Spitzer studies of gravitationally--lensed galaxies at 1<z<3.

J. Rigby, D. Marcillac, E. Egami, G. Rieke, J. Richard, J.-P. Kneib, D. Fadda, C. Willmer, et al. 2008, ApJ, 675, 262

In short: We've obtained high-quality IRS spectra for 23 lensed LIRGs & ULIRGs. The SEDs appear to evolve systematically, and AGN contamination is high. Lensed samples give a sneak preview of JWST science, now.

Abstract:

Gravitational lensing, which amplifies distant galaxies by factors of 3--50, allows us to probe in detail the spectra and physical conditions inside distant star-forming galaxies.

In paper I, we study the IRS spectra of fifteen 24 micron--selected lensed galaxies, whose intrinsic flux densities are near the MIPS confusion limit. The median intrinsic 24 µm flux density of the sample is 130 µJy, enabling a systematic survey of the spectral properties of the very faint 24 µm sources that dominate the number counts of Spitzer cosmological surveys.

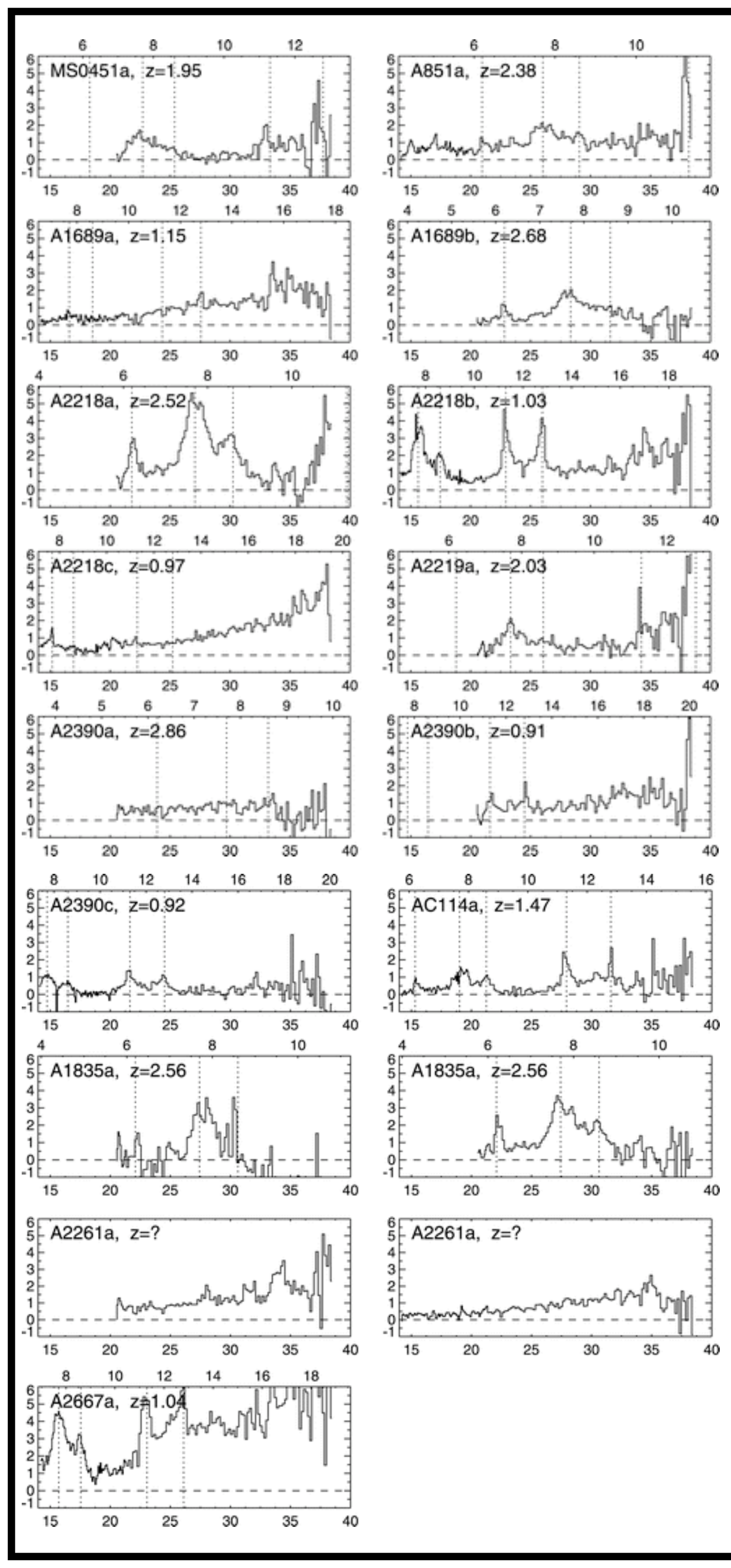
Six of the 19 galaxy spectra (32%) show the strong mid-IR continuua expected of AGNs; X-ray detections confirm the presence of AGNs in three of these cases, and reveal AGNs in two other galaxies. These results suggest that nuclear accretion may contribute more flux to faint 24 µm-selected samples than previously assumed.

