$N(H_2)/I_{CO}$ IN GALACTIC BULGES

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Abstract. Gas masses derived for the bulge regions of the Milky Way and the nearby starburst galaxy NGC 253 using the $C^{18}O$ rotational lines are 5–10 times lower than those from ^{12}CO and a standard X. Also, the distributions of both isotopomers differ. It is suggested that due to the stellar potential, ^{12}CO arises in part from optically thin intercloud gas.

Rotational lines of CO can be easily mapped over large regions of the Galactic plane (e.g., Dame et al. 1987) and can be detected toward more external galaxies than other molecular tracers (e.g., Young et al. 1995). It is, therefore, wishful to think that these measurements have a simple meaning. A correlation between the velocity integrated intensity of CO and the column density of H_2 was first found empirically for a number of clouds in the Galactic disk. Theoretical approaches, which explain and quantify this correlation remarkably well (e.g., Radford et al. 1991; Downes et al. 1993), require that the CO emission is a) optically thick, b) subthermally excited, and c) arises from virialized clouds. In particular, Mauersberger et al. (1996) stress that if a) is not fulfilled, $X = N(H_2)/I_{CO}$ will be 40 times smaller than the commonly assumed value by Strong et al. (1988). In the optically thick case, X is not very sensitive to the assumed CO abundance.

Optically thin tracers, such as the $C^{18}O$ rotational lines or thermal FIR/(sub-)mm continuum, are alternative tracers of H_2 (see Mauersberger et al. 1996 for a compilation of useful relations) and can be used to check the value of X. A map in the $C^{18}O$ $J = 1$–0 line of the inner 500 pc of the Galactic center has recently been obtained with the 1.2 m mini radiotelescope on Cerro Tololo (beam width: $9'$) (Dahmen et al. 1996; Fig.1).

In Table 1, total gas masses from CO are compared with those from dust and $C^{18}O$ in the centers of the Milky Way and the nearby starburst galaxy NGC 253 (Mauersberger et al. 1996). The dust emission as well as

Figure 1. Contours of ^{12}CO (200, 400, 600... K km s^{-1}) and C^{18}O $J = 1$–0 (2.5, 5, 7.5... K km s^{-1}) emission from the Galactic center (Dahmen et al. 1996).

TABLE 1. Gas mass in two galactic bulges

Source	Method[a]			
	^{12}CO	C^{18}O	cold dust	$M_{\rm dyn}$
	(10^8 M$_\odot$)			
Milky Way (inner 500 pc)	1.7[b]	~ 0.15	0.15–0.5[d]	60[g]
NGC 253 (inner 150 pc)	3[b,c]	~ 0.6[e]	0.4[f]	10[h]

a) See Mauersberger et al. (1996) for relations used; b) X from Strong et al. (1988) corrected for calibration error (Bronfman et al. 1988); c) $I_{21}/I_{10} = 0.9$ assumed; d) Sodroski et al. (1995); e) data: Sage et al. (1991); f) flux density: Krügel et al. (1990) corrected for the ^{12}CO (2–1) contribution; dust conversion: $b = 1.9$, $Z = 3$Z$_\odot$, $T_{\rm d} = 30$K (see Mezger 1990). g) Güsten et al. (1989) h) from the CO rotation curve.

the $C^{18}O$ emission lead to values for the gas mass that are 5–10 times lower than the masses from ^{12}CO. The different spatial distributions of ^{12}CO and $C^{18}O$ in the Galactic center show that those cannot both be good tracers of H_2 in that region. Presumably the line widths are not only determined by the clouds' virial masses but by the stellar potential (Stacy et al. 1989; Solomon 1996). In some cases, line widths become large enough that ^{12}CO is no longer optically thick (Stark & Bania 1986). That a "standard" X determined from disk clouds can probably not be applied to clouds in the galactic bulges is also supported by the detection of galaxies where the dynamical mass based on stellar velocities is lower (!) by a factor of 4–10 than the H_2 mass obtained from ^{12}CO (Shier et al. 1994).

Any model of the bulge molecular emission has to take into account that it arises from a multicomponent medium with a range of kinetic temperatures and densities (Mauersberger et al. 1995; Aalto 1996). The Southern mini and the new 60 cm southern mm-wave radiotelescope (Hasegawa 1996) may yield important clues about the more excited gas component in the Galactic bulge.

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