

The Astronomer's Answer

Dust affects astronomical observations at nearly all wavelengths, from X-ray to the radio, and must be corrected for!

Breakthrough Starshot

- Build gram-scale probes complete with navigation and communication equipment, thrusters, etc.
- Build meter-sized and gram-mass light sails for probes
- Build array of lasers capable of achieving 100 Gigawatt power levels
- Accelerate *many* probes to $0.2c$ toward Alpha Cen– will arrive in 20 years

Why Study Dust?

Understanding interstellar dust is essential for a complete astrophysical and cosmological picture of the universe.

Dust Physics is Beautiful

- Spinning dust!
- Ferromagnetic dust!
- Quantum dust!

Inevitable Question

Why would **anyone** study dust?

Inevitable Question

Why isn't **everyone** studying dust?

Outline

- 1 Polarized dust emission as a CMB foreground
- 2 Using observations at other wavelengths to trace the dust

Emission Components

Synchrotron

$$I_\nu = A \left(\frac{\nu}{\nu_0} \right)^\beta$$

Free-free

$$I_\nu = A \left(\frac{\nu}{\nu_0} \right)^{-0.118}$$

Spinning Dust

$$I_\nu = A \left(\frac{\nu}{\nu_0} \right)^2 \exp \left[1 - (\nu/\nu_{\text{pk}})^2 \right]$$

Single Pixel Paradigm

- 1 Work with one realization of all non-dust components in the microwave sky
- 2 Employ a suite of dust models encompassing a range of dust physics
- 3 Employ a suite of mock instruments measuring in seven log-spaced frequency bins

$$\nu_{\min} = \{15, 20, 25, 30, 35, 40\} \text{ GHz}$$

$$\nu_{\max} = \{300, 400, 500, 600, 700, 800\} \text{ GHz}$$

Single Pixel Paradigm

- 1 Work with one realization of all non-dust components in the microwave sky, set to representative amplitudes and SEDs
- 2 Employ a suite of dust models encompassing a range of dust physics
- 3 Employ a suite of mock instruments measuring in seven log-spaced frequency bins
- 4 Add noise based on forecasts for next-generation CMB experiments (100 realizations)
- 5 Perform component separation

Implications for CMB

- First task: mask areas where magnetic field changes dramatically along line of sight (e.g. overlapping clouds)
- More ambitious: work out 3D magnetic field geometry!
- Opens new windows into interstellar turbulence, coupling of B-fields to structures, connection between optical and FIR dust polarization, cosmic ray propagation...

