

COSMOG - Cosmology Oriented Sub-mm Modeling Of Galactic foregroundsA. Kashlinsky¹ and D. Leisawitz²¹SSAI, Code 685, Goddard Space Flight Center, Greenbelt, MD 20771² Code 630, Goddard Space Flight Center, Greenbelt, MD 20771

With upcoming missions in mid- and far-IR there is a need for software packages to reliably simulate the planned observations. This would help in both planning the observation and scanning strategy and in developing the concepts of the far-off missions. As this workshop demonstrated, many of the new missions are to be in the far-IR range of the electromagnetic spectrum and at the same time will map the sky with a sub-arcsec angular resolution.

We present here a computer package for simulating foreground maps for the planned sub-mm and far-IR missions, such as SPECS (Leisawitz et al 2002). The package allows to study confusion limits and simulate cosmological observations for a specified sky location interactively and in real time. Most of the emission at wavelengths long-ward of $\sim 50\mu\text{m}$ is dominated by Galactic cirrus and Zodiacal dust emission. Stellar emission at these wavelengths is weak and is for now neglected. Cosmological sources (distant and not-so-distant) galaxies for specified cosmologies will be added later.

Briefly, the algorithm goes through the following steps:

- A template map at $100\ \mu\text{m}$ and IRAS angular resolution ($\sim 6'$) uses the data of the Galactic dust emission from Schlegel, Finkbeiner & Davis (1998, hereafter SFD). The maps are based on the SFD detailed reanalysis of COBE/DIRBE and IRAS datasets.

The templates serve to normalize the to-be-observed region of the sky to IRAS data for the cirrus emission at $100\ \mu\text{m}$. IRAS data are pixelized with $2.37' \times 2.37'$ pixels and the beam FWHM is $6.1'$. The extra- and inter-polation will be to the required angular scales and wavelengths.

- The user can then specify the following parameters for the output maps:

1. the required angular resolution (an interferometer baseline or a filled-aperture diameter);

2. the required pixelization;
3. the requested sky location or Galactic (b, l) coordinates;
4. the field of view;
5. the wavelength of the observation; and
6. an option to add the zodiacal light component for the desired solar elongation.

- The extrapolation to the requested wavelength is done using the template Galaxy spectrum from Fixsen et al (1998). The Galaxy spectrum is essentially a dust modified black body of $T_{\text{dust}} \sim 20\text{K}$ and the emissivity index $\alpha \simeq -1.7$.

- The zodiacal light spectrum and intensity is taken from COBE DIRBE data (Hauser et al 1998). It is evaluated at the specified Solar elongation angle and wavelength using inter/extrapolation of the the DIRBE zodiacal emission model (Kelsall et al 1998). The angular structure of the zodiacal light emission is not modeled as it is expected to be very small.

- The smaller scale structure of the Galactic cirrus is then generated using Fast Fourier Transforms (FFT) normalized to the coarser IRAS/DIRBE maps.

First the power spectrum of the IRAS sky in the vicinity of the chosen sky location is evaluated. Cirrus is extrapolated to smaller angular scales assuming Gaussian random process and using the spatial spectral index specified by the user. The spectral index indicated by the current observations is $n \sim -2 - 3$ (Gautier et al 1998). The angular structure of the simulated field is normalized to the IRAS power spectrum and large-scale harmonics from the IRAS sky are kept on the relevant angular scales modified by the coupling matrix resulting from transition from coarser IRAS resolution to the user requested pixels.

- The program computes the confusion noise parameters with and without the zodiacal component in the given direction and produces maps with the specified angular resolution and pixelization.

- For a 512×512 pixel field of view the maps are generated in only $\sim 1 - 2$ secs CPU time on

a 300 MHz computer.

Fig. 1 shows the histogram of the 512×512 pixels patch in the Galactic plane ($b_{\text{Gal}} = 1^\circ, l_{\text{Gal}} = 1^\circ$). The size of the pixel is $\simeq 0.3^\circ$. No zodiacal component has been added and the slope of the cirrus power spectrum was chosen to be $n = -2$. The emission has been “observed” by a SPIRIT-like instrument (interferometer baseline of 30 meters) at $\lambda = 100\mu\text{m}$.

