Galactic Science Opportunities with CMB-S4

Susan Clark & Brandon Hensley

CMB-S4 Collaboration Meeting
April 3-6, 2023

Diverse Galactic Science with CMB-S4

- Recent and ongoing work with Stage 3 experiments
- Important context from forecasting efforts for other next-generation experiments
- Science Book Second Edition to include Galactic Science

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The Simons Observatory: Galactic Science Goals and Forecasts

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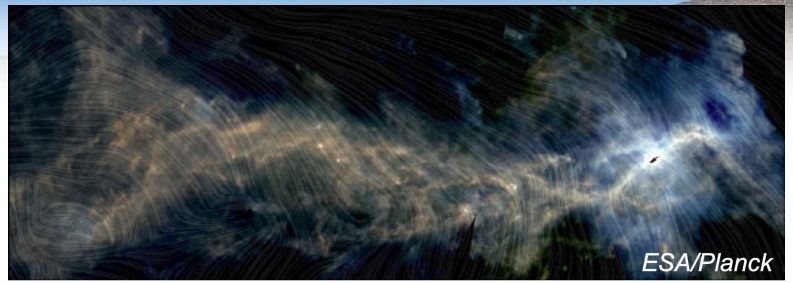
DOI: 10.1093/ptep/0000000000

Probing Cosmic Inflation with the LiteBIRD Cosmic Microwave Background Polarization Survey

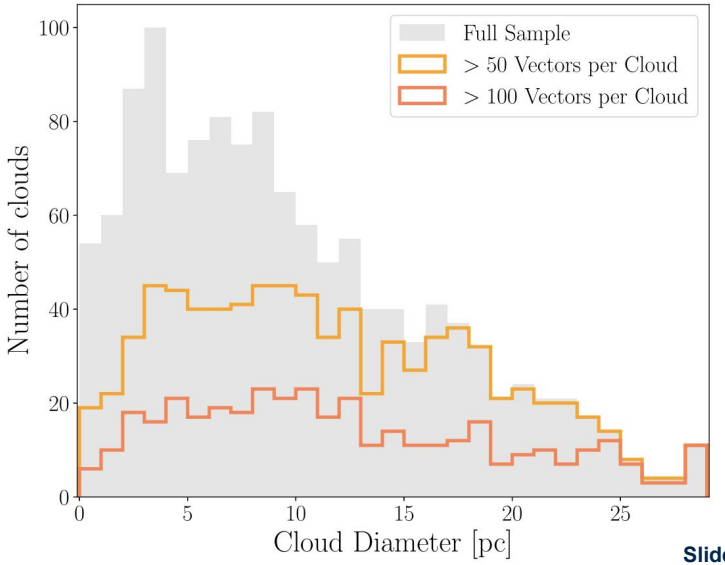
Magnetic Fields in Molecular Clouds



- The role of magnetic fields in the formation and evolution of molecular clouds is poorly understood
- CMB-S4 will measure magnetic fields at scales intermediate between Planck and ALMA
- 0.8′ angular resolution at 270 GHz corresponds to ~0.02 pc at a distance of 100 pc
- Molecular clouds span a range of masses, distances, inclination angles, etc: a statistical sample is critical

