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Observations of CO in the Magellanic irregular galaxy NGC 55*

Andreas Heithausen$, Center for Astrophysics, Cambridge, Mass.,
and
Ralf-Jürgen Dettmar$, Lowell Observatory, Flagstaff, Arizona

Introduction

The content of molecular gas in galaxies, mainly H_2, is one of the key observations to understanding the star formation processes and history. As the CO molecule is the most widely distributed molecule after H_2 and has easily observable mm lines, it is used as a tracer for the molecular gas. The molecular hydrogen column density, $N(H_2)$, is usually derived by scaling the velocity integrated CO line, $W(CO)=\int T_R^* dv$. A typical factor, $X(W(CO))=N(H_2)/W(CO)$, found for the Milky Way is $X_G(W(CO))=2.6\times10^{20}$ [molecules cm^{-2} (K $km^{-1})^{-1}$] (e.g. Bloemen et al. 1986) and very similar values, derived from Milky Way clouds, are used for normal spiral galaxies (e.g. Young et al. 1989). But this factor is not commonly accepted for all regions of our Galaxy. De Vries et al. (1987) found values of 0.5×10^{20} [molecules cm^{-2} (K $km^{-1})^{-1}$] for a number of cirrus clouds (see also Heithausen and Mebold (1988) for a discussion of Galactic X(W(CO) factors).

The basic explanations for the observed higher X values are excitation conditions due to an increased intensity of the ultraviolet (UV) radiation field and abundances effects. This effects are discussed in detail by Maloney and Black (1988). The observed low CO intensities of irregular (Irr) galaxies (Elmegreen et al., 1980, Young et al. 1984, Tacconi and Young 1985, 1987) have been discussed in this context and higher X(W(CO)) values by up to a factor of 10 were suggested by several authors for this type of galaxy (Thronson et al. 1987, Israel 1988, Cohen et al. 1988).

For most Irr galaxies the mass of H_2 is derived by indirect and global methods. Only for nearby objects, like the Small and Large Magellanic Clouds (SMC and LMC), is it possible to get dynamical masses if the molecular clouds are assumed to be in virial equilibrium. This assumption works very well within the Galaxy and if applied to the Magellanic Clouds, the resulting X(W(CO)) values are 6 times higher for the LMC (Cohen et al. 1988) and 25 times higher for the SMC (Rubio et al., 1988) than the average X_G value for our Galaxy.

Observations

NGC 55 is the nearest giant Magellanic-type galaxy beyond the Local Group. It is classified as SBm and shows similarities to the LMC. In order to study the distribution and properties of molecular gas within Magellanic type galaxies in more detail we observed this galaxy in July 1988 in the $J=1 \mapsto 0$ CO line with the 15m Swedish-ESO Submillimeter Telescope (SEST). Spectra were taken with a low resolution acusto optical spectrometer using 728 channels and a velocity resolution of 1.792 km s^{-1} at 115GHz. The integration time was 40 minutes (on+off) resulting in an rms noise of about 15mK.

Results

CO was detected towards the direction where the Hα and 6 cm radiocontinuum emission is strongest (Hummel et al. 1986). We present the gaussian line parameters in Table 1. The distribution of CO corresponds well with the intense HI cloud near the bar of NGC 55. The extent of the CO cloud is about 975 pc along the major axis and 390 pc perpendicular to the major axis. As the radio-continuum and Hα emission also peaks in this region, it is most probably associated with the dominant star forming region in NGC 55. Assuming that the molecular gas is in virial equilibrium,

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* Based on observations obtained with the SEST telescope at ESO/La Silla, Chile

$ on leave from: Radioastronomisches Institut der Universität Bonn, Bonn, FRG we derive a mass of about $8\times10^7 M_\odot$. The comparison to the HI mass of $1.7\times10^7 M_\odot$ for this complex found by Hummel et al. (1986) shows that this cloud is mainly molecular.

