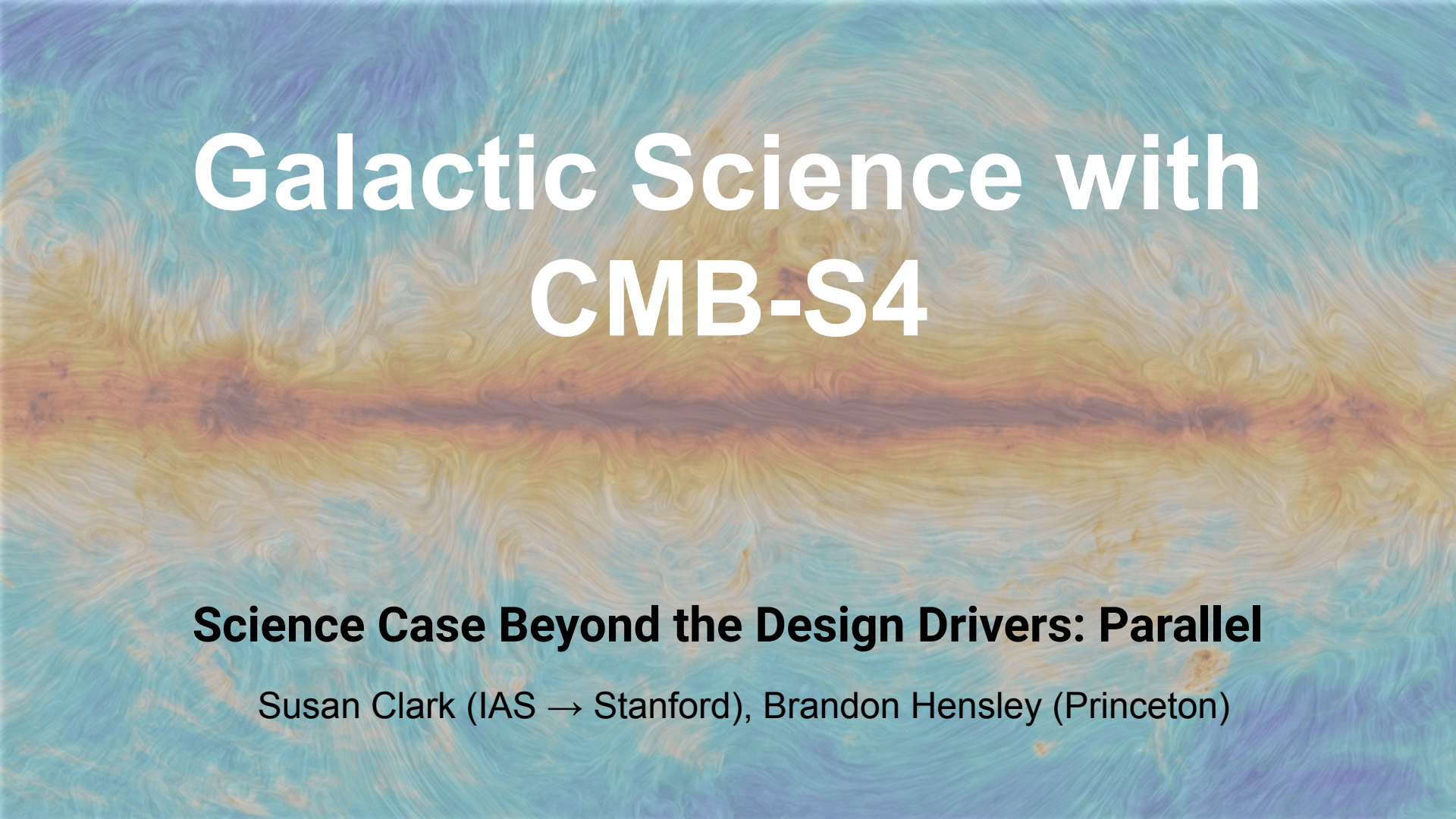


Galactic Science with CMB-S4

Science Case Beyond the Design Drivers: Parallel

Susan Clark (IAS → Stanford), Brandon Hensley (Princeton)

