COMMENTS ON THE DISTRIBUTION OF MOLECULES IN SPIRAL GALAXIES

L. J Rickard
Howard University

Patrick Palmer
University of Chicago

1. AXISYMMETRIC STRUCTURE

Young and Scoville (1982) have argued that the CO distribution, and by inference the H_2 distribution, follows the shape of the blue luminosity of the disk, and is thus exponential. However, full maps of bright-CO galaxies (Rickard and Palmer 1981) show considerable structure, with real peaks and depressions on scales as small as the telescope beam. This means that the noise in the determination of the underlying structure is dominated not by the instrumental contribution but by the intrinsic noise of the structure itself. A correct analysis of the axisymmetric structure requires the use of statistical tests comparing the observations with different hypothetical distributions. One finds that equally good fits can be obtained with exponential distributions, r^{-1} distributions, or even flat disks with central nuclei. However, profiles of the full map data averaged over azimuth, with "error" bars determined by the structural variation with azimuth, show a clear deviation from the optical luminosity profile in the outer disk of NGC 6946. Furthermore, if the profiles for NGC 6946 and IC 342 are fit with exponentials, the scale lengths are rather larger than previously suggested (8.9 and 6.6 kpc, respectively). By sampling only a few radii, one can miss much of the emission of the outer parts of the galaxies, and also underestimate the intrinsic noise of the structure.

These questions involve the CO distribution alone. The step to the H_2 distribution requires additional assumptions about conversion factors. The empirical conversion factor is still uncertain to at least a factor of two; e.g. Frerking et al. (1982) find rather less H_2 per unit CO emission than do Young and Scoville. That factor can have drastic consequences on where the H_2 and HI distributions are found to be comparable, and what the actual shape of the total proton distribution will be. Furthermore, the conversion is probably not constant over the entire disk. Far-IR color temperatures (Rickard and Harvey 1983) and ^{13}CO data (Rickard and Blitz, in preparation) indicate changing characteristic cloud temperatures from the center outward, requiring a similarly varying conversion factor from ^{12}CO integrated intensity to H_2 surface density.

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2. IS THERE SPIRAL STRUCTURE IN THE CO DISTRIBUTIONS OF GALAXIES?

Spiral structure is clearly present in the CO distribution of M31. Linke (1982) reports a high arm-interarm contrast in the SW part of M31. Admittedly, the structure in this region is rather complex; e.g. Unwin (1980), in describing the HI data, prefers to call it a set of spiral-arm segments. But the fact of the contrast is indisputable. On the other hand, M31 is a rather different CO galaxy from most studied. It has no detectable central molecular source, and it has a very low ratio of H_2 to HI mass surface density (about 0.1). Spiral contrast may vary from galaxy to galaxy depending, among other things, on the H_2 to HI ratio.

A galaxy with well-defined, high-compression spiral structure, like M51, that also has a high H_2 to HI ratio (larger than 1 for M51, NGC 6946, IC 342, etc.) would be better for study. Yet full CO maps have so far shown no obvious spiral structure in such galaxies. There is, though, a resolution problem, even for the 45" FCRAO telescope. A convolution of the Tully (1974) Hα spiral pattern with a 1' beam produces a rather spiral-less shape for M51. In order to extract a pattern from the CO data, one must turn to statistical analysis.

Using an axisymmetric model of central source plus flat disk, one finds a best-fit arm-interarm contrast for M51 of about a factor of 4. However, the noise in the map - which is dominated by the intrinsic noise in the structure of the galaxy itself - results in an inability to exclude at the 95% confidence level either the case of a very large contrast or the case of no contrast at all.

IC 342, on the other hand, being at only half the distance, allows better resolution of the spiral pattern. Recent CO observations of the NW quadrant show one region of size about 2' x 3' that is enhanced above the surrounding disk. It coincides in position with a segment of the spiral pattern that is well defined in near-IR photographs (Elmegreen 1982). This feature has recently been confirmed by reobservation with the newly resurfaced NRAO 12-m telescope. The arm-interarm contrast (between the arm segment and the regions on either side at the same azimuth) is about a factor of 3.

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