Table 1: CO line parameters for NGC 55

$\Delta(RA)$ ["]	$\Delta(Decl)$ ["]	T_A [mK]	$v_{cent}(Hel)$ [km s^{-1}]	$FWHM$ [km s^{-1}]	rms [mK]
0	0	32	108	43	11
12	-25	41	117	38	16
25	12	57	109	20	20
31	-31	90	121	38	15
37	-13	57	116	43	19
43	-57	33	129	34	10
50	-38	94	129	35	16
69	-44	61	133	32	15
75	-26	60	130	31	16
88	-51	44	138	35	13

Notes: Positions are offsets in arcseconds relatively to $RA = 00^h12^m23^s.5, Decl. = -39^o28'30"$

a) The $N(H_2)W(CO)$ Ratio

Comparing this mass to an averaged W(CO) value of about 3 K km s^{-1}, we derive a X(W(CO)) ratio of 60×10^{20} [molecules cm^{-2} (K $km^{-1})^{-1}$]. This is approximately 20 times the average value for our Galaxy.

An independent estimate for the mass of the molecular gas can be obtained from the *IRAS* FIR fluxes. The use of the S(60)/S(100) flux ratio results in a dust temperatue of T_D=29K and finally in a dust mass of $M_d=3.37\times10^5 M_\odot$.

If we make use of the relation $M(H_2) \sim 500 M_d$ (Young et al. 1989) that holds for a wide range of spiral galaxies, including the Milky Way, we find $M(H_2) \simeq 1.7\times10^8\ M_\odot$. The molecular mass found indicates that the conversion factor for the molecular mass in Irr galaxies as inferred from CO line emission is indeed higher by up to a factor of 20 compared to the canonical value for the Galaxy.

b) Dependence on Metallicity

Metal abundances are considered to be the most important controlling parameters for the relation between the observable CO and the total content of molecular gas (e.g. Maloney and Black 1988). NGC 55 has low metallicity HII regions (Webster and Smith 1983, Vigroux et. al. 1988, and references therein).

In the absence of known carbon abundances we can only compare the different X values with oxygen and nitrogen abundances directly. In Figure 1 we have plotted X/X_G against O/H and N/H abundances. For comparison with the Milky Way we have also included the values for the Orion nebula from Dufour et al. (1982). While a rough dependence of X/X_G on O/H abundances is found for the whole range of metallicities, a good correllation exists between X/X_G and N/H for the low metallicity Irr galaxies.

The dependence on metallicity discussed here can only be indicative and it is of course still possible that the radiation field plays an important role.

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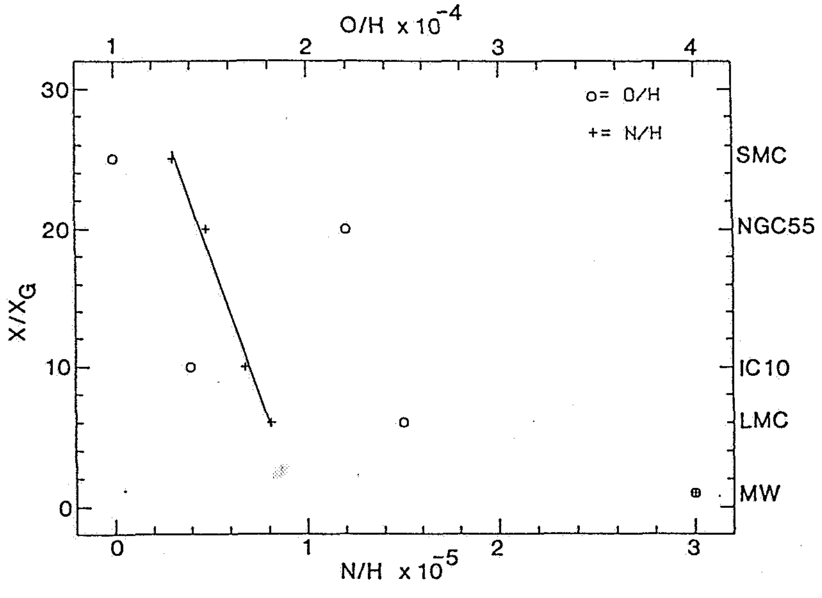

Figure 1: The dependence of X/X_G, the conversion factor X(W(CO) scaled to the average value of our Galaxy, on O/H and N/H abundances. For comparison with the Galaxy abundances for the Orion nebula from Dufour et al. (1982) are included. The continuous line indicates the dependence of X/X_G on N/H for Irr galaxies.