CMBP Galactic Science

Introductory Materials

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Mission Team is studying two options/parts

- Imager: Multi-frequency focal plane. Starting point: EPIC-IM (from previous decadal survey)
- Spectrometer: A Fourier-transform Spectrometer based on the PIXIE design (but larger)

EPIC-IM

Table 3.2 EPIC-IM Bands and Sensitivities

Freq [GHz]	θ_{FWHM} [′]	4 K Telescope Option					30 K Telescope Option				
		N_{bol}[a] [#]	NET [μK√s] bolo[b]	NET [μK√s] band[c]	$w_p^{-1/2}$ [μK-′][d]	δT_{pix}[e] [nK]	N_{bol}[a] [#]	NET [μK√s] bolo[b]	NET [μK√s] band[c]	$w_p^{-1/2}$ [μK-′][d]	δT_{pix}[e] [nK]
30	28	84	84	9.2	14	83	24	83	17	26	150
45	19	364	71	3.7	5.7	34	84	70	8	12	69
70	12	1332	60	1.6	2.5	15	208	60	4.1	6.4	37
100	8.4	2196	54	1.1	1.8	10	444	55	2.6	4.0	24
150	5.6	3048	52	0.9	1.4	8	516	57	2.5	3.8	23
220	3.8	1296	59	1.6	2.5	15	408	77	3.8	5.8	34
340	2.5	744	100	3.7	5.6	33	120	220	20	30	180
500	1.7	1092	350	10	16 (140)[f]	8[g]	108	1500	170	260 (2000)[f]	140[g]
850	1.0	938	15000	280	740 (70)[f]	7[g]	110	250k	24k	40k (3000)[f]	340[g]
Total[h]		**11094**		**0.6**	**0.9**	**5.4**	**2022**		**1.5**	**2.3**	**13**

[a]Two bolometers per focal plane pixel

[b]Sensitivity for a single bolometer to CMB temperature

[c]Sensitivity combining all bolometers in a band

[d]$[8\pi\ NET_{bolo}^2/(T_{mis}\ N_{bol})]^{1/2}(10800/\pi)$

[e]Sensitivity δT_{CMB} in a 2° x 2° pixel

[f]Point source sensitivity in μJy (1σ) per beam without confusion

[g]Surface brightness sensitivity in Jy/sr in a 2° x 2° pixel (1σ)

[h]Combining all bands together

Dust Sensitivities (EPIC-IM)

Table 1.2. Sensitivity of EPIC and Planck to Polarization of Galactic dust.

Mission	Band	Angular Resolution arcmin FWHM	σ(Q) kJy/sr/beam	polarization depth A_V
Planck	350 GHz	5	24	4
EPIC	500 GHz	2	0.9	0.06
EPIC	850 GHz	1	0.7	0.01

The right column shows the minimum column density of dust, measured in visual wavelength optical depth A_V, for which a mission makes accurate polarization measurements.

