Modeling Dust and Starlight in Galaxies Observed by Spitzer and Herschel: NGC 0628 and NGC 6946.

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Abstract

Physical models for interstellar dust are presented for NGC 0628 and NGC 6946, two quite different galaxies observed by the IRAC and MIPS cameras on Spitzer Space Telescope, and the PACS and SPIRE cameras on Herschel Space Observatory. With wavelength coverage from 3.6μm to 500μm the dust models are strongly constrained. For each pixel in each galaxy we estimate (1) the surface density of dust, (2) the fraction of the dust mass contributed by PAHs, and (3) the distribution of intensities of starlight heating the dust grains, and (4) the IR luminosity originating in regions with high starlight intensity. We obtain total dust masses for each galaxy. The overall dust/H mass ratio in each galaxy is 0.010, consistent with what is expected based on the near-solar metallicities.

Dust Model

The present study makes use of combined imaging by Spitzer Space Telescope and Herschel Space Observatory, covering wavelengths from 3.6 to 500, to produce well-resolved maps of the dust in nearby galaxies. The present study is focused on two galaxies, NGC 628 and NGC 6946, as examples to illustrate the methodology. Future work will extend this to all 61 galaxies in the KINGFISH sample.

The natural PSFs to use are those of the PACS160μm, SPIRE250μm, SPIRE350μm, SPIRE500μm, and MIPS160μm cameras, as well as Gaussian PSFs with FWHM in the range 12 - 50. For a given outgoing PSF, only a subset of cameras may be transformed into it safely (i.e, those cameras with FWHM smaller than the outgoing PSF), and we proceed to investigate the most reasonable compatible camera combinations, considering the tradeoff between: (1) angular resolution and (2) availability of long-wavelength data to constrain the dust models.

We employ the dust model of Draine et al. (2007) using "Milky Way" size distributions that reproduce the wavelength-dependent extinction in diffuse regions within a few kpc of the Sun.

For each pixel j, we find the model of dust and starlight that best reproduces the observed SED, within the modeling scheme described by Draine et al. (2007).

The starlight heating intensities in pixel j are characterized by four parameters: γ_j, $U_{\mathrm{min},j}$, U_{max}, and α_j, where the dust mass dM_{d} heated by starlight intensities in $(U, U+dU)$ is

$$\left(\frac{dM_{\mathrm{d}}}{dU}\right)_j = (1-\gamma_j)M_{\mathrm{d},j}\delta(U-U_{\mathrm{min},j})$$

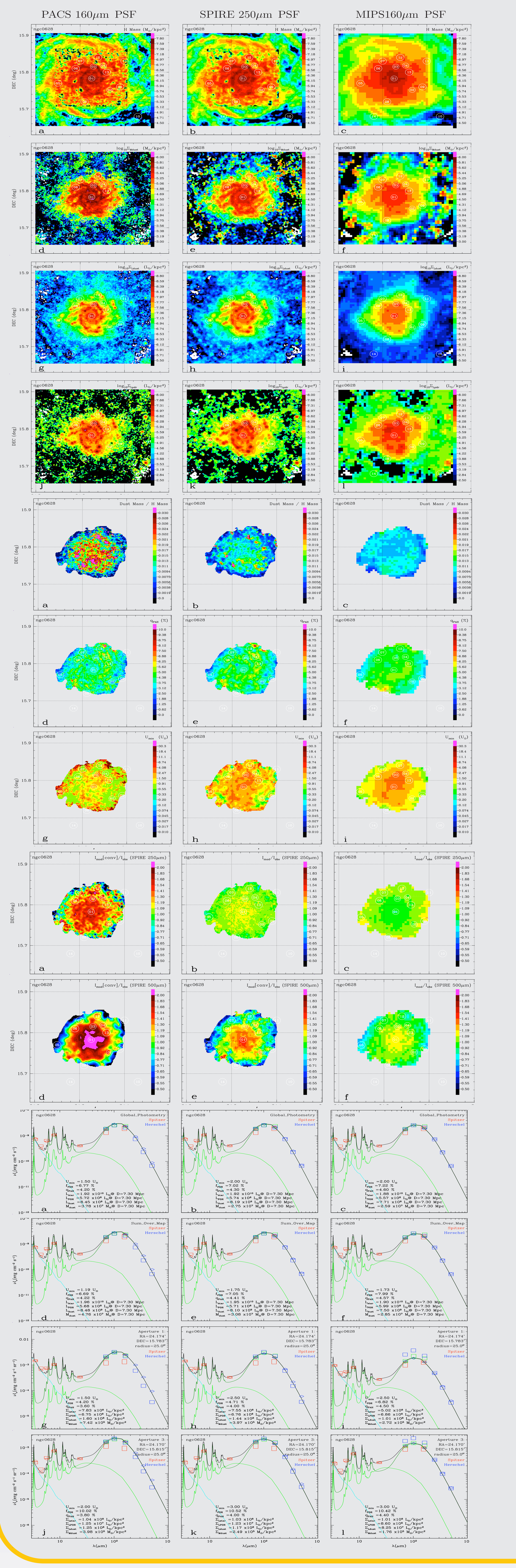
$$+\gamma_j M_{\mathrm{d},j}\frac{(\alpha_j-1)U^{-\alpha_j}}{U_{\mathrm{min},j}^{1-\alpha_j}-U_{\mathrm{max}}^{1-\alpha_j}} \quad \text{for } U_{\mathrm{min},j} \le U \le U_{\mathrm{max}}.$$

