NEAR-INFRARED LINE OBSERVATIONS OF STARBURST GALAXIES

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In order to investigate the relation between galaxy interactions, mergers, and galactic activities, we observed IR luminous galaxies by using UCO 3-m telescope + UCLA double-beam camera (long-slit spectroscopic mode: McLean et al. 1993, 1994) and UKIRT 4-m telescope + IRCAM3 (Fabry-Perot line imaging mode). In the galaxy merging system NGC 6240, the strong H_2 lines are emitted between its two nuclei, which is consistent with the results by Herbst et al. (1990) and van der Werf et al. (1993). From the H_2 line ratios, including sensitive upper limits on highly excited H_2 lines, we conclude that the emission is excited purely by shocks. Previously suggested contributions of UV fluorescent and X-ray heating mechanisms are negligible. From its excitation mechanism and its peak position, we conclude that the emission is from a global shock caused by a galaxy-galaxy collision. The deep CO absorption lines in H and K bands suggest that the continuum emission in the nuclei is dominated by supergiant stars or giants. Although it is difficult to distinguish between these two populations, there are some subtle differences in their infrared spectra (cf., Origlia et al. 1993). The absorption features in NGC 6240 are fit well with those of a K2-3 supergiant star, but not with those of giants. Therefore, we favor supergiants as the dominant stellar population, rather than giants. The domination of those supergiant stars at present means that the triggering starburst phase ended a few $\times 10^7$ years ago. Contrary to the situation for NGC 6240, in the interacting system NGC 3690 + IC 694, most of the H_2 emission lines is concentrated at their nuclei. However, for one of the nuclei the difference in flux distribution between line and continuum is striking i.e., little or no H_2 line emission. Moreover, various emission-line ratios and absorption equivalent widths are very different among nuclei. This difference is probably indicative of a different starburst-phase.

Herbst, T. M., Graham, J. R., Beckwith, S., Tsutsui, K., Soifer, B. T., & Matthews, K. 1990, AJ, 99, 1773

McLean, I. S. et al., 1993, in Infrared Detectors and Instrumentation, ed. A. Fowler (Bellingham: SPIE), 513

McLean, I. S. et al., 1994, in Instrumentation in Astronomy VIII, ed. D. Crawford (Bellingham: SPIE), 457

Origlia, L., Moorwood, A. F. M., & Oliva, E. 1993, A&A, 280, 536

van der Werf, P. P., Genzel, R., Krabbe, A., Blietz, M., Lutz, D., Drapatz, S., Ward, M. J., & Forbes, D. A. 1993, ApJ, 405, 522

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STARBURST AND AGN DIAGNOSTICS FROM INFRARED SPECTROSCOPY

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Our program of near-IR spectroscopy (2–2.4 μm, $\lambda/\Delta\lambda \approx 340$) of luminous infrared galaxies (LIGs) (Goldader et al. 1995, ApJ, 444, 97; Goldader et al. 1996, ApJ, and ApJS, in press) with $L_{IR} \gtrsim 2 \times 10^{11} L_\odot$ has enabled us to search for differences between starburst and AGN spectra in a large, homogeneous sample of galaxies. Of our 55 LIGs, 10 were Seyferts, 13 were LINERs, 25 had H II region-like spectra, and the rest had no optical classifications. We discovered no new broad-line galaxies. Despite the lower extinction at 2 μm ($\approx 0.1\ A_V$), *no new Seyfert 1 nuclei were found.* Either powerful AGN are not present, or they remain obscured even at 2 μm . We found that the Brγ and H_2 1–0S(1) lines of the AGN and other galaxies follow essentially the same trend of increasing in luminosity with L_{IR}. For both lines, the luminosities are about $10^{-5} \times L_{IR}$. The line luminosities, therefore, do not appear to be useful in discriminating between AGN and starbursts, at least to first order. Using red near-IR colors alone to tell starbursts from AGN is also not conclusive, since a number of galaxies (Arp 299: e.g., Wynn-Williams et al. 1991, ApJ, 377, 426; VV114: Doyon et al. 1995, ApJ, 459, 111; and II Zw 96: Goldader et al., in preparation) are known to contain extremely red ($H - K \approx 0.5 - 1$), luminous ($M_K \approx -21$) star forming regions. The strongest difference between the AGN and starbursts seems to be that the 2 μm continua of the broad-line AGN are a few times more luminous than those of the starbursts, and much redder. As a result, even though the K-band emission lines of the AGN are as luminous as those of the starbursts, they have lower equivalent widths ($\sim$ *few* Å) relative to the starbursts (typically 5–30 Å). Seyfert 1 galaxies also show much weaker CO absorption at 2.3 μm than the starbursts, which is consistent with the 2 μm continua of the Seyfert 1 galaxies being largely non-stellar in origin.

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