Spectral Science

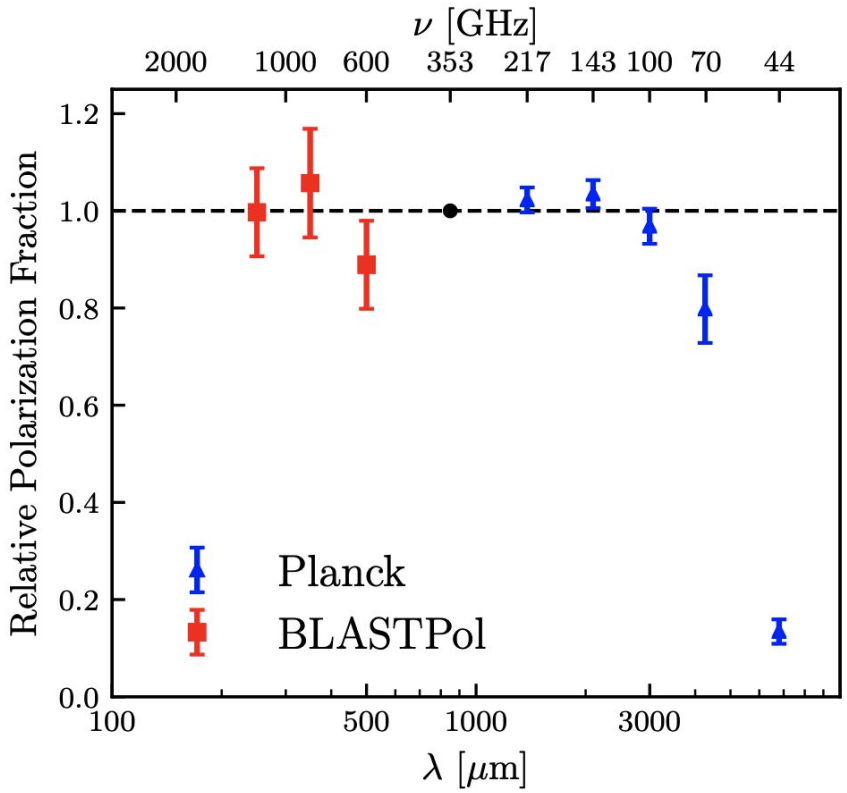
- What is the composition of interstellar dust?
- Is AME polarized?
- How do the combined probes of synchrotron and dust probe the 3D ISM?

Map-Space Science

- How are dust and gas coupled on small spatial scales?
- How do magnetic fields influence the fragmentation of molecular filaments and the formation of stars?
- What is the nature of magnetohydrodynamic turbulence in the ISM?

Dust SED Science

- Does dust come in basically one variety, or different distinct types (e.g., carbonaceous and silicate)?
- **Test**: does the SED in total intensity look the same as polarized intensity?
- Current mm measurements favor one component (Draine & Hensley 2020), but some two component models not ruled out (see Guillet et al. 2018)
- Ashton et al. 2018, Hensley et al. Decadal White Paper

