legacy makes clear how big an impact these data products would have across astrophysics

A Leap in Sensitivity and Angular Resolution

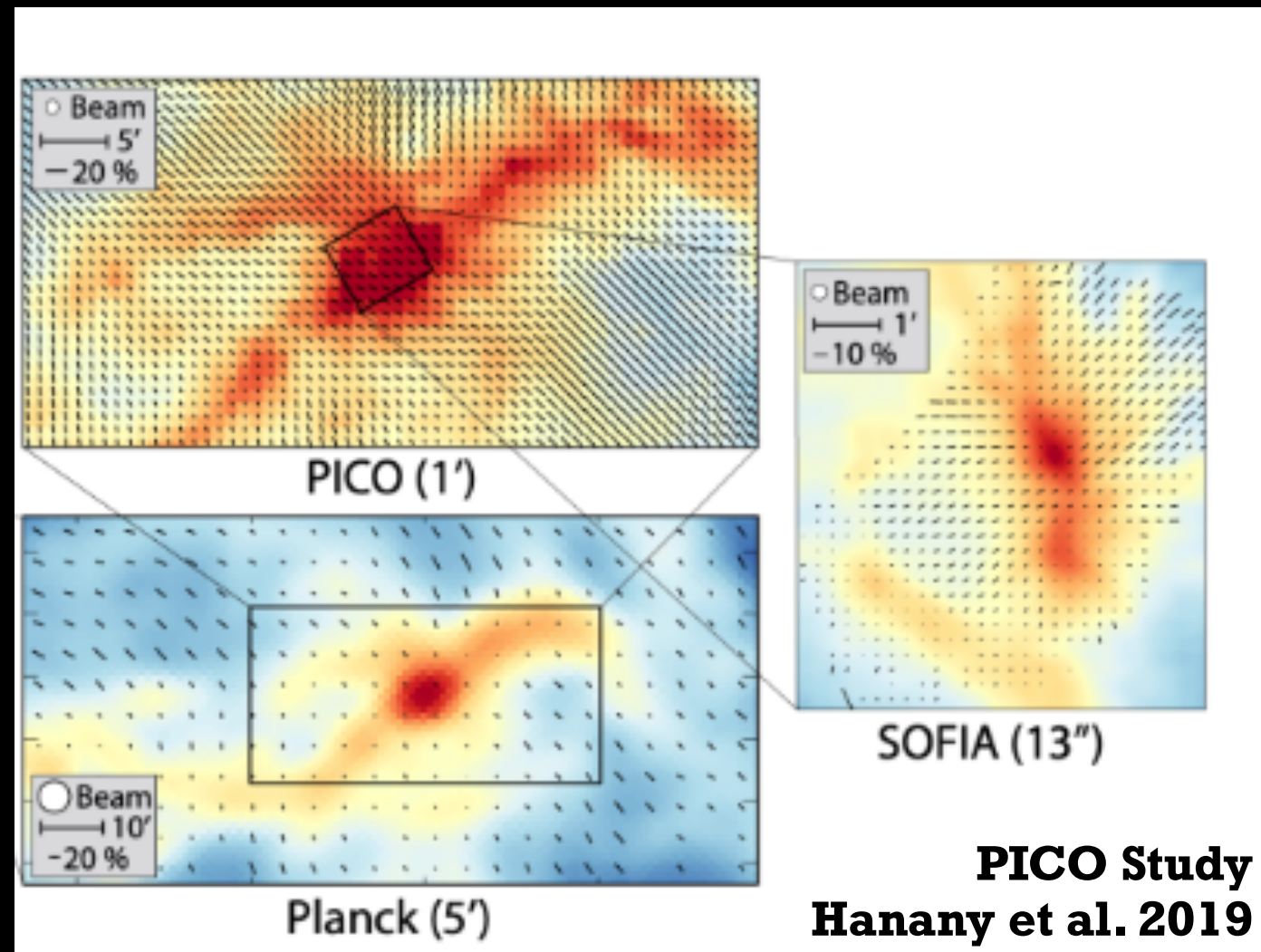
- A CMB Probe+ would make signal-dominated measurements of dust polarization at arcminute resolution over the full sky

PICO Study Hanany et al. 2019



Magnetic Field Mapping

- Reach ~ 0.1 pc scales in nearby clouds, bridging the gap between core scale and cloud scale
- Maps of >2000 molecular clouds each with 1,000-100,000+ measurements
- Powers a statistical study of the role of magnetic fields in cloud formation and star formation



Nearby Galaxies



Lopez-Rodriguez et al. 2023

- Full-sky polarization survey at arcminute resolution yields a treasury of resolved nearby galaxy data
- Complementary wavelength coverage to SOFIA (limited to brightest galaxies and regions) and proposed PRIMA mission
- Planck was severely limited, difficulty mapping even the LMC in the most sensitive channel

ISM Turbulence

- The interstellar medium is shaped by magnetohydrodynamic turbulence
- Polarization power spectra are sensitive to statistical properties of the density and magnetic fields
- Does the power law spectrum extend to arbitrarily small scales? Is there a break?