Almost all the spectra show aromatic emission features; the measured aromatic flux ratios do not show evolution from z=0.

We compare the rest-frame 8 micron and total infrared luminosities, and find that the behavior of this luminosity evolves modestly from z=0 to z=2.5, such that high--redshift galaxies are relatively stronger aromatic emitters. This finding implies systematic evolution in the structure and/or metallicity of IR-luminous galaxies with redshift, and has implications for 24 micron--derived estimates of star formation rate.

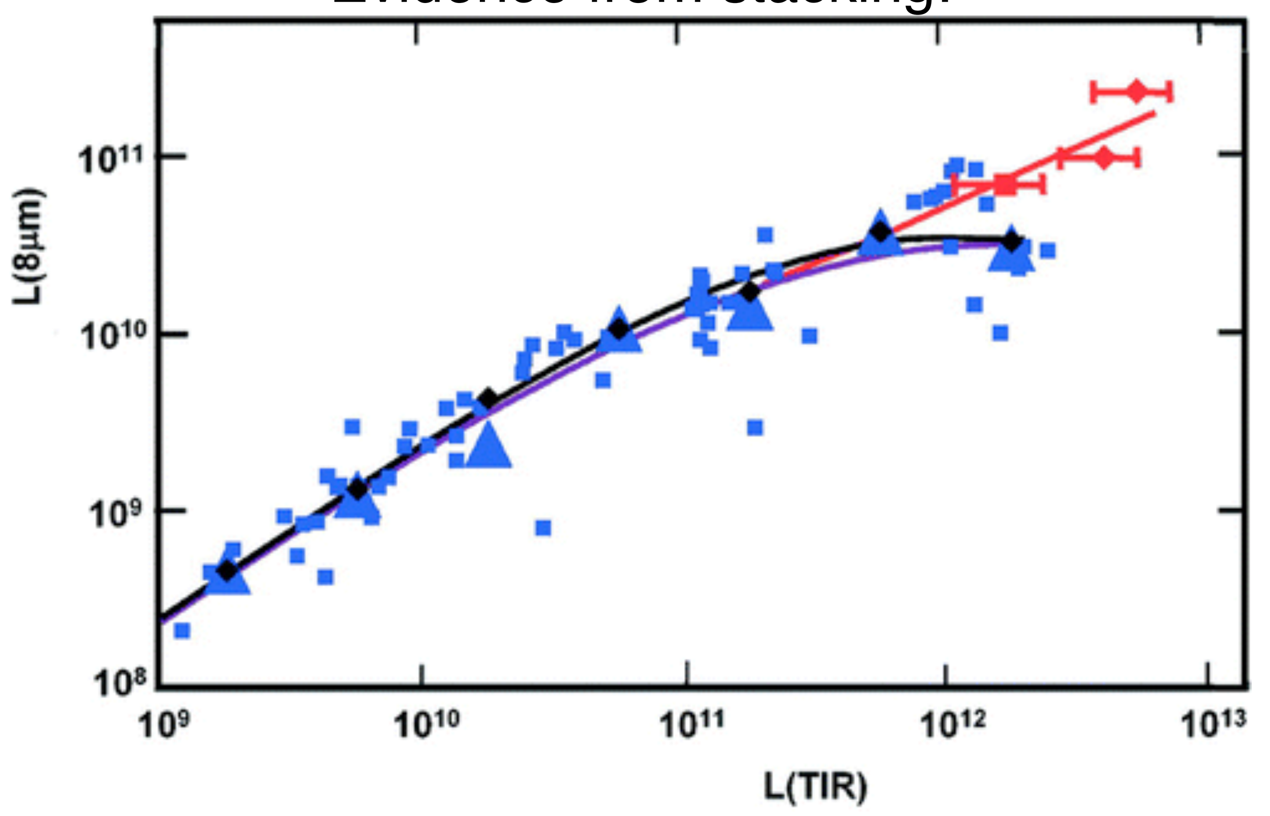
We obtained spectra for 8 more galaxies in Cycle 4, and are proceeding with the analysis.