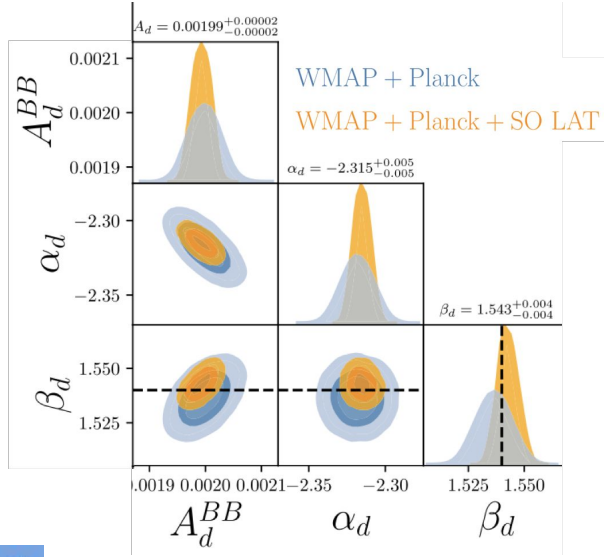
SO Forecast at 280 GHz

Hensley, Clark et al 2022

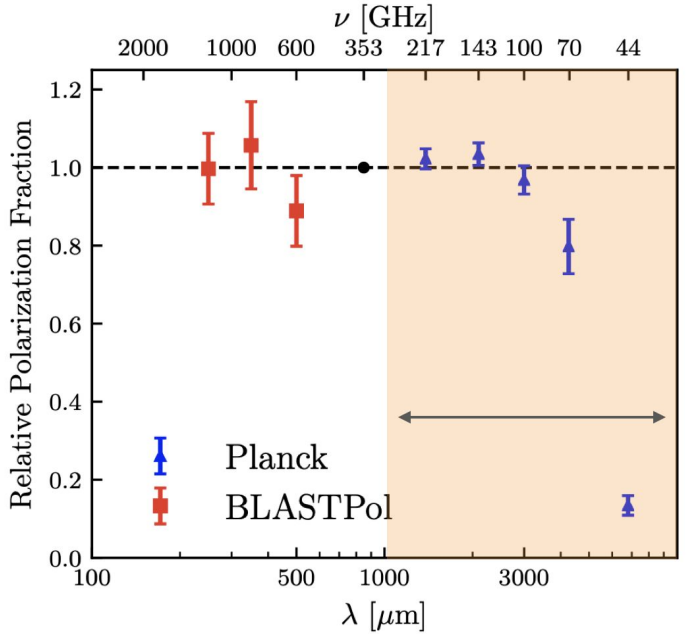


Dust SED science

- 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?
- Multi-frequency analyses and cross-correlation with starlight polarization will constrain dust properties



