A Gentle Breeze or a Hurricane? Revealing the Secrets of Galactic Winds in a Neighboring Galaxy

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Background & Motivation

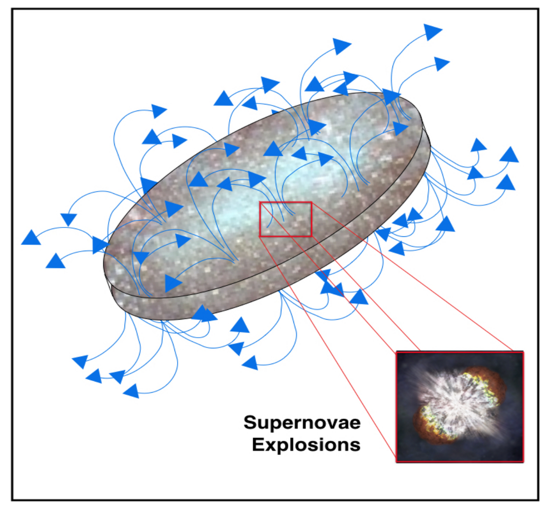


Figure 1: A cartoon of a galaxy with gaseous material escaping from the disk due to supernovae explosions. (Image credit for the galaxy goes to Eckhard Slawik and the artist depiction of a supernovae explosion is credited to NASA/CXC/M.Weiss.)

Massive stars die through supernovae explosions which propel enormous amounts of energy into the surrounding gaseous material. Galactic winds form from the gas escaping the disk of the galaxy.

In order to form future stars, a galaxy needs gaseous materials. However, supernovae explosions drive the available gas outside the galaxy. By studying galactic winds, we can better understand how a galaxy's environment is related to its evolutionary progression.

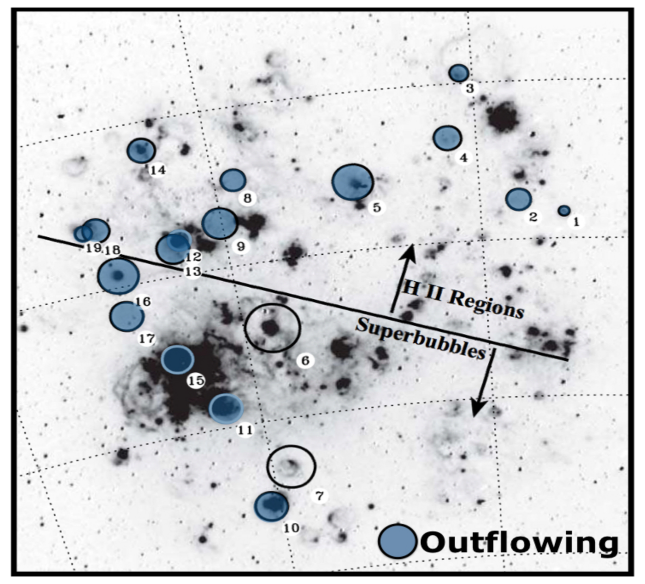


Figure 2: A modified reprint from Lehner & Howk 2007 showing areas of outflowing gas in a nearby galaxy.