IRS spectra



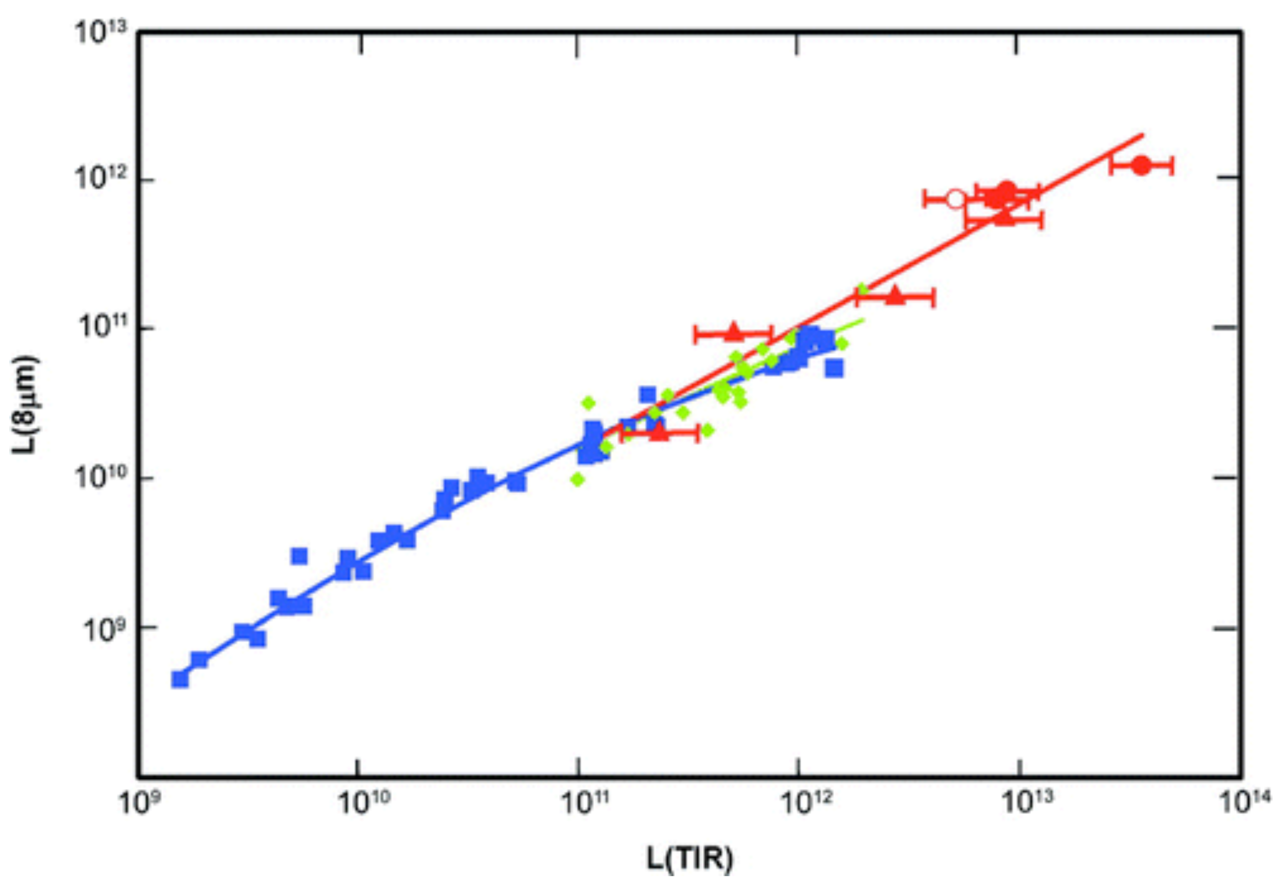
Key result: In star-forming galaxies, the aromatic -to-total IR luminosity ratio appears to evolve with redshift.

