

# Interstellar Gas and Massive Stars in External Galaxies



## Initial Results for the Galaxies M33 and NGC4517

Maria T. Patterson, Rene Walterbos

New Mexico State University, Las Cruces, NM 88003



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UNIVERSITY

### Abstract

Understanding the intricate relationship between gas and stars is critical to understanding star formation in an evolving galaxy. Over time, compressed regions of neutral hydrogen create clouds of molecular gas, which then gravitationally collapse to form stars. In turn, the radiation from these young stars then affects the surrounding gas. I aim to further explore this interplay to gain a deeper understanding of the evolution of gas in a galaxy and the star formation process.

Using new high-resolution data of neutral hydrogen gas in the nearby galaxies M31, M33, and the LMC, we observe that high density neutral hydrogen is organized into filamentary structures and small isolated clouds roughly 300 lightyears across. (Braun et. al. 2009). I study the correlation between these clumps of dense hydrogen and regions of star formation, using far-infrared data at 24 microns taken with the Spitzer Space Telescope to identify star forming regions. The goal of this aspect of the project is to find out if star formation preferentially occurs in the high density filaments or if there are other causes for the filamentary nature of the gas. In a second project, I study the radiative effect of young, massive stars on the surrounding interstellar gas. The hot UV stellar photons ionize and heat the remaining hydrogen gas, thereby self-regulating the star formation process. We study in detail how this ionization takes place in external galaxies using emission line photometry of the ionized gas.

### Analysis

Figure 1. shows the opaque neutral hydrogen gas and star forming regions in the galaxy M33. Enclosed in the red boxes are seven regions I chose to look at in detail. By looking at the intensity of 21 cm emission as well as the intensity of 24 micron emission in the same pixel of both images, I can directly look for correlations between neutral hydrogen gas density and star formation. Although there are some regions of high opacity gas that overlap with star forming regions, there are both areas of high density neutral hydrogen with no star formation as well as regions of star formation in low density gas. The optically thick neutral hydrogen gas does not seem to be correlated with 24 micron emission. There does, however, seem to be a possible threshold for neutral hydrogen gas column density around  $2 \times 10^{21} \text{ cm}^{-2}$  below which 24 micron emission is not observed. This could indicate a possible threshold in the density of gas before star formation can occur.

Fig. 2

**Right:** An H $\alpha$  image of the edge-on galaxy NGC891. The H $\alpha$  emission line traces recent star formation since young, hot stars ionize the surrounding medium and cause light at this wavelength to be emitted. NGC891 is an Sb galaxy with high star formation rate per area. (Figure from Hoopes et. al., 1999)

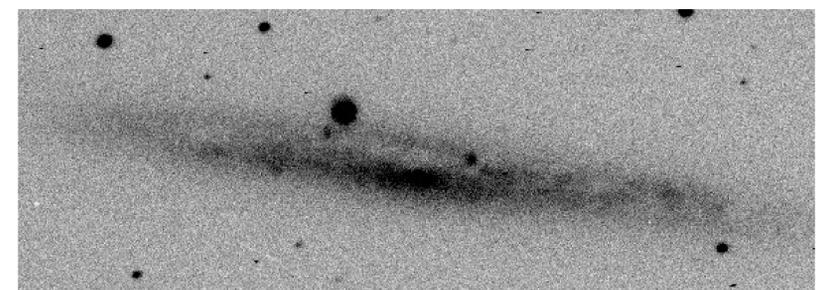
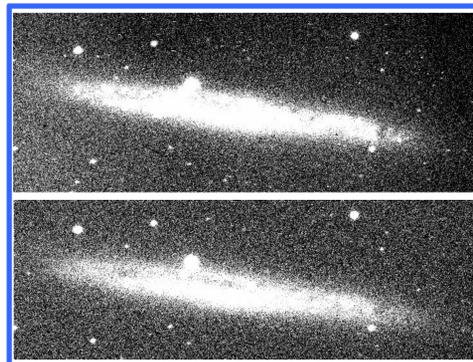
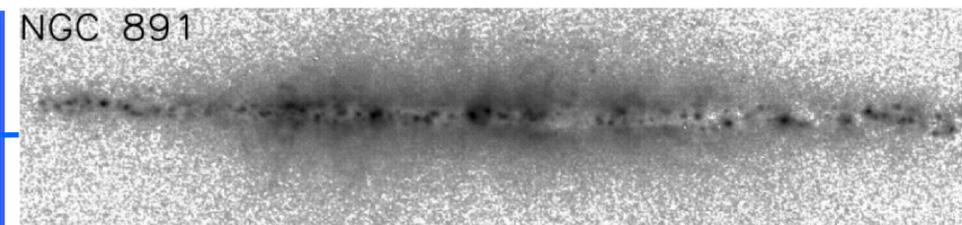


Fig. 3

**Top Left:** Two images of the edge-on galaxy NGC4517 taken through an H $\alpha$  narrow band emission line filter (top) and a red continuum filter (bottom) with the NMSU 1-meter telescope at Apache Point Observatory. In order to produce an image of the star forming regions, such as the image of NGC891 in Figure 2., the underlying continuum light must be subtracted from the H $\alpha$  narrow band emission line filter image.