SO forecast in Hensley+ 2022, led by **Valentina Fanfani**

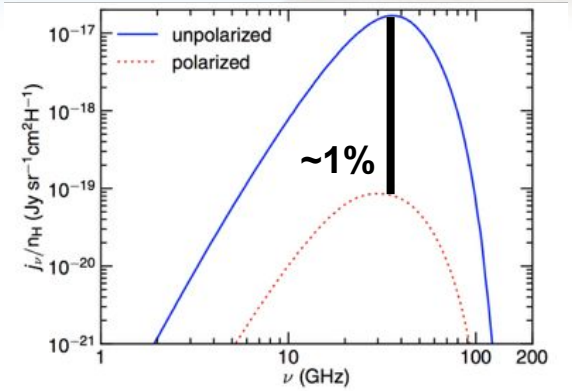


Hensley & Draine 2021

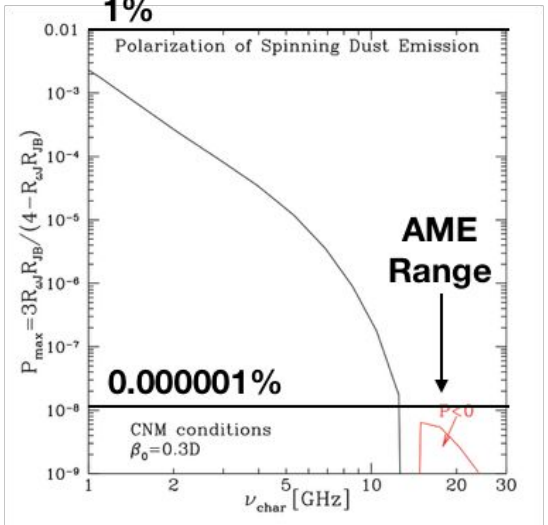
Anomalous Microwave Emission

- 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



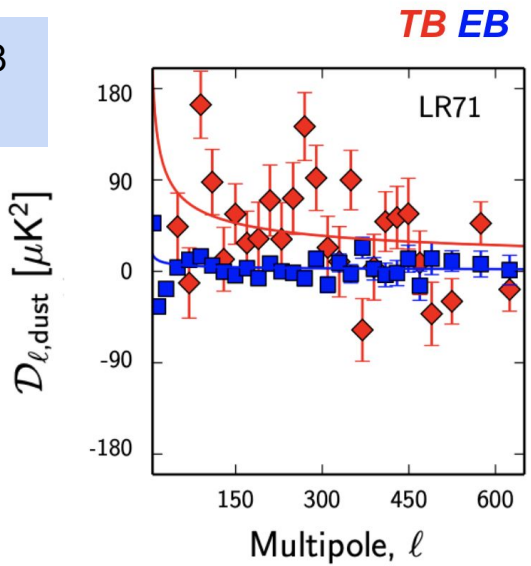
OR No polarization



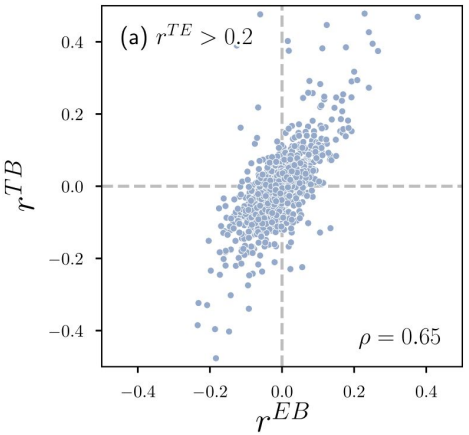
ISM Turbulence

- 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?

Planck 2018 Results XI



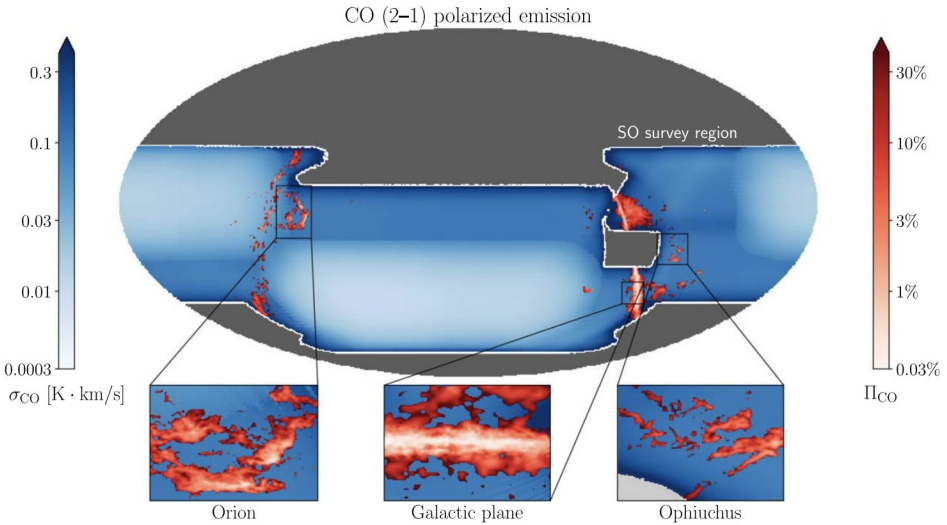
Clark+ 2021



See also:
Huffenberger+ 2020
Cukierman+ 2022

Additional Galactic Science

- Structure of the 3D ISM in conjunction with starlight polarization and 3D dust maps
- Synchrotron—dust correlation and constraints on the Galactic magnetic field
- Synchrotron SED science
- Small-scale dust polarization structure and correlation with gas tracers
- CO maps and polarization in molecular clouds
- Compact Galactic sources (e.g. Clancy, Puglisi, et al. 2023)
- New statistics for relating magnetic ISM observations to theory



SO Forecasts of CO polarization (Hensley+ 2022)

Discussion Questions

- Are there additional Galactic science opportunities?
- What unique science is enabled by CMB-S4?
  - Magellanic System and other Pole-specific targets
- What new science will be enabled by the combination of CMB-S4 and LiteBIRD?
  - What should we do now to prepare?

Guan+ 2021