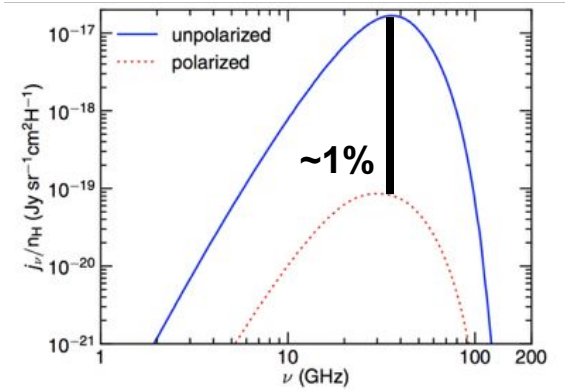


Hensley & Draine 2021

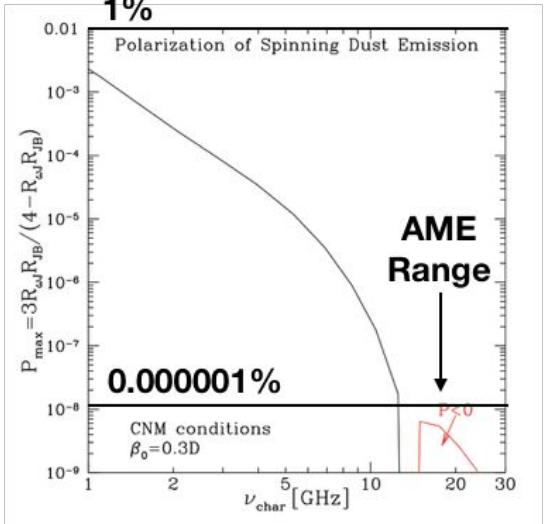
Anomalous Microwave Emission

- AME polarization has not been detected, with upper limits of ~1%
- Theorists divided: some say ~1% expected (e.g., Hoang et al 2013, 2014), others say completely negligible (Draine & Hensley 2016)
- CMB-S4 20 and 27 GHz channels are near the peak so ideal for a search
- Can also constrain other low frequency dust emission mechanisms, like magnetic dipole emission (dust is very Fe-rich!)

Percent level polarization

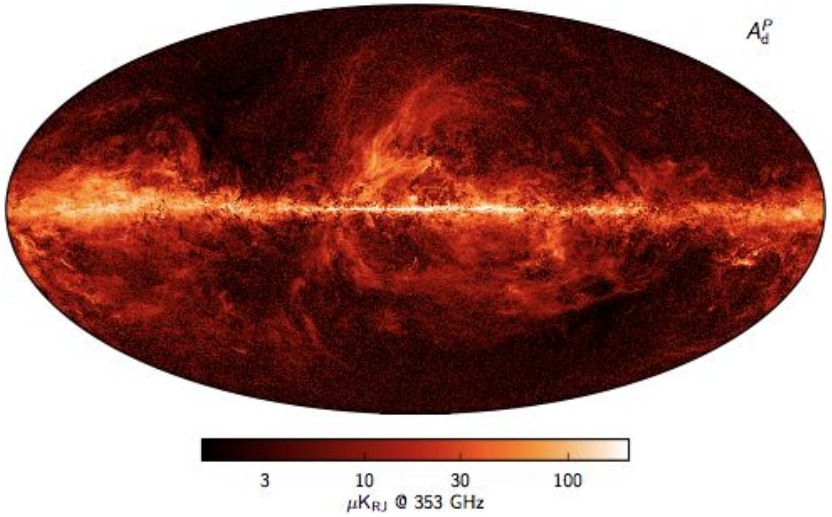


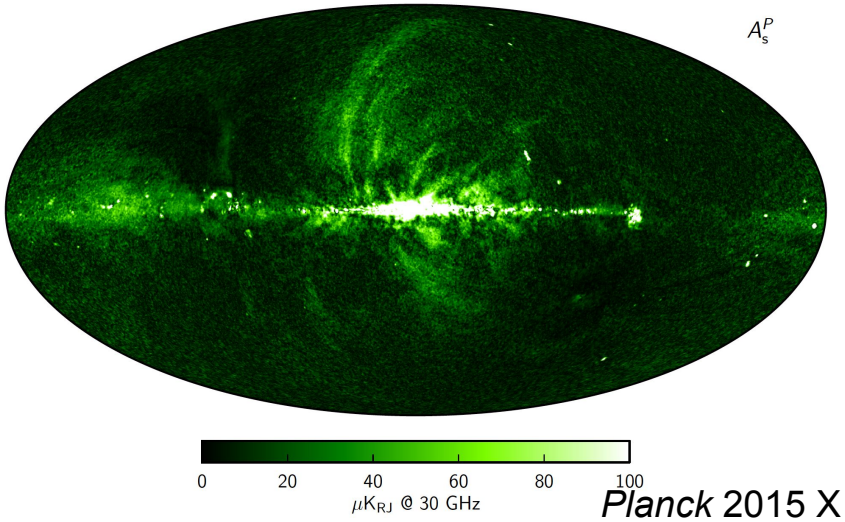
OR No polarization



Dust and Synchrotron

- Dust and synchrotron polarization have some level of correlation at large angular scales, ~20% (e.g. Choi & Page 2015, Krachmalnicoff et al. 2018)
- Dust polarization largely probes the neutral medium
- Synchrotron polarization probes cosmic ray electrons
- How closely are their polarized intensities and polarization angles coupled? What do we learn about ISM structure?
- Additional 3D magnetic field constraints with starlight polarization (e.g. PASIPHAE) + *Gaia*

