The Relations Among 8, 24, and 160 μm Dust Emission within Nearby Galaxies

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Abstract

We investigate the relations among the stellar continuum-subtracted 8 μm polycyclic aromatic hydrocarbon (PAH 8 μm) emission, 24 μm hot dust emission, and 160 μm cold dust emission in fifteen nearby face-on spiral galaxies in the Spitzer Infrared Nearby Galaxies Survey sample. The relation between PAH 8 and 24 μm emission measured in ~2 kpc regions is found to exhibit a significant amount of scatter, and strong spatial variations are observed in the (PAH 8 μm)/24 μm surface brightness ratio. However, PAH 8 μm emission is found to be well-correlated with 160 μm emission on spatial scales of ~2 kpc, and the (PAH 8 μm)/160 μm surface brightness ratio is generally observed to increase as the 160 μm surface brightness increases. These results suggest that the PAHs are associated with the diffuse, cold dust that produces most of the 160μm emission in these galaxies, and the variations in the (PAH 8 μm)/160 μm ratio may generally be indicative of either the intensity or the spectrum of the interstellar radiation field that is heating both the PAHs and the diffuse interstellar dust.

Introduction

We have two major goals in this project:

- We want to follow-up results from *Spitzer* that show scatter in the relation between PAH 8 μm emission and 24 μm warm dust emission (e.g. Helou et al. 2004; Dale et al. 2005; Calzetti et al. 2005, 2007; Bendo et al. 2006)
- We want to more closely examine the correlation between PAH 8 μm emission and cold dust emission found by Haas et al. (2002) and Bendo et al. (2006).

We used two approaches to examine these issues in a set of 15 face-on spiral galaxies from the SINGS sample:

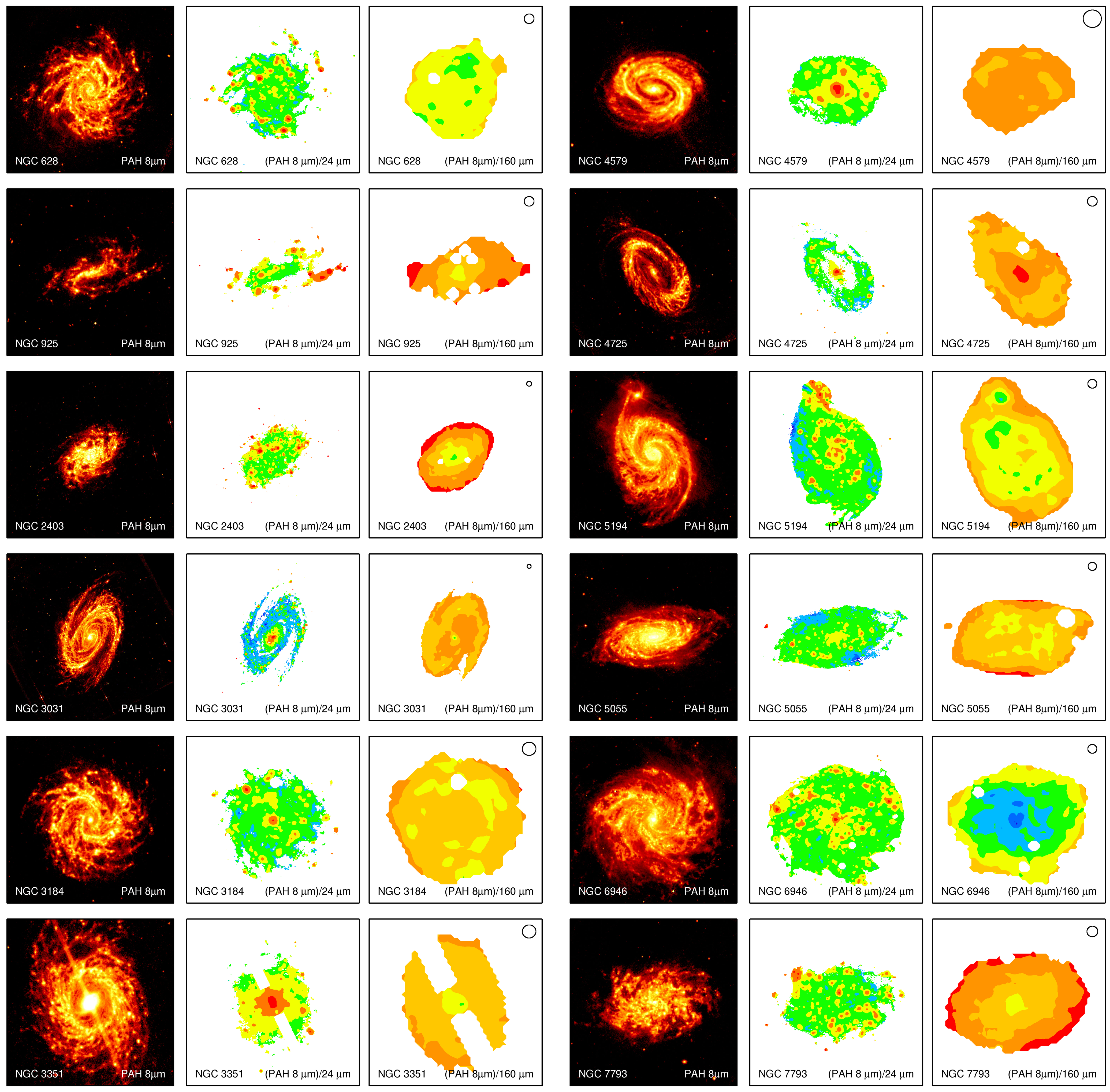
- We created ratio maps of the (PAH 8 μm)/24 μm and (PAH 8 μm)/160 μm ratios where the resolutions of the data were all matched to each other.
- We matched the resolution of all data to the resolution of the 160 μm data, divided the galaxies into 45″ square regions (which correspond to spatial scales of ~2 kpc), and measured flux densities in these regions. We then examined how the (PAH 8 μm)/24 μm and (PAH 8 μm)/160 μm ratios varied as a function of infrared surface brightness.