Evidence from stacking:



Compare the stacked samples at z=2 (red symbols) to individual galaxies at z=0 (blue squares), and stacked galaxies at z=0 (blue triangles). The highest-luminosity z=0 stacked point is significantly below the z=2 points. (Red square from Daddi +05; red diamonds from Papovich +07.)

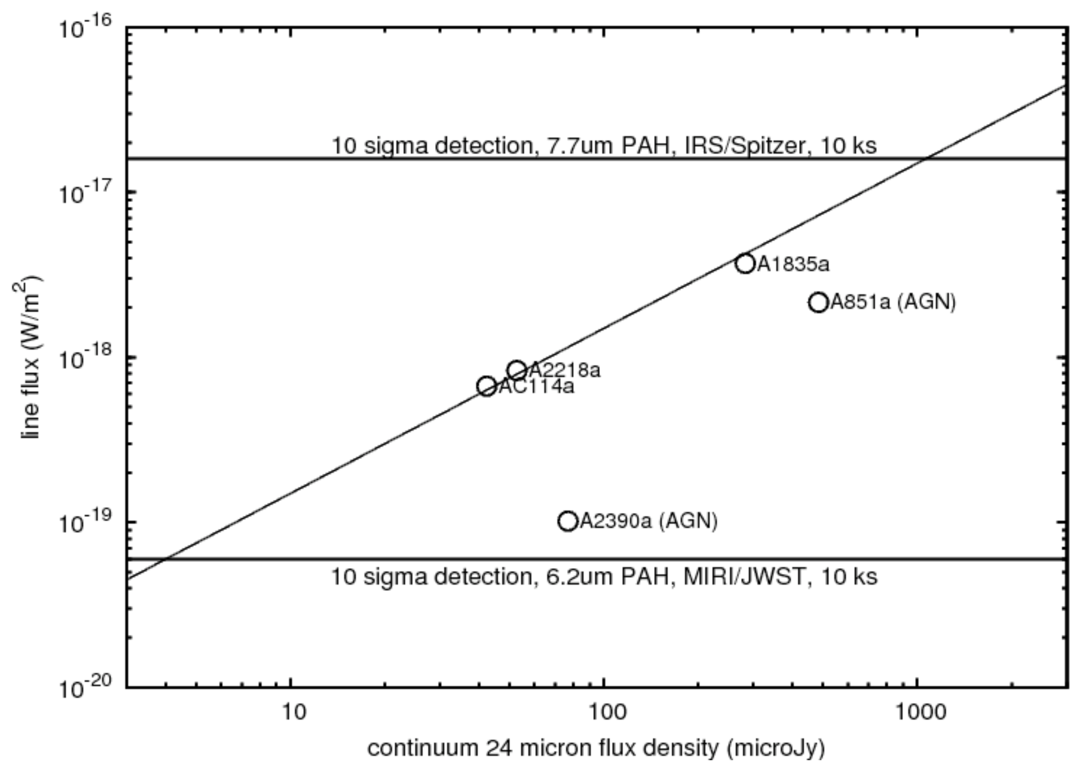
Evidence from individual galaxies:



Red symbols show z=2.5 galaxies, and blue symbols the z=0 galaxies. Again, the red points lie systematically above the best-fitting z=0 line. **It appears that high-redshift galaxies are more efficient at creating aromatic feature luminosity, for the same total infrared luminosity, than z=0 galaxies.**

Red circles: unlensed galaxies at z=2.5 (Yan+ 07).
Red triangles: lensed galaxies at z=2.5 (Rigby+ 08).
Blue squares: z=0 LIRGs and ULIRGs.
Yellow points: z=0.85 galaxies from Marcillac +06.

