Analyzing Neutral Hydrogen and Midplane Pressure in Galaxy NGC 3941

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Introduction

The study of the cold gas, atomic (HI) and molecular (H_2) hydrogen, is often conducted for inputs into models of galaxy evolution. The density of HI regions determines eventual H_2 forming regions and is an important factor in star formation. We thus study the neutral gas in NGC 3941 to analyze such trends.

Galaxy NGC 3941

NGC 3941 is a CO poor early-type galaxy that exhibits a counter-rotating HI disk that extends beyond its optical range, suggesting a past merger event (Fisher, 1997). Additionally, it is a double-barred galaxy with small inner spirals structures (Erwin & Sparke, 2002; Laurikainen, 2005).

In this study, we investigate the ***ratio of R_{mol} (H_2/HI) to the hydrostatic midplane pressure in NGC 3941.***

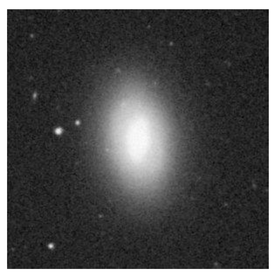

Figure 1: Digital Sky Survey image of NGC 3941 in R band. The galaxy is 12.4 kpc in diameter and is located in Ursa Major (McGlynn et al., 2008).

References

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Methods

We use HI observations from the VLA D,C,B Arrays, existing CO images from the Atlas[3D] survey, and stellar volume densities derived from K-band Spitzer images to calculate the hydrostatic midplane pressure with the equation below.

$$P(0) = G\Sigma_g^2 + [(G\Sigma_g^2)^2 + 2G\Sigma_g^2\rho_s\sigma_g^2]^{1/2}$$

All VLA data calibration and imaging was done using standard calibration tasks in the CASA software package.

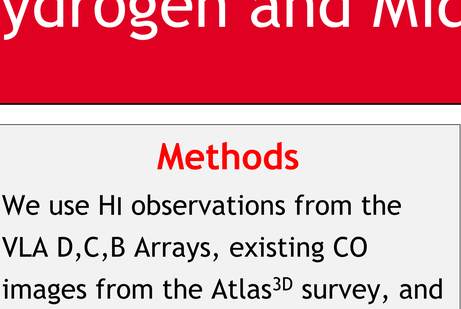

Figure 2: Open source image of the Very Large Array in New Mexico.

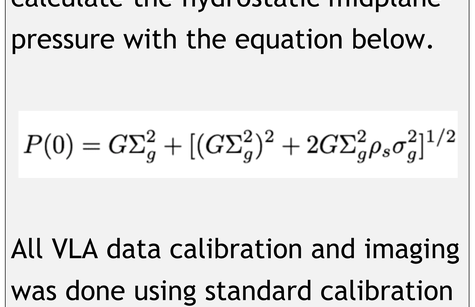

Figure 3: Image of the antenna positions in the Very Large Array. A reference antenna is chosen towards the center of the array to calibrate data.

Results

Compared to past imaging, we produce 3-5 times higher resolution HI images of NGC. The neutral hydrogen is resolved into an HI hole at the center of the galaxy and two HI rings, likely due to a double bar in the center of the galaxy (Murugeshan, 2023). When comparing H_2/HI to midplane pressure, the trend is similar to that derived for spiral galaxies, a surprising result! This may be due to the presence of spiral arms previously detected in deep optical imaging (Laurikainen et al., 2005), causing the pressure to be similar to spiral galaxies.