Meisner+Finkbeiner 2014



Diffuse dust emission, 4.3x3.8 deg

The Nature of Dust

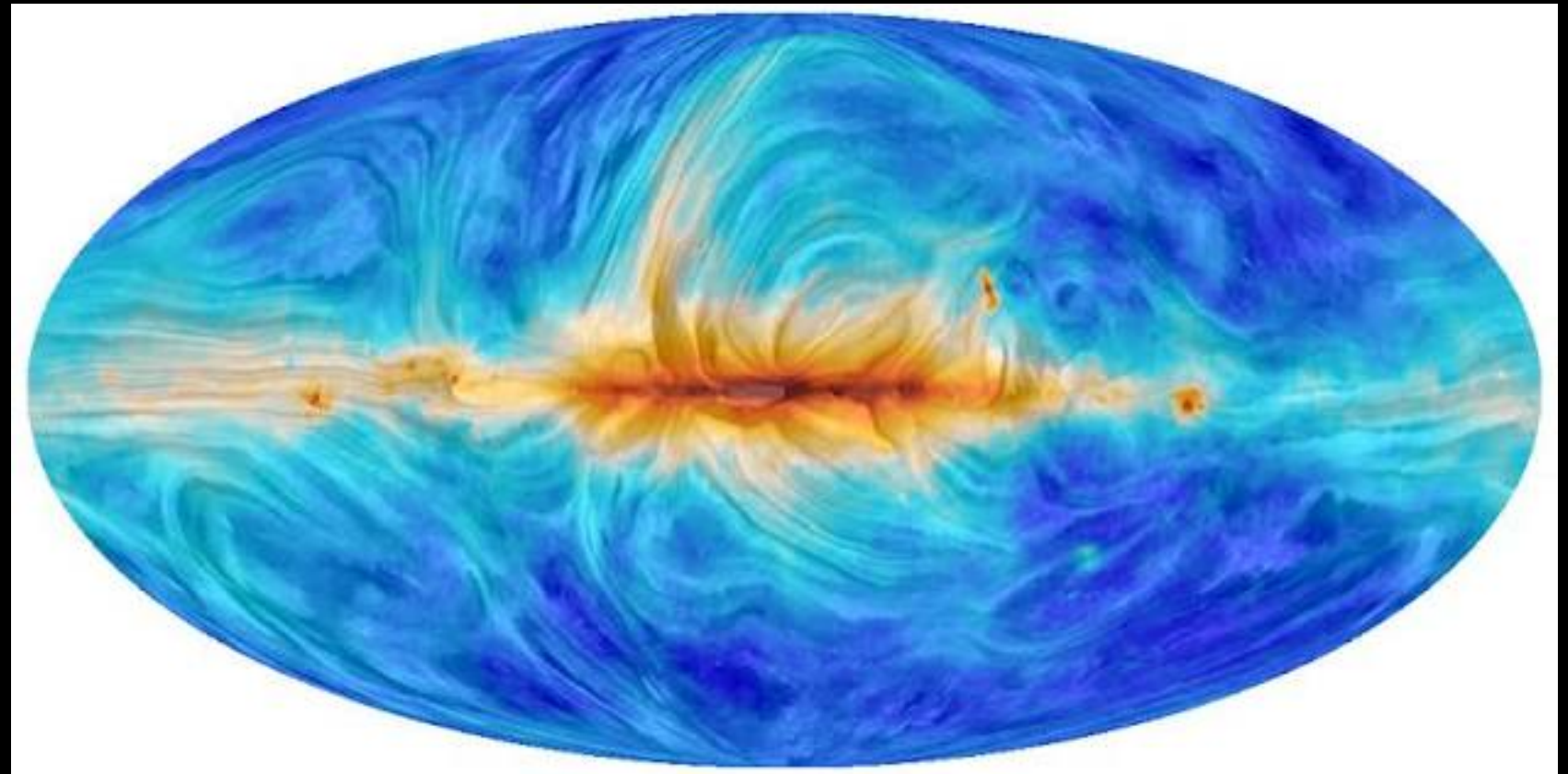
- Does dust come in basically one variety, or different distinct types (e.g., carbonaceous and silicate)?
- **Test**: does the dust SED in total intensity look the same as polarized intensity?
- Current mm measurements favor one component (Hensley & Draine 2023), but two component models not ruled out (Guillet et al. 2018, Ysard et al. 2024)



Galactic Synchrotron Emission

ESA/Planck

- Synchrotron emission comes from relativistic electrons interacting with magnetic fields



- How correlated are dust and synchrotron polarization and why? Where in the Milky Way does the synchrotron emission come from? How do cosmic rays propagate through our galaxy?
- Low frequency channels give a full-sky view of synchrotron polarization uncontaminated by Faraday rotation