PIXIE Parameters

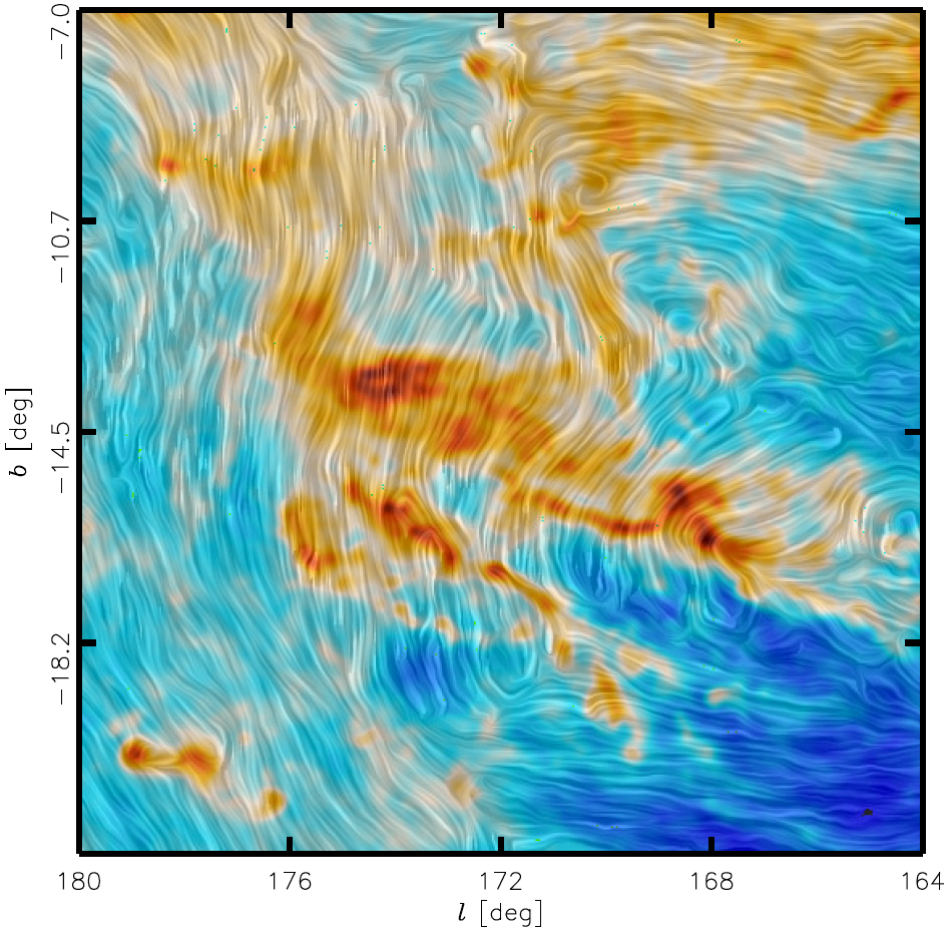
Angular Resolution	2.6 degrees
Frequency Coverage	30-6000 GHz
Frequency Resolution	15 GHz

Science Questions:

1) The Role of Magnetic Fields in Star Formation
2) Magnetic Fields/Turbulence in the Diffuse ISM
3) Properties of Dust grains/grain alignment
4) Magnetic fields in nearby galaxies
5) Other topics?

Magnetic Fields in Star Formation

- Planck resolution: 10 arcmin in most molecular clouds
- CMB Probe: 1 to 2.5 arcmins
- Questions:
  - What linear scales do we need to resolve?
    - 2.5 arcmin resolution ~ 0.1 pc @150 pc distance.

