MOLECULAR GAS CONTENT OF GALAXIES IN THE HYDRA-CENTAURUS SUPERCLUSTER

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Abstract

A survey of bright spiral galaxies in the Hydra-Centaurus supercluster for the CO(1-0) transition at 115 GHz was performed with the 15m Swedish-ESO submillimeter telescope (SEST). A total of 30 galaxies have been detected in the CO(1-0) transition out of 47 observed, which is a detection rate over 60%. Global physical parameters of these galaxies derived from optical, CO, HI, and IR measurements compare very well with properties of galaxies in the Virgo cluster.

The Hydra I cluster (Abell 1060) is one of the nearest clusters and very similar to the Virgo cluster in many global parameters like type, population, size, and shape. Both clusters have comparable velocity dispersions (i.e. total mass) and are spiral rich. Hydra is well isolated in velocity space and appears more circular (Kwast 1966), and might be dynamically more relaxed, although the center may contain significant substructures (Fitchett and Meritt 1988) or projected foreground groups. Both clusters contain low luminosity central X-ray sources. We assume a distance of 68.4 Mpc for Hydra I in order to allow direct comparison with some (nearly) complete galaxy samples.

The Centaurus cluster provides a valuable contrast to Virgo and Coma. It is intermediate in distance and in galaxy population type with a relatively well defined S0-dominated core and an extensive S-rich halo. Its richness class in the Abell scale is 1 or 2 which is richer than Virgo and poorer than Coma. Centaurus is irregular in appearance like Virgo. Its complex structure in the radial velocity domain is interpreted as subclustering. We adopt a weighted average distance of 64 Mpc for Centaurus.

The comparison samples are:

a) the sample of nearby galaxies which includes 146 spiral and irregular galaxies with corrected redshifts $v_0 \leq 500 kms^{-1}$ (**KKT** the Kraan-Korteweg - Tammann sample), their global parameters as given by Huchtmeier and Richter 1988;

b) the sample of spiral and irregular galaxies in the Virgo cluster with HI observations available (252 galaxies, Huchtmeier and Richter 1989b);

c) the sample of bright spiral galaxies in Virgo with CO (J=1-0) observations available with good signal-to-noise ratio (57 galaxies, Stark et al. 1986, Kenney and Young 1988, Lees et al. 1991). This will be an ideal reference sample for comparisons with other clusters. The distance assumed for deriving global properties of Virgo cluster galaxies was 21.88 Mpc.

The observations were performed with the 15m Swedish-ESO submillimeter telescope (SEST) at La Silla in January 1990 and 1991 under favorable meteorological conditions. At a frequency of 115 GHz the half power beamwidth (HPBW) of this telescope is 43 arcsec. The cooled Schottky heterodyne receiver had a typical receiver temperature of 240K ; the system temperature was typically 350 to 500 K depending on elevation and humidity. An accousto-optic spectrometer with a bandwidth of 500 MHz yielded a channel width of 0.69 MHz or about 1.8 km/s. Nonlinearities in the frequency scale of the AOS were corrected by the computer software. For more details on telescope information and operation see Booth et al.(1989).

The CO line integral was used to derive the total mass of molecular hydrogen $M(H_2)$ assuming a conversion factor of $N(H_2)/I_{CO} = 2.810^{20} cm^{-2}(Kkms^{-1})$. The conversion factor derived in our galaxy is generally used for extragalactic systems. One should consider these H_2 masses as "nominal" masses. The IRAS fluxes at 60μ and 100μ are from Helou et al.(1988). In those cases where fluxes were not given we searched Roberts et al.(1991) and Lonsdale et al.(1985) in that order of priority. The infrared

luminosity L_{IR} and the amount of cool dust M_{dust} were derived from IRAS fluxes at 60μm and 100μm following Young et al. (1989).