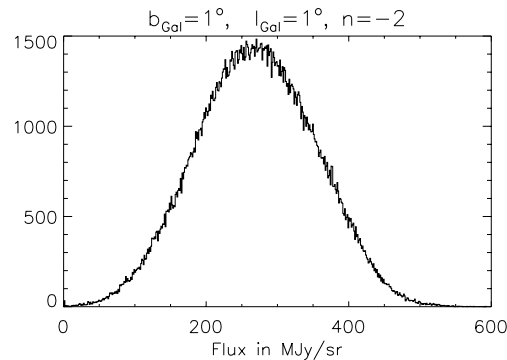


Fig. 1.—

Figure 2 shows the maps of putative observations by SPIRIT instruments of 3 patches at different Galactic locations assuming different slopes of the small scale cirrus power spectrum. The middle panels have Zodiacal component added at Solar elongation $e_{\odot} = 119^\circ$, the maximal in that direction.

Figure 3 illustrates the dependence on the wavelength of observation for $n = -2.5$ and Galactic patch of 512×512 $0.3''$ square pixels at $(b_{\text{Gal}}, l_{\text{Gal}}) = (-45^\circ, 150^\circ)$. The interferometer resolution is $\simeq 1.2 \text{baseline} / \lambda$ and the longer wavelengths will have super-arcmin resolution even with SPIRIT.

Finally Figure 4 shows the dependence on the baseline of the interferometer for observations at $\lambda = 1 \text{ mm}$ and assuming $n = -2.5$. Clearly the higher resolution of SPECS would be better for observations in the presence of Galactic confusion.

REFERENCES

Hauser, M. et al 1998,Ap.J.,508,25

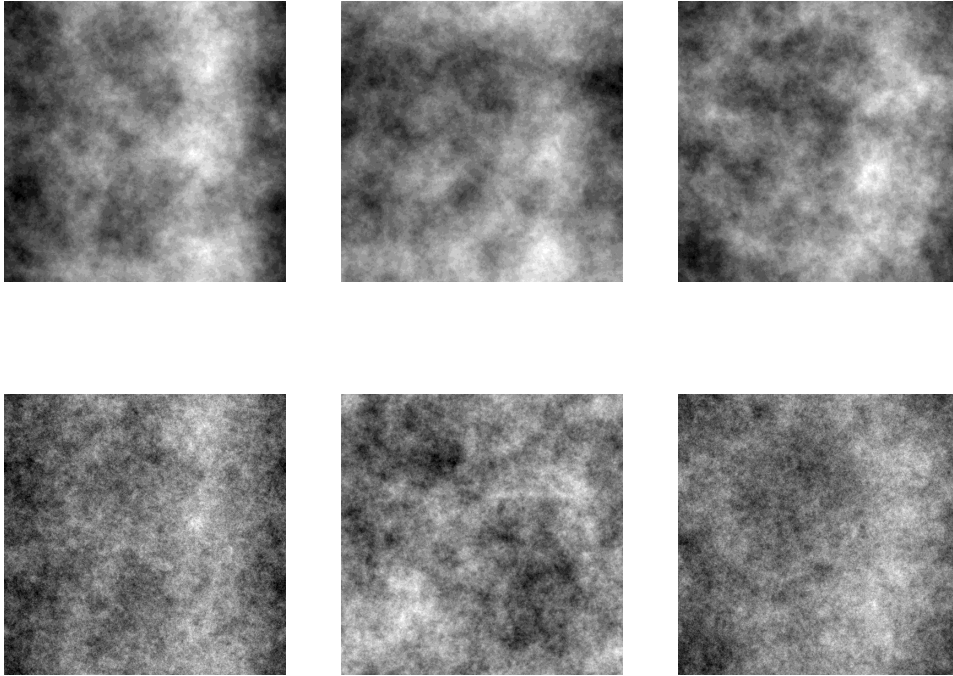


Fig. 2.— Top panels correspond to $n = -3$ and lower panels to $n = -2$. The panels from left to right correspond to $(b_{\text{Gal}}, l_{\text{Gal}}) = (1^\circ, 1^\circ), (1^\circ, 100^\circ), (80^\circ, 200^\circ)$.

Gautier, T.N. et al. 1992, *AJ*, 103, 1313

Kelsall, T. et al. 1998, *Ap.J.*, 508, 44

Leisawitz, D. et al. 2002, astro-ph/0202085

Schlegel, D. J., Finkbeiner, D. P. & Davis, M. 1998, *Ap.J.*, 500, 525 (SFD)