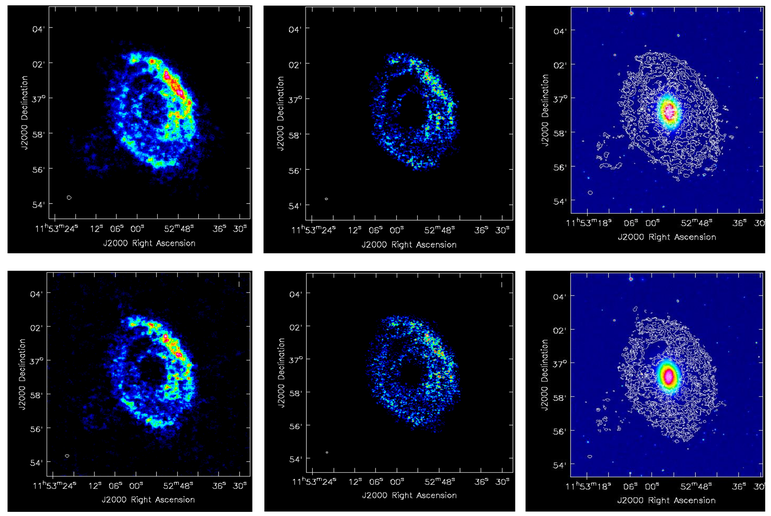

Figure 4: Moment/Contour maps of the HI content in NGC 3941
Top: B+C+D array Natural (14"), Robust (8"), Natural Contour Map
Bottom: B+C array Natural(12"), Robust(7"), Natural Contour Map
Key Features: Two HI rings are observed and an HI hole is at the center of the galaxy with some HI at the center. A companion dwarf galaxy is also seen.

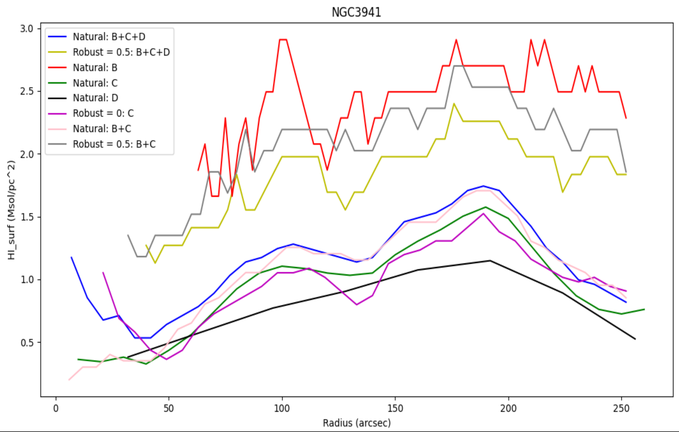

Figure 5: The radial HI surface density distribution derived from azimuthal averages in the HI maps.
Key Features: A peak at 0 arcsec, a dip at 50 arcsec, and two other peaks at 100 and 175 arcsec indicate two rings of hydrogen within NGC 3941.Higher resolution images detect higher density HI, but resolve out the more diffuse HI In the center.

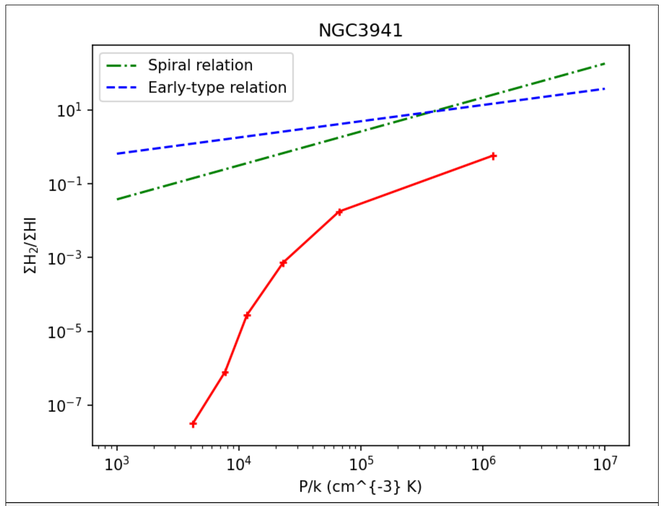

Figure 6: Depiction of the Midplane Pressure to H2/HI ratio. Blue represents the recent relation for early-type galaxies, green is the relation for spiral galaxies (Walter et al., 2008).

Key Features: The slope of our galaxy is ***much closer to the spiral relation, even though it's an early-type galaxy***.

Future Work

More research is needed into the extent of the spiral arms within NGC 3941, as well as explanations for the HI rings and their size. This galaxy was one of 32 early-type galaxies selected by Dr. Lucero to further understand the R_{mol} to pressure relationship for early-type galaxies, and how that diverges from spiral galaxies. This analysis will be extended to the rest of the galaxy sample.

Acknowledgements

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