The global H_2-to-HI mass ratio has been studied as a function of morphological type. The mean value of $M(H_2)/M(HI)$ decreases from 4.0 ± 1.9 for S0/Sa galaxies to 0.2 ± 0.1 for Sd/Sm galaxies. For a mixture of morphological types as in our samples we would expect the cold gas to be available in about equal amounts in mass as neutral and molecular hydrogen. The range of values occupied by the Virgo sample shows a good correlation. The Hydra galaxies fit quite well to the "bright end" of the Virgo range. Comparison of molecular gas masses with IRAS derived dust masses leads to mean gas-to-dust ratios of the order of $\sim$ 600 rather than a value of $\sim$ 150 (e.g.Spitzer 1978) as observed for our galaxy. Devereux and Young (1990b) find the mean inner disk gas to warm dust ratio to $\sim$ 1000 with no significant variation as a function of morphological type or dust temperature (e.g. Young and Scoville 1991). There is general agreement for the gas-to-dust ratios observed in field galaxies and the two cluster populations discussed in this paper. The ratio of infrared luminosity to the mass of molecular hydrogen L_{IR}/M_{H2} is considered as a measure for the formation of bright stars (e.g. Young and Scoville 1991). High star formation efficiences are present in interactive galaxies (Sanders and Mirabel 1985, Young et al. 1986, Solomon and Sage 1988).

It is interesting to see that elliptical galaxies which have been detected in CO (e.g. Roberts et al. 1991, Lees et al. 1991, Huchtmeier and Tammann 1992) populate the same range as spiral galaxies . But all those ellipticals are somewhat peculiar (for example: NGC7176 is an interacting system, NGC3928 is known as a Makarian galaxy) and are probably not representative for the class of elliptical galaxies (e.g. Bregman et al. 1992).

The small number of HI observations available for the Centaurus cluster does not permit any statement about HI deficiency. There are more observations available for the Hydra cluster; there is evidence for a mild HI deficiency in this cluster.

When comparing global parameters for the Virgo and Hydra-Centaurus galaxies we find a general agreement for both clusters which is not too surprising in view of the similarity of both clusters. Due to the greater distance of Hydra (sensitivity problem) only the bright end of the galaxy population of this cluster is accessible for CO observations presently.

References

Bregman, J.N., Hogg, D.E., Roberts, M.S. 1992 : ApJ 387,484

Booth, R.S., Delgardo, G., Hagström, M., Johannson, L.E.B., Murphy, D.C., Olberg, M., Whyborn, N.D., Greve, A., Hansson, B., Lindström, C.O., Rydberg, A. 1989 : A&A 260,350

Devereux, N., Young, J.S. 1990b : ApJ 359,42

Fitchett, M., Merritt, D. 1988 : ApJ 335,18

Helou, G., Khan, I.R., Malek, L., Boehmer, L. 1988 : ApJSS 68,151

Huchtmeier, W.K., Richter, O.-G. 1988 : A&A 203,337

Huchtmeier, W.K., Richter, O.-G. 1989b : A&A 210,1

Huchtmeier, W.K., Tammann, G.A. 1992 : A&A 257,455

Kenney, J.D., Young, J.S. 1988 : ApJSS 66,261

Kwast, T. 1966 : Acta Astr. 74,708

Lees, J.F., Knapp, G.R., Rupen, M.P., Phillips, T.G. 1991 ApJ 379,177

Londsdale, C.J., Helou, G., Good, J.R., Rice, W. 1985 : *Cataloged Galaxies and Quasars Observed in the IRAS Survey* NASA JPL D-1932

Roberts, M.S., Hogg, D.E., Forman, W.E., Jones, C. 1991 : ApJSS 75,757

Sanders, D.B., Mirabel, I.F. 1985 ApJ 298,L31

Solomon, P.M., Sage, L. 1988 : ApJ 334,613

Spitzer, L. 1978 *Physical Processes in the Interstellar Medium* Wiley,New York p.162

Stark, A.A., Knapp, G.R., Bally, J., Wilson, R.W., Penzias, A.A., Rowe, H.E., 1986 : ApJ 310,660

Young, J.S., Schloerb, F.P., Kenney, J., Lord, S.D. 1986a : ApJ 304,443

Young, J.S., Xie, S., Kenney, J.D.P., Rice, W.L., 1989 : ApJSS 70,699

Young, J.S., Scoville, N.Z., 1991 : Ann.Rev.Astron&Astrophys. 29,381