# PHYSICAL CONDITIONS OF THE GAS IN THE CENTER OF THE NEARBY SPIRAL GALAXY IC 342

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## 1. Introduction

One of our nearest neighbors is a large spiral galaxy with abundant molecular gas in its nucleus. IC 342, a face-on Scd galaxy at a distance of 1.8 Mpc, is close enough to give us a view of individual molecular clouds with millimeter interferometry. The CO distribution in the nucleus of IC 342 consists of two very open spiral arms (Lo et al. 1984; Ishizuki et al. 1990) that continue to within 50 pc of the dynamical center (Turner & Hurt 1992). The total extent of the nuclear "mini-spiral" is $\sim$ 500 pc. Corresponding arms are observed in H$\alpha$ (J.S. Young, private comm.). However, the H$\alpha$ arms are systematically offset by 50-100 pc from the CO arms (Turner & Hurt 1992). The offset of the H$\alpha$ arms to the outer, leading edge of the CO arms is consistent with a picture of density wave-induced star formation in the arms (Turner & Hurt 1992). Energy dissipation and angular momentum transfer in spiral arms is believed to drive a slow drift of gas inward; if this is the case, the molecular "mini-spiral" in IC 342 is short-lived, and will probably no longer exist in another $10^8$ years.

## 2. Tides, Densities, and Temperatures

Accompanying the arm features are large velocity gradients, as expected for orbits in a density wave or bar potential. The observed velocity gradient across the 50-100 pc width of the arms is $\sim$40 km s$^{-1}$ (Turner & Hurt 1992). Tidal effects on the clouds are severe. Stark et al. (1989) estimate for the Galactic Center and Downes at al. (1992) for IC 342 that the molecular clouds must have densities of $> 10^4$ cm$^{-3}$ to survive. Are there gravitation-



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ally bound clouds in IC 342? Clearly there are, because the H$\alpha$ emission indicates that these clouds are forming stars.

Do we see this dense gas in IC 342? Observations of HCN (Downes et al. 1992), and $^{13}$CO (Turner & Hurt 1992) indicate that there is dense gas, located primarily in a few clouds of $\sim$ 50 pc extent within a more diffuse component visible in $^{12}$CO (Wright et al. 1993). However the $^{13}$CO and HCN distributions are not identical. Near the main radio continuum source and most actively star forming region, $^{13}$CO is relatively weak and HCN is strong. $^{13}$CO is probably suppressed in this region because of the high gas temperatures, and because of the lack of fractionation effects which favor $^{13}$CO production in cool molecular clouds. HCN may be radiatively rather than collisionally excited in this region by the high infrared radiation field near the starburst. So in the region of most intense star formation, where we are very much interested in the gas properties, our knowledge of the dense gas distribution is limited.

What is the excitation of the gas in IC 342? There is clearly quite warm (T$\sim$ 70K) gas in the nucleus of IC 342 (Martin & Ho 1986). However the relative amounts of warm and cool gas are not established, since the emissivities of the brightest, optically thick molecular lines are usually dominated by warm gas. Analysis of the excitation of the low J CO lines indicate that the emission from these lines is dominated by warm, outer layers of molecular clouds, in "photodissociation regions" (Eckart et al. 1990; Turner et al. 1993). Gas properties in these regions change so quickly that the CO(2-1)/CO(1-0) ratio is actually indicative of optically thin gas. The rarer isotopic transitions, while better tracers of the bulk of the molecular gas, have ratios of $^{13}CO(2-1)/^{13}CO(1-0) \sim 1$ (Meier et al. 1997). Thus the $^{13}$CO low J lines are optically thick. To determine the true temperature of the cores of these molecular clouds, optically thin tracers are required, and. Until then, the relative amounts of warm and cool gas in the nucleus of IC 342 must be regarded as uncertain.

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