Other Galactic Emission

- **Anomalous Microwave Emission** (aka **Spinning Dust Emission**): What is its carrier? Is the emission polarized? Is this a window into complex molecules of the ISM?
- **CO Emission**: Potential to map the sky in molecular lines, and may not even need spectroscopy to do it
- **Magnetic Dust**: Does superparamagnetic material leave an imprint on the mm-wave sky via magnetic dipole emission? Need sensitive polarimetry to test

Exo-Oort Clouds

- No Oort cloud has ever been directly imaged, not even our own
- 2×10^4 au Oort cloud at 300 pc = 1 arcmin
- Submm/mm well matched for detecting thermal emission with stacking
- Methodology already used to constrain debris disks with Planck (Nibauer+ 2020)

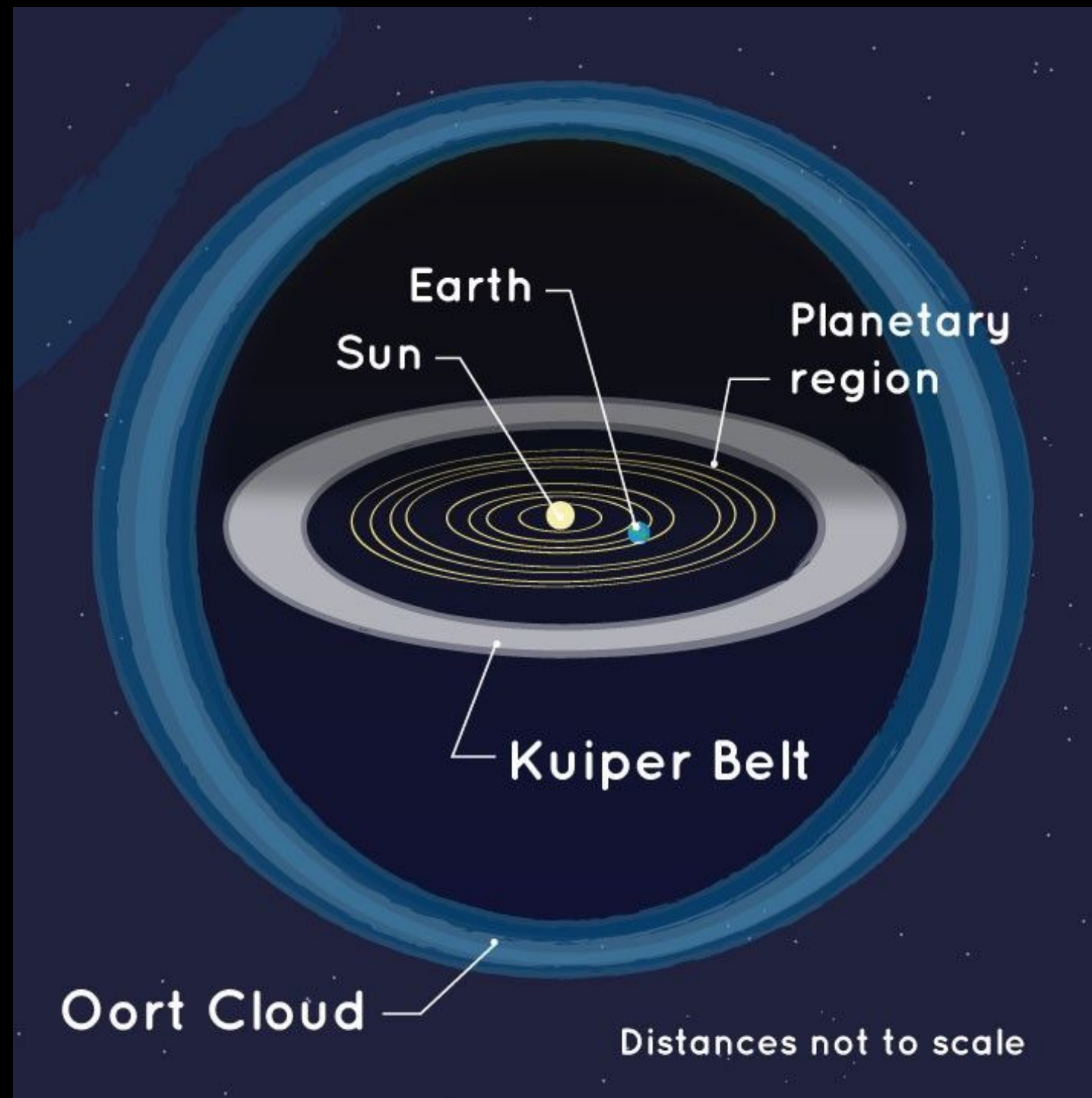


Image: <https://science.nasa.gov/solar-system/oort-cloud/>

Summary and Outlook

- A CMB Probe+ powers science beyond the CMB: this talk highlighted interstellar astrophysics
- With orders of magnitude gains in sensitivity and factors of several in angular resolution over the Planck mission, a CMB Probe+ is a transformational leap in our ability to measure the interstellar medium of the Milky Way, including the magnetic fields that thread it
- Galactic emission is an important foreground for CMB science: an ASTRA study would help optimize mission design