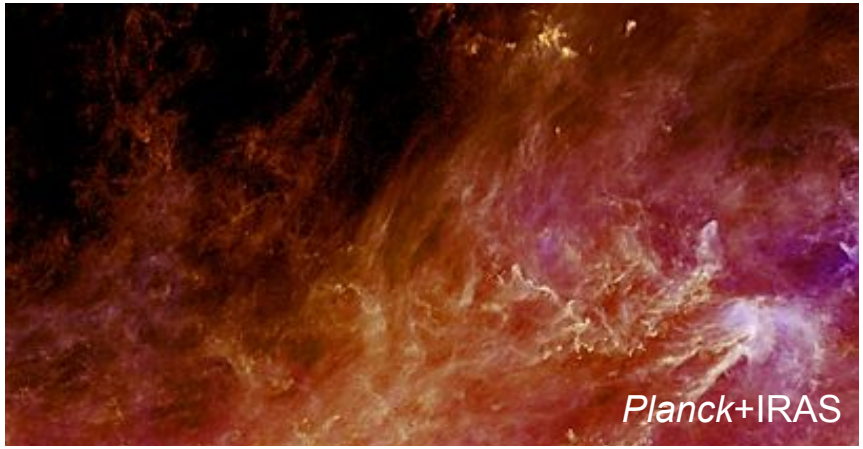


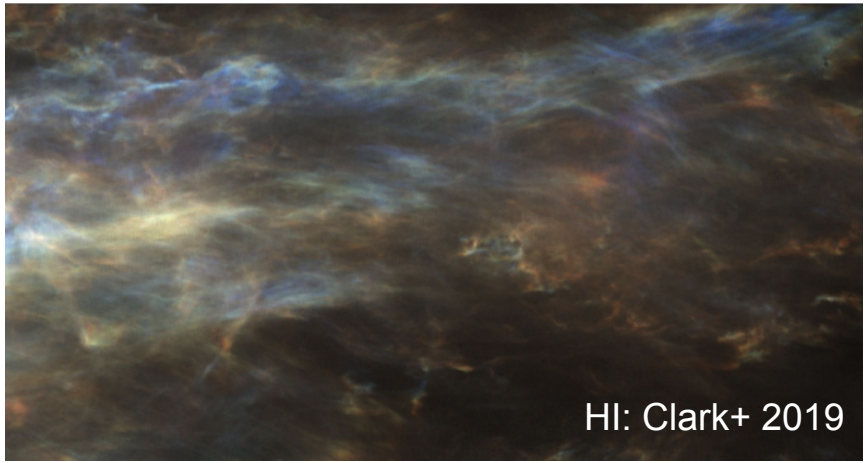


Planck 2015 X

How are dust and gas coupled on small angular scales?

