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Environmental Effects on the ISM and Star Formation Properties of Nearby Spiral Galaxies

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Abstract. We studied molecular gas properties in a sample of 98 H I - flux selected spiral galaxies within ~ 25 Mpc using the CO $J = 3 - 2$ line, observed with the JCMT, and subdivided into isolated, group, and Virgo subsamples. We find a larger mean H_2 mass in the Virgo galaxies compared to group galaxies, despite their lower mean H I mass. Combining our data with complementary Hα star formation rate measurements, Virgo galaxies have a longer molecular gas depletion times compared to group galaxies, perhaps due to heating processes in the cluster environment or differences in the turbulent pressure.

Keywords. galaxies: ISM, galaxies: spiral, ISM: molecules, stars: formation

1. Introduction and Sample Overview

The properties of galaxies, as well as their evolution, are influenced by their local environment, from isolated galaxies to groups of tens of galaxies to clusters of hundreds or even thousands of galaxies. Past studies have shown a deficiency of atomic hydrogen (Chamaraux *et al.*1980) and a reduction in the scale length of Hα emission (Koopmann *et al.*2006) in cluster spirals. Many possible physical processes have been invoked to explain these effects, such as harassment from other cluster members, starvation from their gas supply, and ram-pressure stripping. Whether these processes can affect the molecular gas component deep inside the potential well of the galaxy remains an unresolved question.

The sample consists of 98 gas rich (H I flux > 6.3 Jy km/s), nearby (< 25 Mpc), spiral galaxies. This includes 39 galaxies in the Virgo Cluster, 42 in smaller groups from the Garcia *et al.*1993 catalogue, and 17 in isolated environments. We use CO$(3-2)$ data observed with the JCMT (James Clerk Maxwell Telescope) using HARP-B from the Nearby Galaxies Legacy Survey (NGLS) (Wilson *et al.*2012) and two follow up surveys. Additional data include H I fluxes from HyperLEDA (Paturel *et al.*2003), stellar masses primarily from the S^4G Survey (Sheth *et al.*2010), and Hα star formation rates from the NGLS Hα paper (Sanchez-Gallego *et al.*2012), GOLDmine database (Gavazzi *et al.*2013), and the HRS Survey Hα paper (Boselli *et al.*2015)

Only $\sim 44\%$ of galaxies were detected in the CO$(3-2)$ line, therefore we have decided to incorporate the use of censored data using survival analysis. Once the survival functions are found using the Kaplan-Meier estimator, we can then calculate important statistics, such as medians and means, and perform the appropriate statistical tests.

2. Results and Implications

We find a higher mean log H_2 mass in the Virgo sample (8.34 ± 0.13 [$M_\odot$]) compared to the group sample (7.98 ± 0.08 [$M_\odot$]). Combined with the known H I deficiency for spirals in the Virgo cluster and their higher ratio of M(H_2) to M(H I), this suggests that the cluster environment

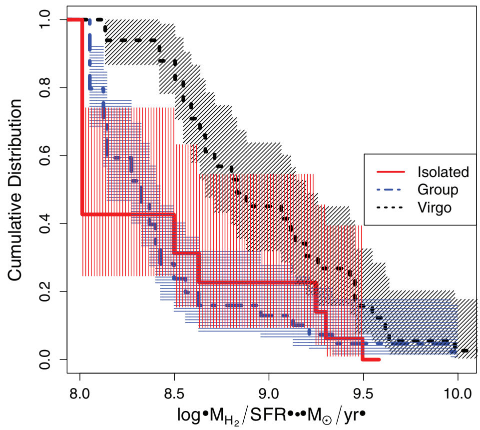

Figure 1. Survival functions for the molecular gas depletion time in the isolated (solid line), group (dot-dash line), and Virgo (dashed line) sample galaxies using the Kaplan-Meier estimator. The 'steps' in the distribution correspond to detections. The 95% confidence intervals are overlaid for the three distributions, showing differences between the Virgo and group samples.

may be aiding in the conversion process of atomic to molecular gas. Conversely, the longer mean log H_2 gas depletion times for cluster galaxies (8.97 ± 0.06 [yr]) compared with the group galaxies (8.44 ± 0.07 [yr]) indicates that Virgo galaxies are less efficient in converting their molecular gas reservoir into stars, perhaps due to heating processes in the cluster environment or differences in the turbulent pressure. This is presented graphically in Figure 1, with the cumulative distribution functions for the three samples with the use of survival analysis.

For our whole sample, we find the strongest correlation in galaxy properties between $M(H_2)$ and stellar mass. Looking at the H_2 gas depletion times, we find a positive correlation with M_* and a negative correlation with the specific star formation rate. The correlation with M_* suggests a reduction in star forming efficiency in high mass galaxies and more 'bursty' star formation in low mass galaxies. The correlation with sSFR suggests a link between a galaxy's star formation history and potential future star formation.

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