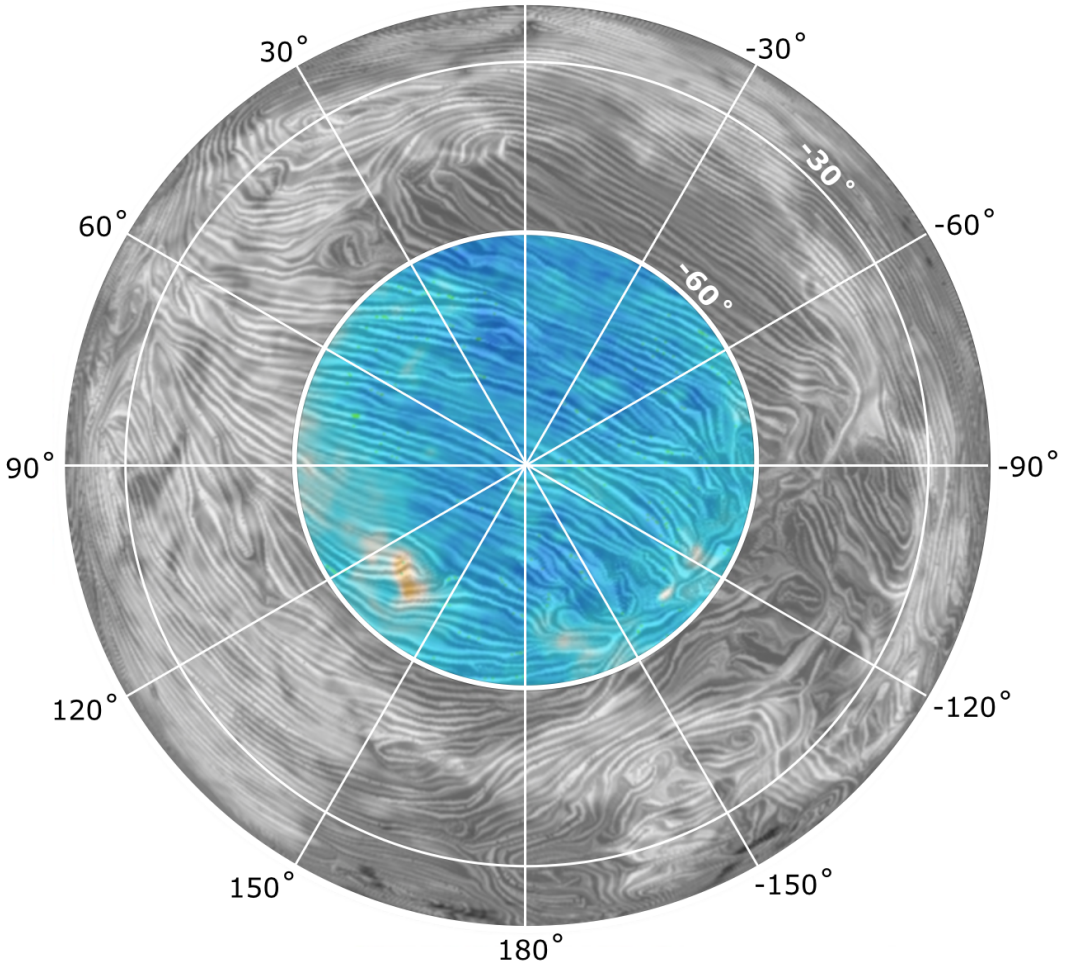


Planck Int XXXV (2016)
LIC image of the magnetic field in Taurus at 353 GHz with 10 arcmin resolution

Magnetic Fields and Turbulence in the Diffuse ISM

- Planck Resolution: 10 arcmin to 1 degree
- Questions:
  - What dust column sensitivity level/resolution do we need?
  - Is this science likely to be achieved by ground-based optical/near-IR polarimeters before CMB probe launches?

Planck 353 GHz magnetic field map of the Southern Galactic Cap with 1 degree resolution



Dust Polarization Spectra

- Questions:
  - What spectral coverage do we need?
  - What predictions from dust models/alignment models can we test?

Gandilo et al. 2016 BLASTPol Polarization Spectrum of Vela C:

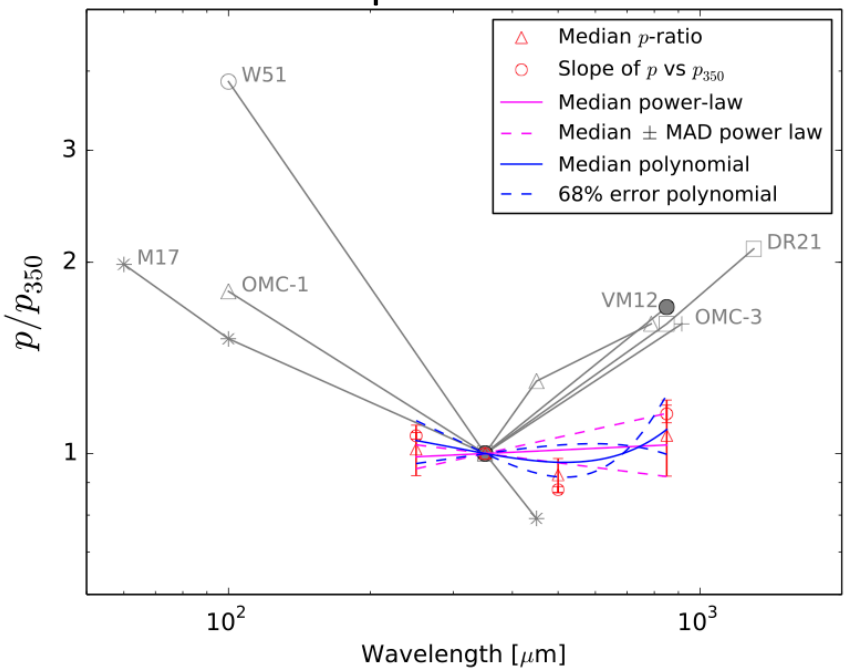


Figure 4. Polarization spectra from previous work (gray), with new Vela C data added (colors). Points at 850 μm separated horizontally for clarity. W51, OMC-1 p_{100}/p_{350}, and DR21 p_{1300}/p_{350} from Vaillancourt (2002). All previous measurements of p_{850}/p_{350} from Vaillancourt & Matthews (2012). The solid circle represents their median ratio for 15 clouds. OMC-1 p_{450}/p_{350} from Vaillancourt et al. (2008). M17 from Zeng et al. (2013). Red triangles are median polarization ratios with MAD error bars. Red circles are best-fit slopes to scatter plots of p/p_{350}. Magenta lines are spectra using the power-law fit parameters, and blue lines are spectra using the second-order polynomial fit parameters. Solid lines use the median values of the fit parameters and dashed lines reflect the distribution in the fit parameters (see the text).

Other “Galactic” Science Cases

- Tracing magnetic fields in nearby Galaxies?

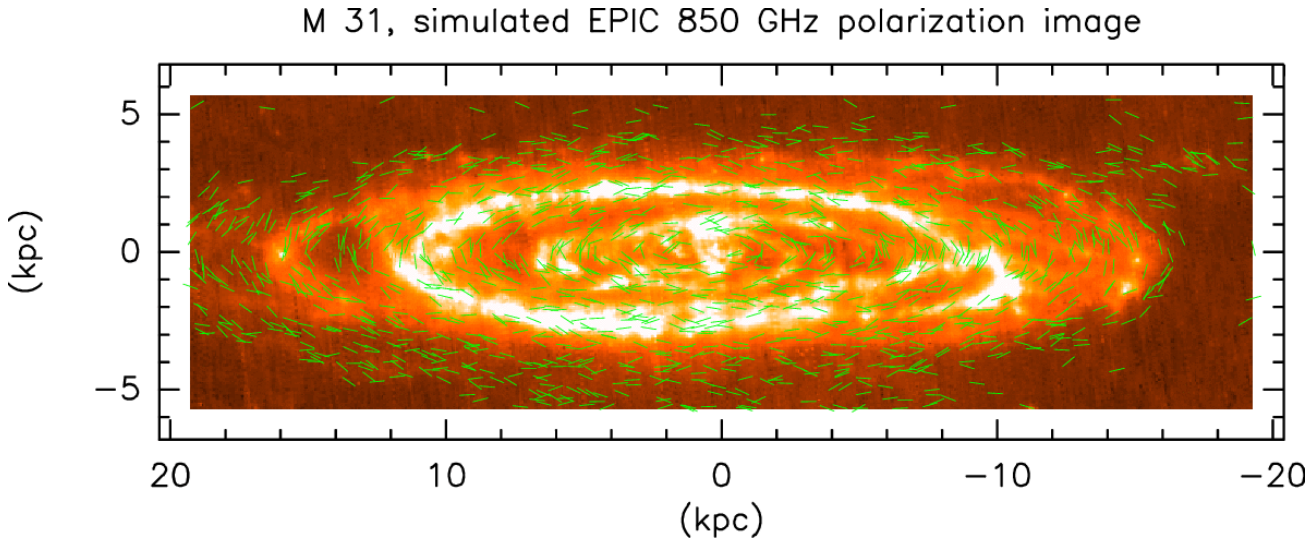


Fig. 1.9. Simulated dust polarization map of the Andromeda Galaxy with EPIC. The color scale shows Spitzer 160 μm emission [80], which has about the same resolution as EPIC at 850 GHz. Randomized green magnetic field vectors are shown where EPIC has enough sensitivity to detect polarization with accuracy $\sigma_P < 0.3\%$; for clarity, only one vector per 5 resolution elements is shown. No instrument in the field or in development has the sensitivity and resolution to map dust emission polarization for other spiral galaxies, until EPIC.

(Figure taken from the EPIC proposal https://zzz.physics.umn.edu/_media/groups/ipsig/epic-im-report.pdf)