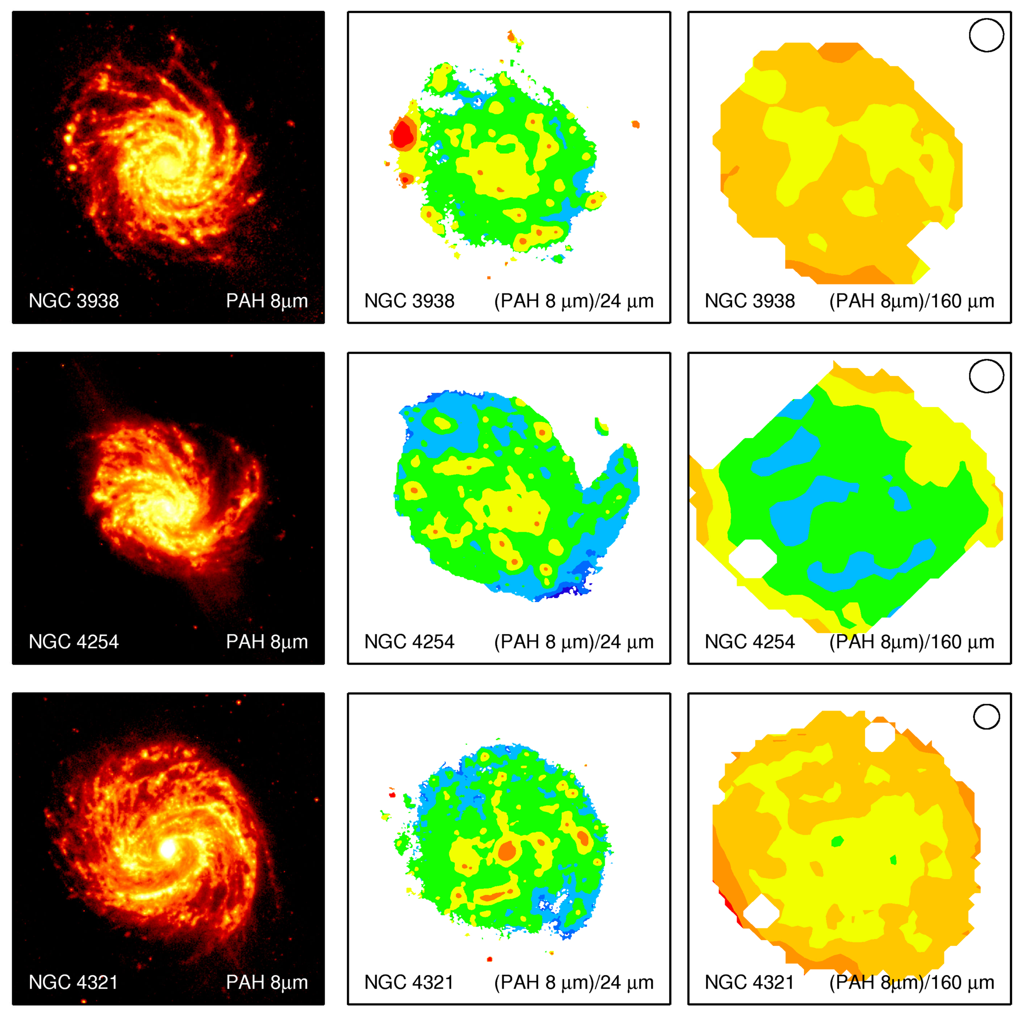
Results

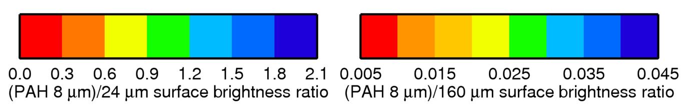
- The significant scatter between the (PAH 8 μm)/24 μm ratio and 24 μm surface brightness and the wide variations in the slope of the relation from galaxy to galaxy both suggest that PAH 8 μm emission is poorly correlated with 24 μm warm dust emission. This suggest that PAH 8 μm emission is inhibited in star-forming regions and other infrared-bright regions.
- The tight correlation between the (PAH 8 μm)/160 μm ratio and 160 μm surface brightness indicates that PAH 8 μm emission is associated with cold dust on scales of ~2 kpc. The results also suggest that the (PAH 8 μm)/160 μm ratio itself may be indicative of the intensity of the radiation field that heats the cold dust.
- Although the (PAH 8 μm)/160 μm ratio also appears correlated with galactocentric radius, the correlation between the ratio and 160 μm surface brightness is stronger. Moreover, the presence of large scale structures in the (PAH 8 μm)/160 μm ratio maps suggests that the ratio depends more strongly on surface brightness than radius.
- The (PAH 8 μm)/24 μm and (PAH 8 μm)/160 μm radial gradients are uncorrelated with metallicity gradients, which suggests that the variations in PAH 8 μm emission relative to warm or cold dust is not driven by metallicity in these galaxies.

