THE FCRAO EXTRAGALACTIC CO SURVEY

J.S. YOUNG, L.E. ALLEN, N.A. DEVEREUX, P.M. KNEZEK, and S. XIE
Department of Physics and Astronomy and
Five College Radio Astronomy Observatory
University of Massachusetts, Amherst MA 01003 USA

1. Introduction

We have observed CO J=1-0 emission in 300 galaxies at 45" resolution as part of the FCRAO Extragalactic CO Survey. The target galaxies were selected on the basis of their optical and infrared properties, such that they are either brighter than 12th magnitude in the blue, or brighter than 10 Jy at 100 μm. This data set has been used to investigate the global ratio of molecular to atomic gas mass, the fraction of galaxy mass in neutral gas, and the yield of high mass stars per unit mass of molecular gas, all as a function of morphological type and environment.

2. Results

We have derived global molecular gas masses assuming the proportionality constant between CO integrated intensities and H_2 column densities of Bloemen et al. (1986). From a comparison of the molecular gas masses with HI masses, Hα luminosites, and IRAS-derived IR luminosites and warm dust masses, we have reached the following conclusions.

1) From the small *scatter* in the ratio of inner disk gas ($HI+H_2$) to warm dust, derived from three independently determined quantities, Devereux and Young (1990b) conclude that *global H_2 masses for luminous spiral galaxies are accurate to +/-30%.* This result is discussed further in our Panel Discussion contribution in these proceedings.

2) For 150 of the Survey galaxies classified as spirals and for which HI masses were available in the literature, Young and Knezek (1989) find that the mean ratio of molecular to atomic gas mass decreases by a factor of 20 from S0/Sa galaxies to Sd/Sm galaxies; the mean H_2/HI ratio is 4.0 +/- 1.9 for the early types and 0.2 +/- 0.1 for the late types. Within this sample, the mean gas surface density is only 2 times higher in the late type spirals than in the early types. Thus, *the dominant phase of the gas changes along the Hubble sequence for spirals.*

3) We have determined the rates of massive star formation in the Survey galaxies from Hα CCD imaging and from IRAS 60 and 100 μm fluxes. We find that *the mean global ratios of $L_{IR}/M(H_2)$ and $L_{H\alpha}/M(H_2)$ show little variation as a function of morphological type for types Sa-Scd*, as suggested previously (Rengarajan and Verma 1986; Young, Xie, Kenney, and Rice 1989).

F. Combes and F. Casoli (eds.), Dynamics of Galaxies and Their Molecular Cloud Distributions, 148–150.

Assuming that the IR luminosity provides a measure of the high mass star formation rate (Devereux and Young 1990a), then the similar ratios of L_{IR} or $L_{H\alpha}$ to $M(H_2)$ indicate that the average global yield of high mass stars per unit mass of molecular gas, or the star formation efficiency, is independent of spiral type. The mean value of $L_{IR}/M(H_2)$ among spirals in the Survey is 5 L_o/M_o (see Figure 1).

4) Within the optical disk, the fraction of the galaxy mass [M_{dyn}] in the form of neutral gas {[M(HI)+$M(H_2)$]/M_{dyn}} increases from 4% for the Sa/Sab galaxies to 25% for the Scd galaxies (Young 1990). This variation is primarily due to the presence of more massive nuclear bulges in the early type galaxies.

3. Discussion and Conclusions

It is now possible to relate the global variations in the ratio of molecular to atomic gas mass and in the star formation efficiency to the size scales on which clouds and stars form. The fact that the mean high mass star formation efficiency is similar for all spiral types is consistent with star formation being a small scale process, independent of the large scale distribution of mass within a galaxy. On the other hand, cloud formation is a process which operates on a considerably larger scale than star formation. Given that the H_2/HI ratio decreases by a factor of 20 from early type to late type spirals, we find that the dominant gas *phase* is sensitive to the degree of central mass concentration in a galaxy. It should be borne in mind, however, that although there are significant variations in the the relative amounts of molecular and atomic gas in galaxies, the mean gas surface densities of late type spirals are only 2 times higher than those for the early types. Thus, in terms of the total gas surface density and star formation efficiency, early and late type spiral disks are very similar; in terms of the *global* properties of spiral galaxies, the Hubble sequence appears to be primarily a sequence of changing bulge-to-disk ratio.

Acknowledgements. We gratefully acknowledge the allocation of observing time over the past 10 years on the 14 m FCRAO telescope. We also thank all Survey participants over the years for their contributions, including M. Claussen, J. Case, J. Carpenter, Y. Huang, J. Kenney, S. Lord, P. Schloerb, S. Schneider, L. Tacconi, L. Tacconi-Garman, and P. Viscuso.

References

Bloemen, J.B.G.L. 1986, *Astr.Ap.*, **154**, 25.

Devereux, N. and Young, J.S. 1990a, *ApJ.(Letters)*, **350**, L25.