Thus a fraction $(1-\gamma_j)$ of the dust mass in pixel j is assumed to be heated by starlight with intensity $U = U_{\mathrm{min},j}$, with the remaining fraction γ_j exposed to a distribution of starlight intensities between $U_{\mathrm{min},j}$ and U_{max}.

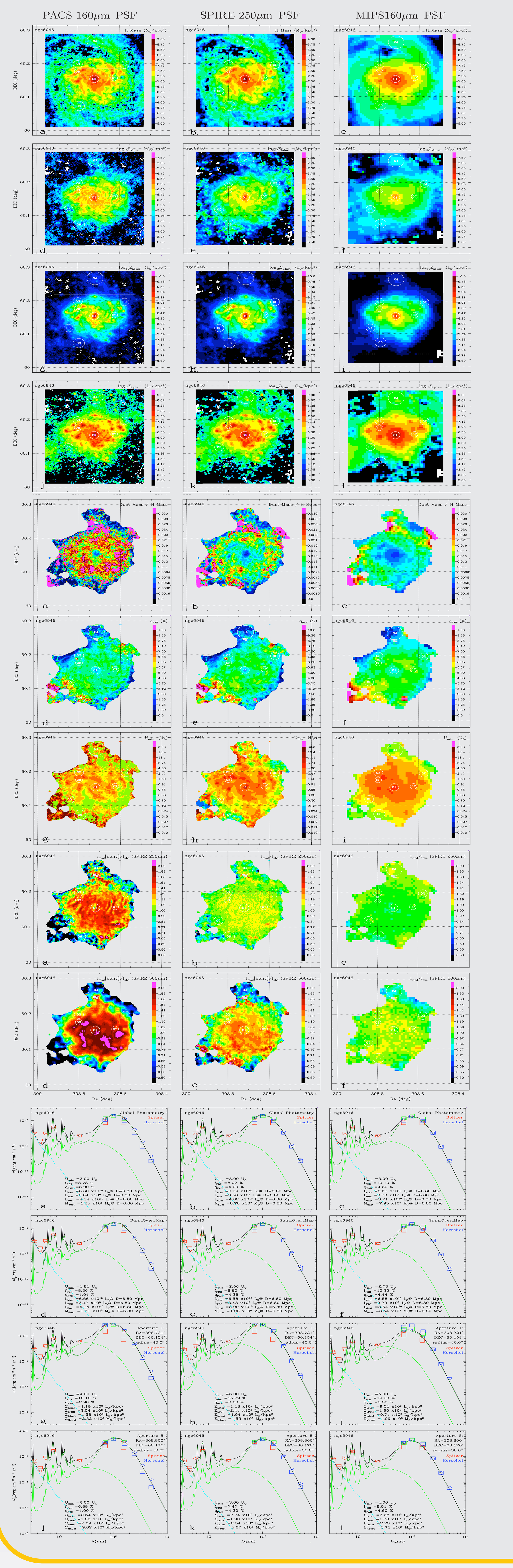
The limits on adjustable parameters are:

Parameter	min	max	comments
$\Omega_\star$	0	∞	nonnegative
M_{d}	0	∞	nonnegative
q_{PAH}	0.00	0.10	in steps $\Delta q_{\mathrm{PAH}} = 0.001$
γ	0.0	1.00	nonnegative
U_{min}	0.7	30	when $\lambda_{\mathrm{max}} = 160\mu$m
	0.07	30	when $\lambda_{\mathrm{max}} = 250\mu$m
	0.01	30	when $\lambda_{\mathrm{max}} = 350\mu$m
	0.01	30	when $\lambda_{\mathrm{max}} \ge 500\mu$m
U_{max}	10^6	10^6	(not adjusted)
α	2.0	2.0	(not adjusted)

NGC0628



NGC6946



References

[1] Aniano, G., Draine, B., KINGFISH team, in prep., and references therein...