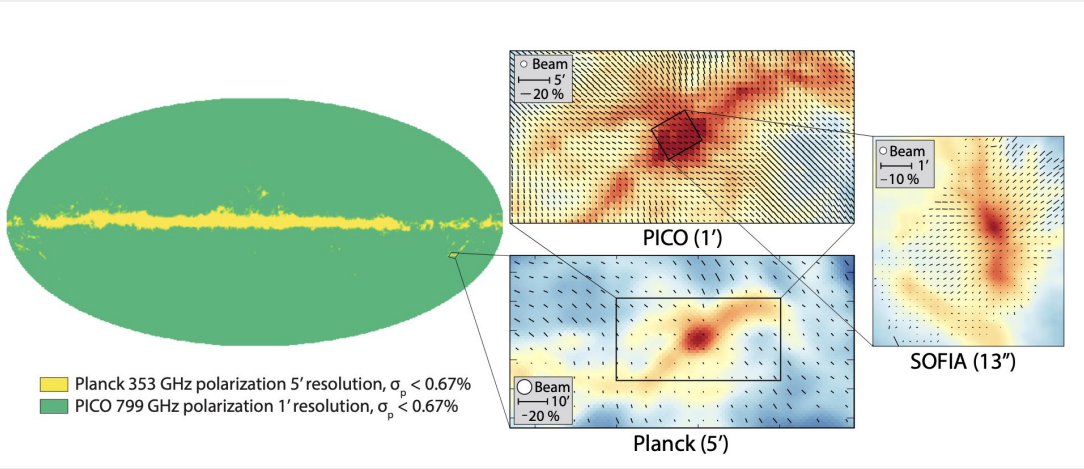
- Dust and gas are well-mixed on large scales
- High-resolution observations reveal that diffuse HI is organized into slender, filamentary structures
- Does the dust polarization structure behave similarly at small scales?





Magnetic Fields from Cold Cores to the ISM

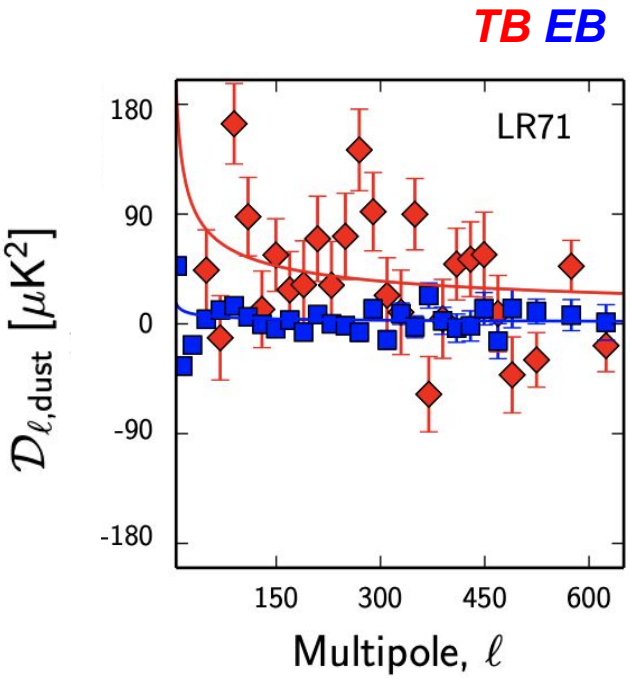
- The role of magnetic fields in the formation and fragmentation of molecular clouds is not well understood.
- CMB-S4 can resolve magnetic field structure from the diffuse ISM down to the core scale in molecular clouds (0.1 pc)



From the PICO proposal, arXiv:1902.10541

ISM Turbulence

- The interstellar medium is shaped by magnetohydrodynamic turbulence.
- Polarization power spectra and other metrics are sensitive to statistical properties of the density and magnetic fields.
- How can we use maps of the dust and synchrotron polarization to probe turbulence parameters?
- E.g.: Does the positive TB correlation extend to higher multipoles? What does this teach us about ISM physics?



Planck 2018 Results XI

Pan-Experiment Galactic Science Group

- A community effort to organize Galactic science with CMB experiments
- Pan-Experiment organization: open to members of CMB-S4, ACT, BICEP/Keck, CCAT-prime, LiteBIRD, SO, SPT.
  - If you are a member of another organization that would like to join as an affiliated experiment, please get in touch.
- Dedicated to Galactic science: all the topics mentioned here and beyond
- Organized by Susan Clark and Brandon Hensley
- Currently meeting weekly: Wednesdays at 9am PT / noon ET / 6pm CET
  - Weeks alternate between discussion of Galactic emission models and a ‘journal club’
- Join us! Simply fill out this brief form: https://forms.gle/E2vGobSpZWSr1PjT7

See also: Brandon Hensley’s fireslide