VELOCITY RESOLVED SPECTROSCOPY OF MOLECULAR HYDROGEN EMISSION IN NGC6240

G.S. Wright, T.R. Geballe
Joint Astronomy Centre, 665 Komohana Street, Hilo, HI96720.

and

J. R. Graham
649 Campbell Hall, University of California, Berkeley, CA94720.

NGC6240 is a member of the class of luminous galaxies which emit a significant fraction of their total light in the infrared. Based on its highly disturbed morphology, Fosbury and Wall (1979) suggested that the system may be a merger of two gas rich galaxies. It has two nuclei separated by 2 arcsec which are visible in the near infrared and at radio wavelengths (Fried and Schultz 1983, Condon *et al.* 1982) and CO observations show that the galaxy contains a large mass (3×10^{10} $M_\odot$) of molecular gas (Young *et al.* 1984). Unusually strong H_2 emission lines dominate the near infrared spectrum of this galaxy (Joseph *et al.* 1984, Depoy *et al.* 1986). The galaxy emits $\sim 4\times10^{7}$ $L_\odot$ in the 2.12μm v=1-0 S(1) line alone, an order of magnitude more than other merging or starburst galaxies.

While it is clear that the H_2 emission must be related to the other copious activity displayed by NGC6240, the source of the excitation is poorly understood. The weakness of the hydrogen recombination lines indicates that there is insufficient UV to excite the H_2 fluorescently, irrespective of whether a model based on star formation or Seyfert type activity is used. The H_2 line ratios are consistent with most of the H_2 being collisionallly excited (Lester *et al.* 1988). It is frequently argued that since NGC6240 is the product of a recent merger of two galaxies, the H_2 emission is excited in global shocks arising from interaction driven cloud collisions. Given the starburst nature of NGC6240 inferred from the deep CO absorption bands which indicate the presence of a massive population of red supergiants, excitation in star formation regions or supernova remnants has also been proposed. Although global shocks are energetically feasible, explain the known characteristics of the H_2 emission and are attractive on account of their simplicity, other activity could equally well account for the observed emission.

Herbst *et al.* (1990) and Elston and Maloney (1990) have imaged the H_2 emission and shown that it is spatially extended on a scales > 1 kpc and does not follow the distribution of the continuum emission around the nucleus. The H_2 line is resolved with a FWHM $\sim 500km/s$, which is consistent with the global shock model, but it is harder to explain in terms of the starburst model (the velocity dispersion in the quiescent CO lines is $\sim 300km/s$).

To provide a better understanding of the physical processes responsible for the H_2 emission from NGC6240 we have begun a programme to obtain high spectral resolution observations using the echelle in CGS4 (Mountain *et al.* 1990) on the UKIRT. Preliminary data which were obtained in February 1991 are presented here. It is intended to obtain further observations with twice the spatial and spectral resolution in June of this year.

The spectrum presented in Figure 1 was obtained in a 3 arsec slit along the two nuclei with a resolution of 36 km/s. This spectrum confirms a $\sim 600km/s$ FWHM but shows broad asymmetrical line wings extending up to at least 1200 km/s. The shock excited optical emission lines from the central 3-5 kpc which are believed to be generated by a superwind from the starburst have FWHM $\sim 1200km/s$. This result may therefore be evidence linking the H_2 emission with the superwind. We speculate that the high velocity H_2 emission may be from molecular gas swept up and shocked by the superwind. In this case all the observational properties of NGC6240 could be explained in terms of a massive burst of star formation. It is difficult to produce these high velocities with global shocks from the merger of two galaxies. However a line width $\sim 1500km/s$ is typical of that seen from Seyfert type active nuclei. Further observations to delineate the spatial extent of the broad line emission are planned. Such data should enable us to determine whether the emission is instead associated with obscured Seyfert activity in one of the nuclei.

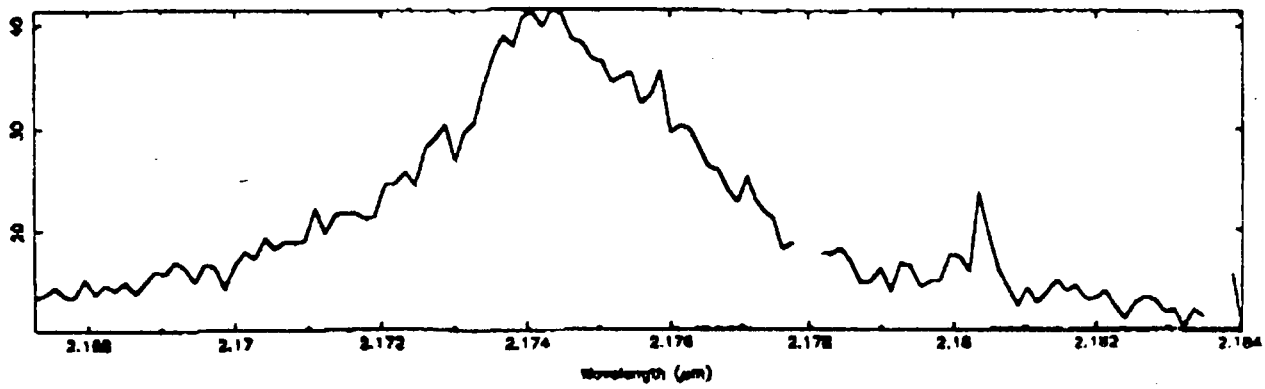

Figure 1. Infrared echelle spectrogram of H_2 1-0S(1) in NGC6240 at a resolution of 35 km/s

References

Condon, J. J., Condon, M. A., Gisler, G., & Puschell, J. J. 1982, *ApJ*, **252**, 102.
Depoy, D. L., Becklin, E. E., & Wynn-Williams, C. G. 1986, *ApJ*, **307**, 116.
Elston, R. & Maloney, P. 1990, *ApJ*, **357**, 91.
Fosbury, R. A. E., & Wall, J. V. 1978, *MNRAS*, **189**, 79.
Fried, J. W., & Schultz, H. 1983, *A&A*, **118**, 166.
Herbst, T. M., Graham, J. R., Beckwith, S., Tsutsui, K., Soifer, B. T., & Matthews, K. 1990, *AJ*, **99**, 1773.
Joseph, R. D., Wright, G. S., & Wade, R. 1984, *Nature*, **311**, 132.
Lester, D. F., Harvey, P. M., & Carr, J. S. 1988, *ApJ*, **329**, 641.
Mountain, C. M., Robertson, D. J., Lee T. J., & Wade, R. 1990, *Instrumentation in Astronomy VII SPIE* , **1235**, p25.
Young, J. S., Kenny, J. Lord, S. D., and Schloerb, F. P. 1984, *ApJ*, **287**, L65.