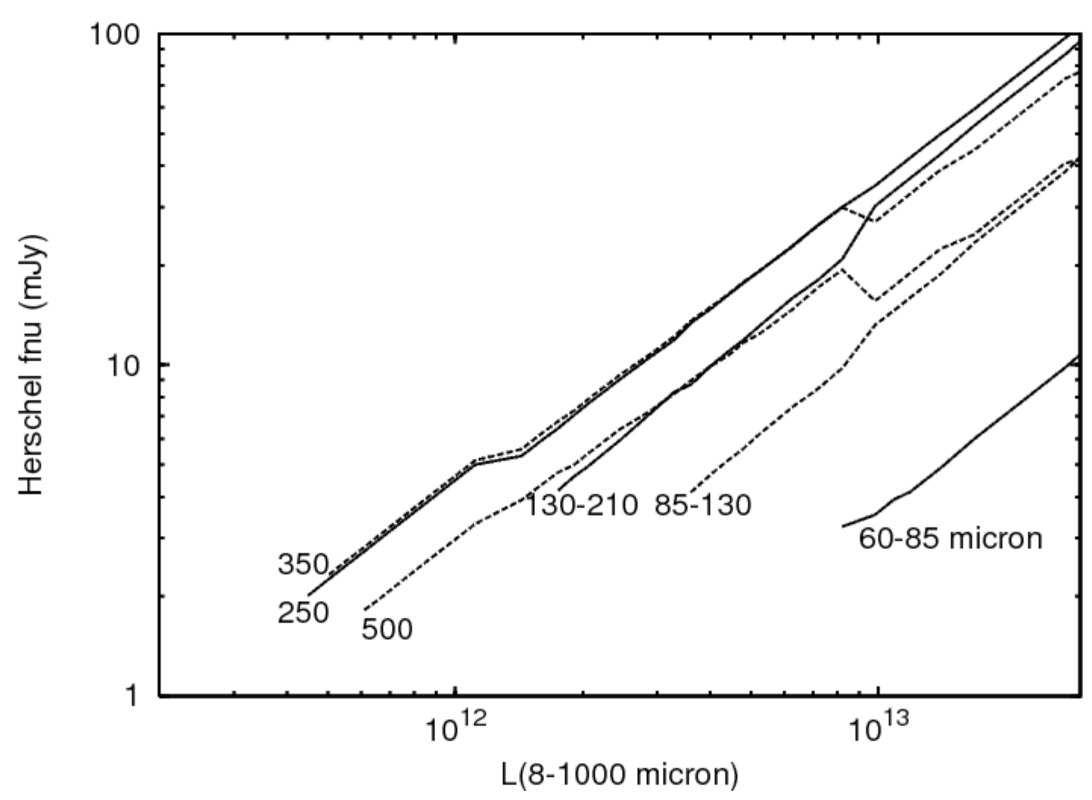
Lensed galaxies are intrinsically faint. How much fainter will JWST spectroscopy probe?



MIRI on JWST can detect the 6.2um PAH feature at z=2.5 in star-forming galaxies down to sub-LIRGs (f(24um)<4 microJy).

If Spitzer can detect it with MIPS 24um, JWST can take a PAH spectrum.

How do these intrinsic L(TIR) compare to Herschel?



These are 5 sigma, 1 hr sensitivities for z=2.5.

The lensed 1<z<3 sample have L(TIR) of LIRGs and ULIRGs.

Herschel's longer wavelengths reach LIRGs in 1 hr. Much better constraints on total infrared luminosities.