Devereux, N. and Young, J.S. 1990b, *ApJ.*, in press (Aug. 10).

Rengarajan, T.N. and Verma, R.P. 1987, in IAU No. 115 *Star Forming Regions* (eds. M. Peimbert and J. Jugaku).

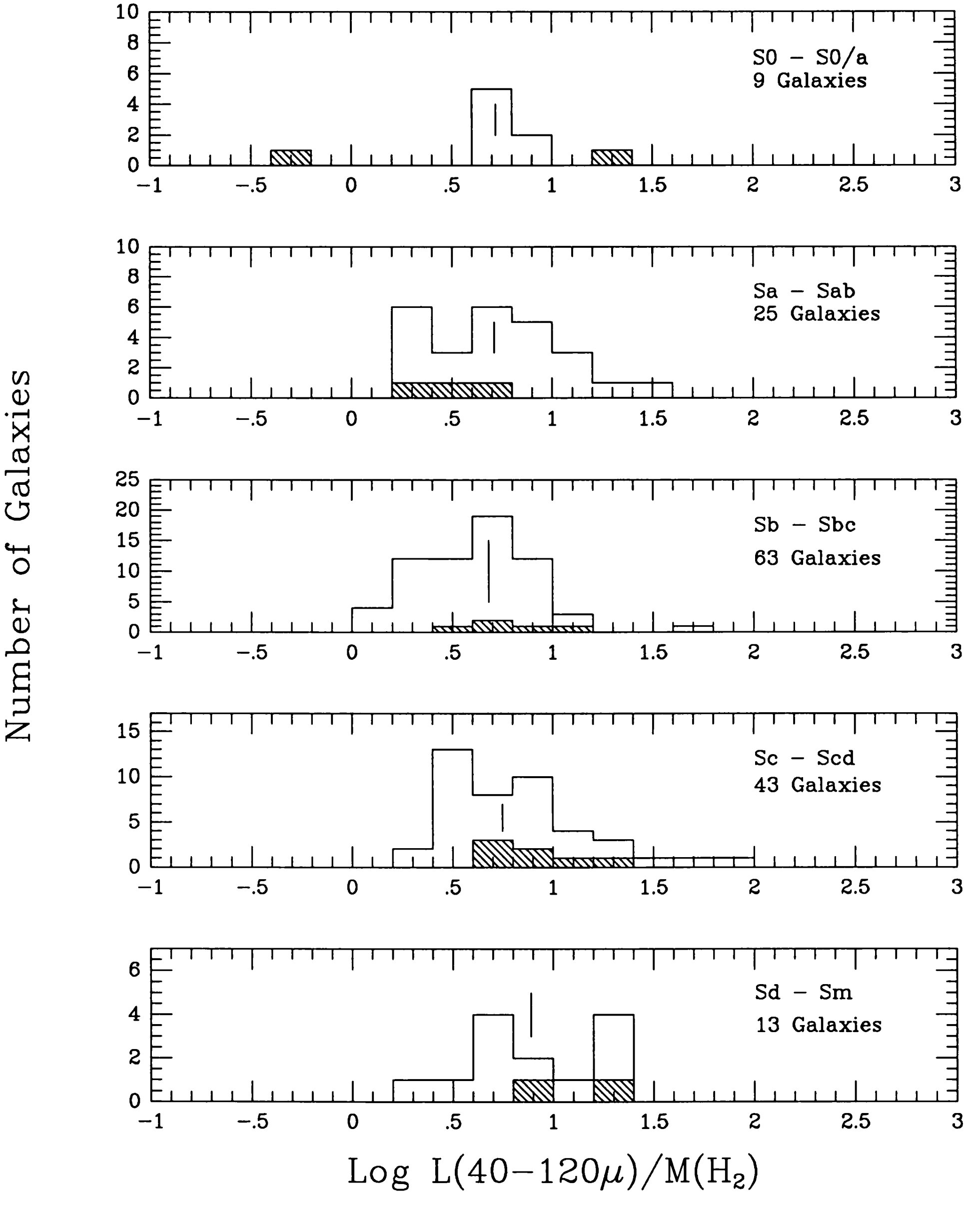
Young, J.S. 1990, in the Second Wyoming Conference on the *ISM in Galaxies* (eds. M. Shull and H. Thronson).

Young, J.S. and Knezek, P.M. 1989, *ApJ.(Letters)*, **347**, L55.

Young, J.S., Xie, S., Kenney, J., and Rice, W.L. 1989, *ApJ.Suppl.*, **70**, 699.

https://doi.org/10.1017/S0074180900243787 Published online by Cambridge University Press

Figure 1. Histograms of the ratio $L_{IR}/M(H_2)$ as a function of morphological type among spiral galaxies. Hatched areas represent lower limits to the ratio. The vertical tic mark in each panel represents the median value of $L_{IR}/M(H_2)$ for that type.



https://doi.org/10.1017/S0074180900243787 Published online by Cambridge University Press