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Mid-IR Spectroscopy of High-z SMGs: First Results

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Abstract. We present mid-infrared spectra of 5 submmillimeter galaxies at redshifts $z = 0.65 - 2.38$ taken with the Infrared Spectrograph aboard the *Spitzer Space Telescope*. Four of these sources have strong PAH features and the strength of these features are consistent with these galaxies being dominated by star formation. The other source displays a Mrk 231-type broad emission feature at restframe $\sim$8 μm that does not conform to the typical 7.7/8.6 μm PAH complex in starburst galaxies, suggesting a more substantial AGN contribution.

Deep submm-wave surveys have uncovered a population of highly obscured, ultra-luminous infrared (IR) galaxies (ULIRGs; $L_{\rm IR} > 2-5\times10^{12}\,{\rm L}_{\odot}$) at $z\sim2$ (Blain et al. 2002), coincident with the epoch of peak global star formation and quasar activity. X-ray evidence suggests that $\sim 28-50\%$ of these submm-galaxies (SMGs) host an AGN, although at face value it appears that the AGN contribution does not dominate the bolometric luminosity and that powerful starbursts (SB) contribute more significantly (Alexander et al. 2005). The mid-IR is relatively immune to the effects of obscuration at optical and X-ray wavelengths and thus gives a clearer view of the physical nature of the power source. We have started a program using the Infrared Spectrograph (IRS; Houck et al. 2004) aboard the *Spitzer Space Telescope* to study 26 high-z SMGs, using the radio-identified sample with spectroscopic redshifts, compiled by Chapman et al. (2005).

Emission from Polycyclic Aromatic Hydrocarbons (PAHs) (e.g. restframe 6.2, 7.7, 8.6, 11.3 and 12.7 μm) is associated with SB-activity (Helou 1999) and is typically absent in powerful AGN (Voit 1992). PAH strength can thus be used to estimate the relative contributions from SB and AGN activity, as a stronger mid-IR continuum (produced by an AGN) dilutes the strength of PAH features. According to the line-to-continuum (l/c) diagnostic presented by Genzel et al. (1998) systems with $({\rm l/c})_{7.7\mu{\rm m}} \geq 1$ are classified as SB−dominated and those with $({\rm l/c})_{7.7\mu{\rm m}} \leq 1$, as AGN-dominated.

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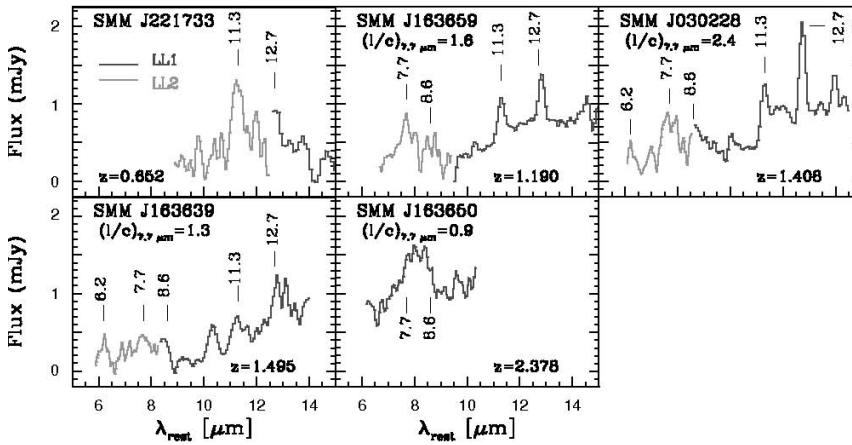

Figure 1. 1D *Spitzer* IRS flux-calibrated spectra for 5 SMGs. All spectra have been smoothed by 3 pixels, with the black (red) curve representing the first order (LL1: $\lambda_{obs} = 19.5 - 38\,\mu$m) of the low-resolution IRS mode and the grey (green) curve, the second order (LL2: $\lambda_{obs} = 14 - 21.3\,\mu$m). PAH emission features are indicated at the various restframe wavelengths.

The spectra for the first 5 targets observed early in our program are shown in Fig. 1. SMM J221733 +001120, SMM J163659 +405728, SMM J030228 +000654, and SMM J163639 +405636 have spectra with strong PAH features. The other target, SMM J163650 +405735, shows a Mrk 231-type broad feature at rest-frame $\sim$8 μm unlike the typical 7.7/8.6 μm PAH complex in starburst galaxies, suggesting more substantial AGN contribution. Three out of the four SMGs in our sample with a 7.7-μm PAH detection have $(l/c)_{7.7\mu m} \geq 1$, suggesting that these SMGs are SB-dominated. We encourage the reader to refer to Menéndez-Delmestre et al. (2007) for a more detailed discussion.

Our results provide contributing evidence that SMGs host both SB and AGN activity, but that SB appears to dominate the bolometric luminosity.

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