References

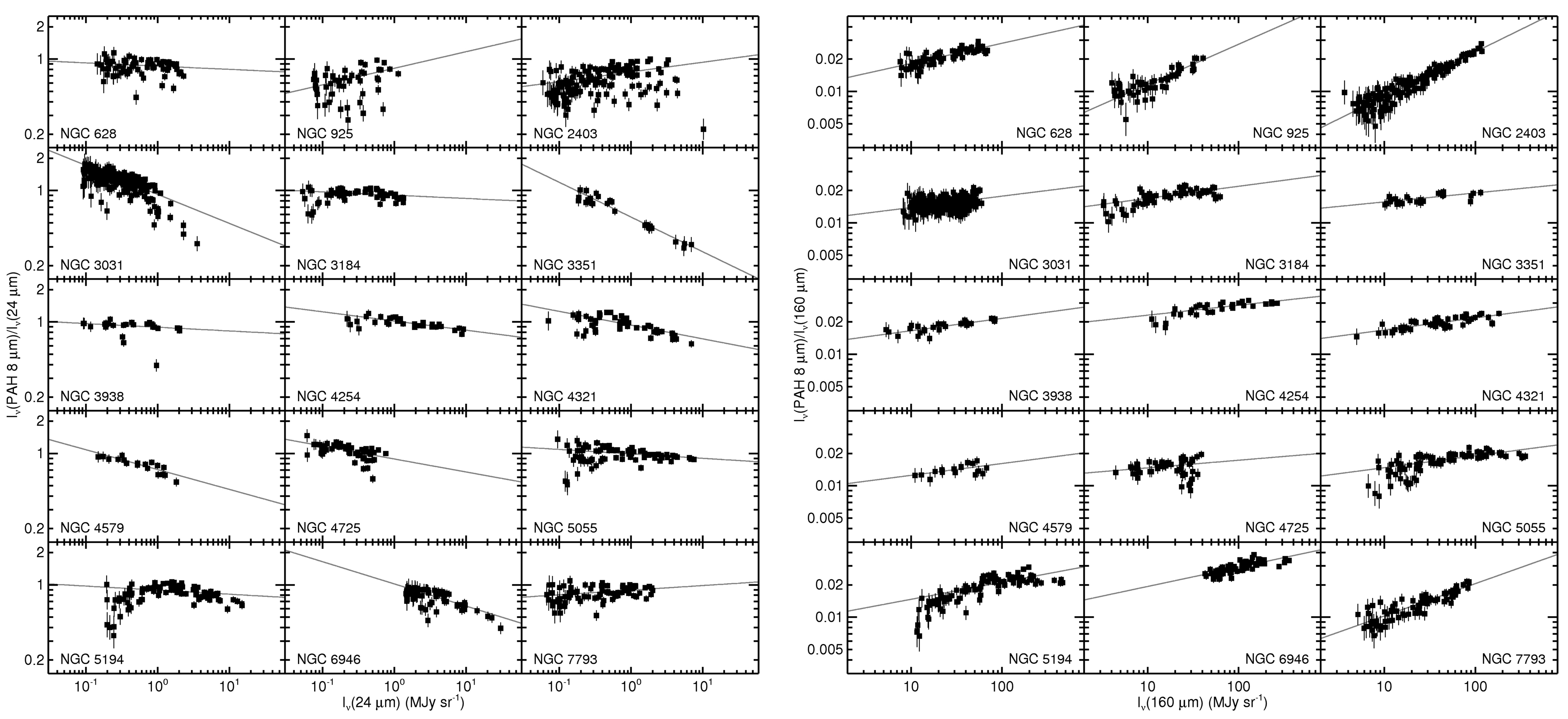
Bendo, G. J., et al. 2006, ApJ, 652, 283
Calzetti, D., et al. 2005, ApJ, 633, 871
Calzetti, D., et al. 2007, ApJ, 666, 870
Dale, D. A., et al. 2005, ApJ, 633, 857
Haas, M., Klaas, U., & Bianchi, S. 2002, A&A, 385, L23
Helou, G., et al. 2004, ApJS, 154, 253







These plots show how PAH 8 μm emission varies relative to 24 and 160 μm emission in the galaxies in the sample. In the ratio maps, blue colors correspond to regions with relatively strong PAH emission, red colors correspond to regions with relatively strong 24 or 160 μm emission, and white corresponds to regions with low S/N, foreground stars or artifacts. The circles show the 40″ FWHM of the PSF for the 160 μm data. When comparing PAH 8 μm emission to 24 μm warm dust emission, it is apparent that the ratio varies strongly among the galaxies here. In particular, the PAH 8 μm emission is relatively weak in infrared-bright regions and relatively strong in the diffuse ISM. However, the (PAH 8 μm)/160 μm ratio appears to be correlated with 160 μm surface brightness, although it does not vary in some galaxies. The ratio is enhanced in some large scale structures (such as the spiral arms in NGC 3031) but not in individual star-forming regions.



The figure above shows how the (PAH 8 μm)/24 μm ratio and the (PAH 8 μm)/160 μm ratio vary versus surface brightness as measured in 45″ regions across the disks of the sample galaxies. If PAH 8 μm emission was correlated with emission in either the 24 or 160 μm band with no color variations present, then the data in these plots would exhibit little scatter, and the slopes of the best fit lines would be 0. In the plots of the (PAH 8 μm)/24 μm ratio, the slopes of the data differ from 0 in many cases, the slopes vary significantly from galaxy to galaxy, and the data exhibit significant scatter. This demonstrates that PAH 8 μm emission is poorly correlated with 24 μm warm dust emission, so it cannot be used as a proxy for warm dust or star formation on these angular scales. In the plots of the (PAH 8 μm)/160 μm ratio, however, the scatter is relatively small, which demonstrates that PAH 8 μm emission is well-correlated with 160 μm cold dust emission. However, the (PAH 8 μm)/160 μm ratio increases as the 160 μm surface brightness increases, possibly indicating that the ratio is related to the intensity of the radiation field that heats the cold dust.