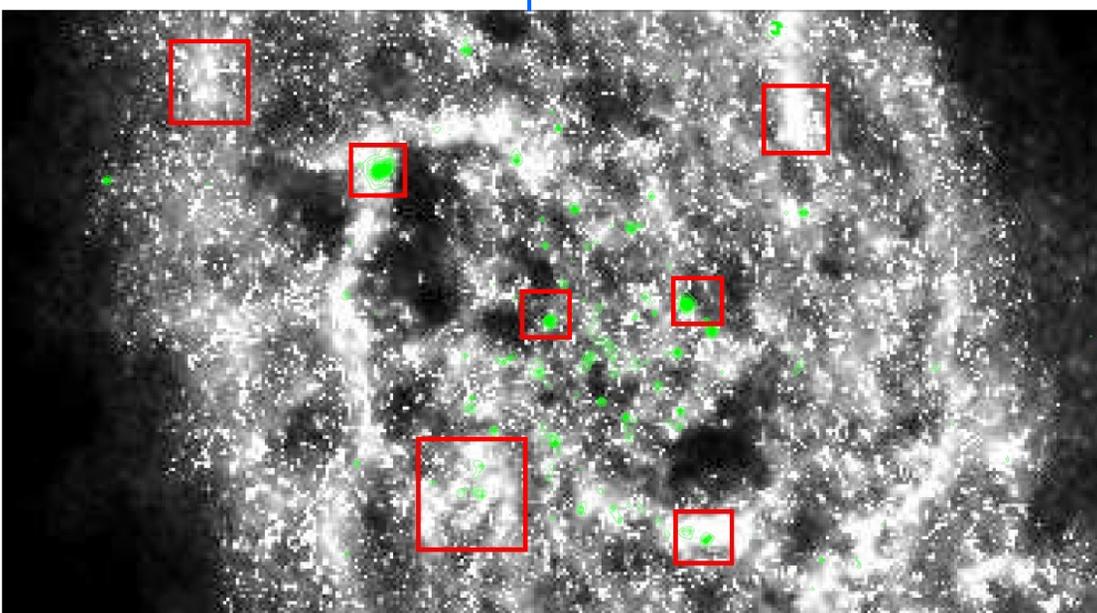
**Top Right:** A continuum subtracted H $\alpha$  image of NGC4517, similar to the image of NGC891 in Figure 2. The white regions in the dark disk are areas of ionized gas from recent star formation.

Fig. 1

**Top Left:** A column density map of opacity corrected neutral hydrogen gas in the galaxy M33, made from 21 cm data taken with the Very Large Array. The brightest white regions mark the highest column densities of neutral hydrogen gas.

**Top Right:** M33 imaged at 24 microns with the Spitzer Space Telescope. The brightest white regions of high 24 micron emission from dust heated by hot stars can be used to trace areas of recent star formation (e.g. Calzetti et. al. 2005).

**Bottom:** A central region of the above left M33 neutral hydrogen column density map overlain in green with 24 micron contours from the above right image. This image shows the coincidence of high density gas with star forming regions. The red boxes enclose specific regions I chose to analyze further.



### Summary

Although there are regions of the galaxy M33 which show both high density neutral hydrogen gas and 24 micron emission, high density gas does not always have a 24 micron counterpart, and 24 micron emission is seen where the gas is optically thin. No definite correlation is seen between optically thick neutral hydrogen column density and star forming regions. However, there may be a possible threshold in the density of the gas before 24 micron emission is observed, as seen in the seven boxed regions in Figure 1.

Our future plans include studying several edge-on galaxies such as NGC4517 in Figure 3. We will be imaging them in the H $\alpha$  emission line and comparing the vertical extent of the ionized gas from star formation to existing data showing the vertical extent of the neutral hydrogen gas. H $\alpha$  emission line imaging of the extraplanar diffuse ionized gas as compared to the neutral hydrogen gas can give insight into the role of young, massive stars and their influence on the surrounding gaseous medium.

### References

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Calzetti, D., et al. 2005, ApJ, 633, 871  
Hoopes, C.G., Walterbos, R.A.M., Rand, R.J., 1999, ApJ, 522, 669  
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