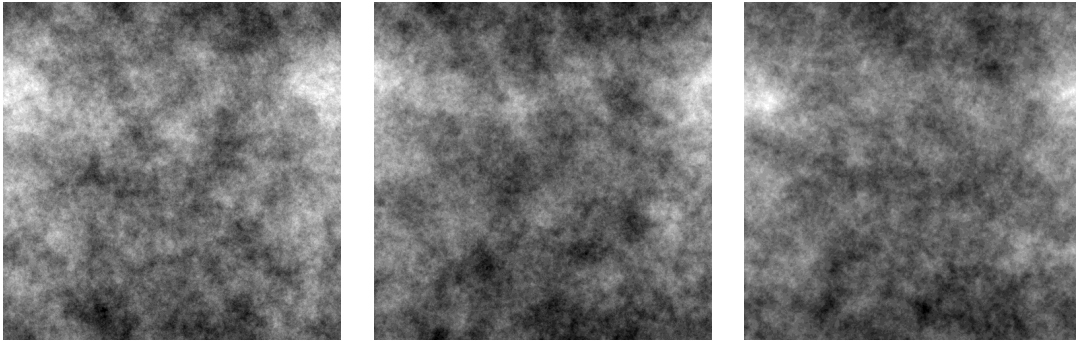


Fig. 3.— Same patch with $n = -2.5$ but observed with SPIRIT at 100, 500 and 1000 μm from left to right.

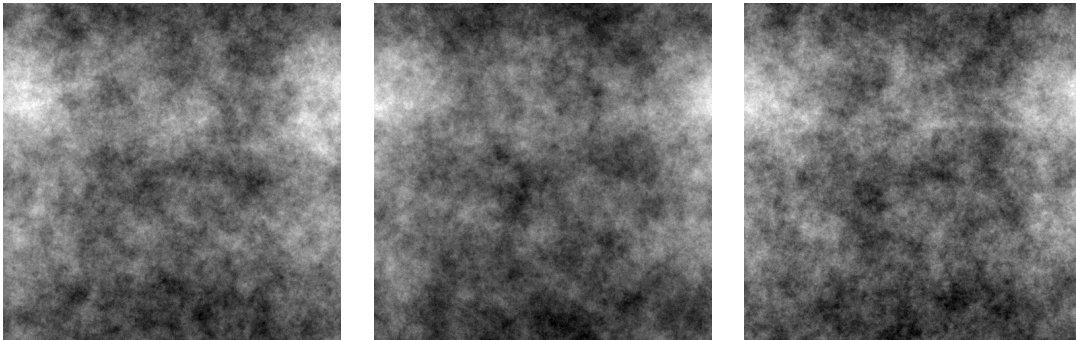


Fig. 4.— Same patch “observed” with space interferometer with baseline = 100, 300, 1000 meters from left to right.

APPENDIX

Below are shown examples of the IDL procedure interface and results of the runs:

IDL

```
>.r cosmog Background data files must be loaded ONLY in the first IDL run
```

```
Were the background data files file loaded? Yes/No - y
```

```
Were the background data files file loaded? Yes/No - y
```

```
choose Galactic latitude of your area: bgal = -85
```

```
choose Galactic longitude of your area: lgal = 10
```

```
enter wavelength in micron: lambda = 100
```

Would you like to add zodiacal component to Galactic cirrus? Yes/No - n

Default map shows a square patch FOV of N=4 on the side - i.e. 4x4 IRAS pixels (50.55 arcmin²)

Would you like to change it? Type: Yes/No - y

Choose the new N (must be power of 2): 16

Choose to use either filled aperture telescope or interferometer

Is it interferometer? Yes/No - ? y

SPIRIT is the default baseline (30 m) or 3.44*lambda(mm) arcsec resolution

Would you like to change it? Type: Yes/No - n

Your resolution is: 0.343775 arcsec

Default is Npix=512 pixels per FOV: i.e. pixel = (4.44375 arcsec)²

Would you like to change it? Type: Yes/No - y

Choose the Npix from [...64,128,256,512...] (CPU time goes like Npix ln Npix) 128

Your new pixel = (17.7750 arcsec)²

choose cirrus spectral index (-3 < ns < -2) ns = -2.

The maximal, minimal, mean and median flux values are =

Fmax = 0.061137522 MJy/sr

Fmin = 0.042085866 MJy/sr

Fmedian = 0.0515721 MJy/sr

Fmean = 0.051615465 MJy/sr

Fzodi = 0.000000 MJy/sr

mean Fcirrus = 0.92955385 MJy/sr

$\sigma_F = 0.0030275102 \text{ MJy/sr}$

Specify window number for histogram: $nw = 3$

The default values for flux in the map are F_{max} , F_{min}

Would you like to change the flux limit in the map? Yes/No - nb

Default map is always shown as (512,512) array.

Specify window number for 512x512 map: $nw = 4$

Would you like to show the map in log? Yes/No - n