

# The Luminous, the Massive and the Dusty: a Near- to Mid-Infrared Spectroscopic Study of Submillimeter Galaxies

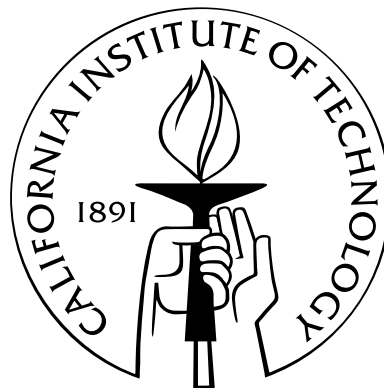
Thesis by

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# Abstract

Submillimeter (submm) surveys have uncovered a population of dust-enshrouded ultra-luminous galaxies ( $L_{8-1000\mu\text{m}} \gtrsim \text{few} \times 10^{12} L_{\odot}$ ) that are inconspicuous in deep surveys at shorter wavelengths. Inferred to have high star-formation rates (SFRs  $\gtrsim 1000 M_{\odot} \text{ yr}^{-1}$ ), submm-selected galaxies (SMGs) contribute significantly to the global SFR density at  $z \sim 2 - 3$  and are thus critical players in building up stars in galaxies. Many SMGs have been shown to display X-ray, optical and near-infrared (IR) signatures of active galactic nuclei (AGN), prompting the question: how significant is the AGN contribution to their total luminosity? Central to understanding SMGs is the study of the nature of their power source, their internal dynamics, their SFRs and their masses. We study mid-IR and near-IR spectra of SMGs to investigate these aspects.

We have obtained the largest sample of 24 SMGs to date with the mid-IR *Spitzer* Infrared Spectrograph (IRS) at  $z \sim 0.65 - 3.2$ . Broad emission features from polycyclic aromatic hydrocarbons – typically associated to intense star-formation – are almost ubiquitous in the sample and the composite spectrum is well fit by a combination of a starburst component with an additional power law representing a  $\lesssim 35\%$  AGN contribution to the bolometric luminosity. We find weak silicate absorption in contrast to local ultra-luminous IR galaxies (ULIRGs), suggesting that the mid-IR visible star formation in SMGs occurs in a more extended component.

We also study the near-IR emission of SMGs with the OH-Suppressing Infrared Imaging Spectrograph (OSIRIS), together with the Keck Laser-Guide Star Adaptive Optics system, to investigate the distribution and dynamics of the ionized gas. The two-dimensional insight of these observations allow us to distinguish and quantify

the compact AGN emission, which allows us to refine estimates of dynamical masses, SFRs and gas masses for the population. With a spatially-resolved spectroscopic insight into the kpc-scale structure of these galaxies, we find that the  $H\alpha$  emission in SMGs extends over scales  $\sim 4 - 17$  kpc, setting SMGs apart from local ULIRGs, where intense emission is confined to the central  $\lesssim 1$  kpc.

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