Our Neighboring Galaxy

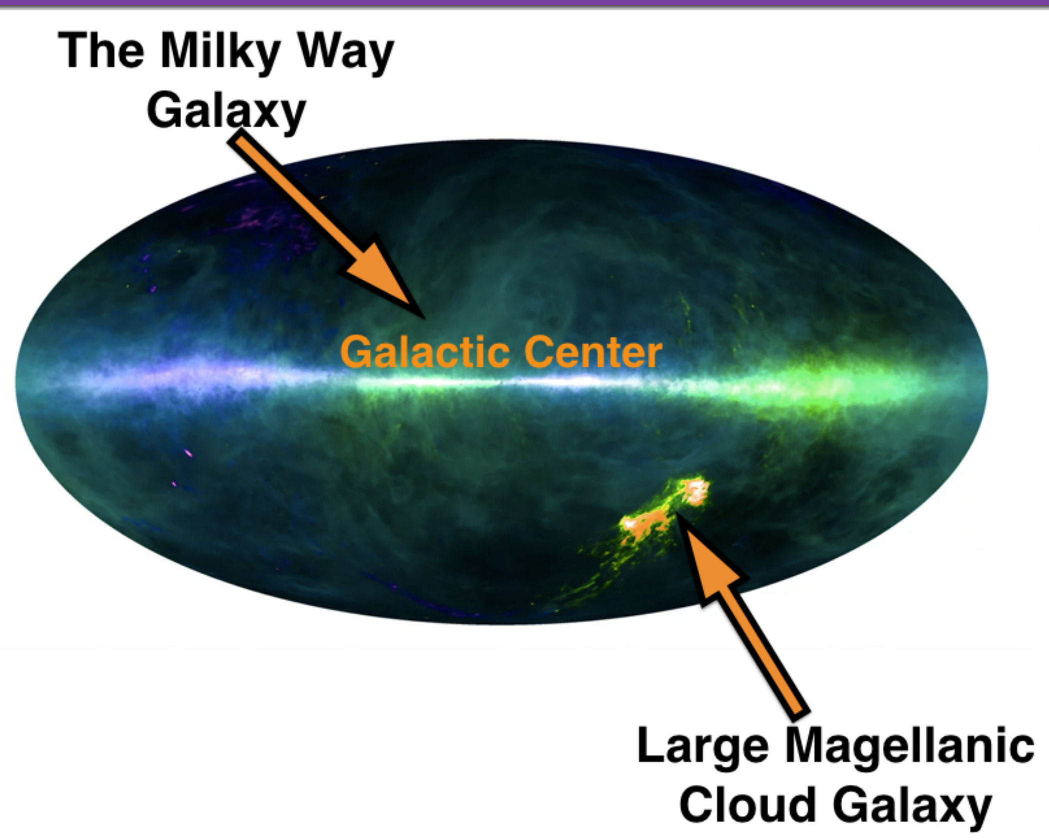


Figure 3: Here is the neutral hydrogen emission map of our galaxy and our neighboring galaxy the Large Magellanic Cloud (LMC) from the HI4PI survey[2]. The Milky Way is the prominent glowing band in the central region and the LMC is off to its lower right.

Our closest gas-rich neighboring galaxy is the Large Magellanic Cloud (LMC). The LMC is the ideal candidate to investigate galactic winds as it is located only one Milky Way diameter away from us[7], oriented in a face-on direction[3,5], and expelling 85 million Sun's worth of gas[1]. These characteristics give researchers an unprecedented view into the stellar activity driving the outflows.

An Active Starburst Region

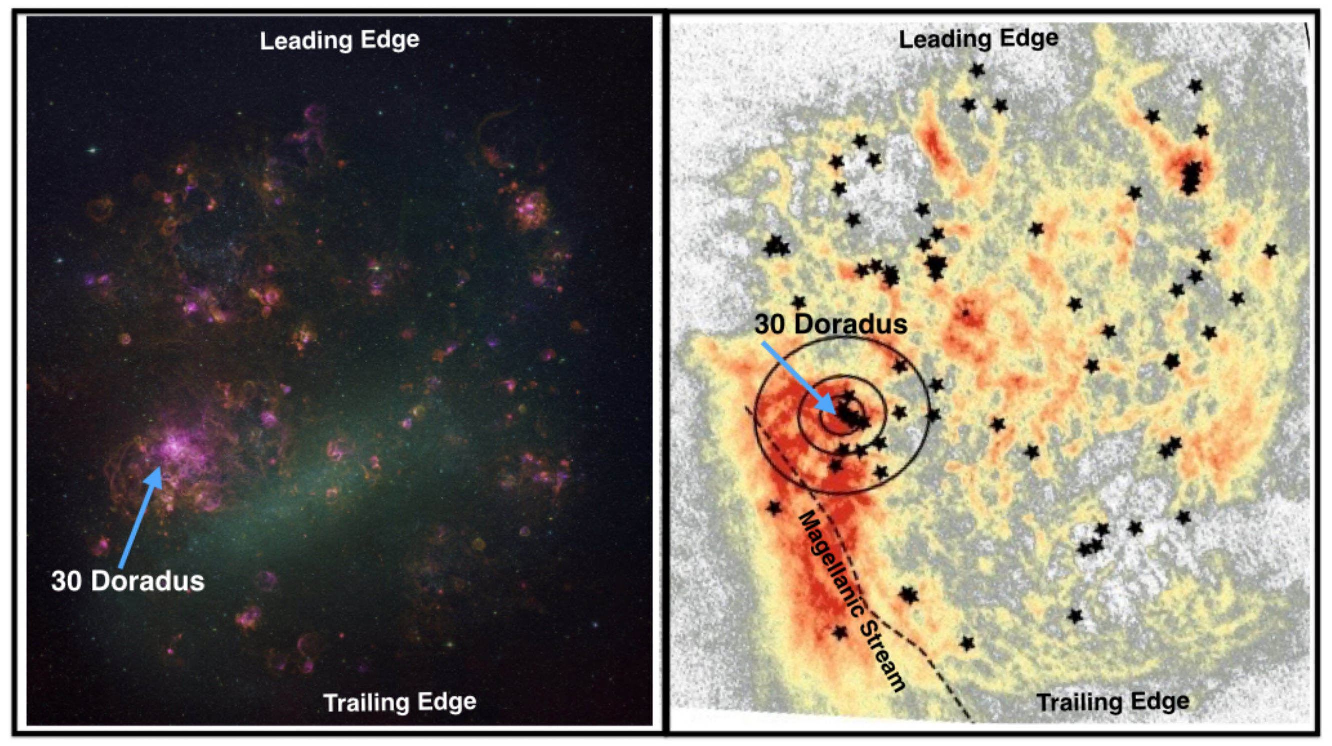


Figure 4: The left image is from the Magellanic Cloud Emission Line Survey (MCELS) and shows the location of the ionized gas in the interstellar medium (ISM) of the LMC. The red hues show ionized hydrogen, green traces sulfur, and the yellow colors display areas with oxygen (Image Credit: C. Smith, S. Points, and the MCELS Team and NOIRLab/NSF/AURA). The image on the right displays the neutral hydrogen emission in the LMC with data from the Galactic All-Sky Survey (GASS). The orientation of the LMC is referenced as well as the location of the starburst region 30 Doradus. Brighter red regions are locations with more stellar activity occurring.

We are using observations from the Hubble Space Telescope (HST) to probe the chemical absorption fingerprints of the light that pass through the LMC's galactic wind. We are investigating the wind through ~150 bright, massive stars in the LMC.

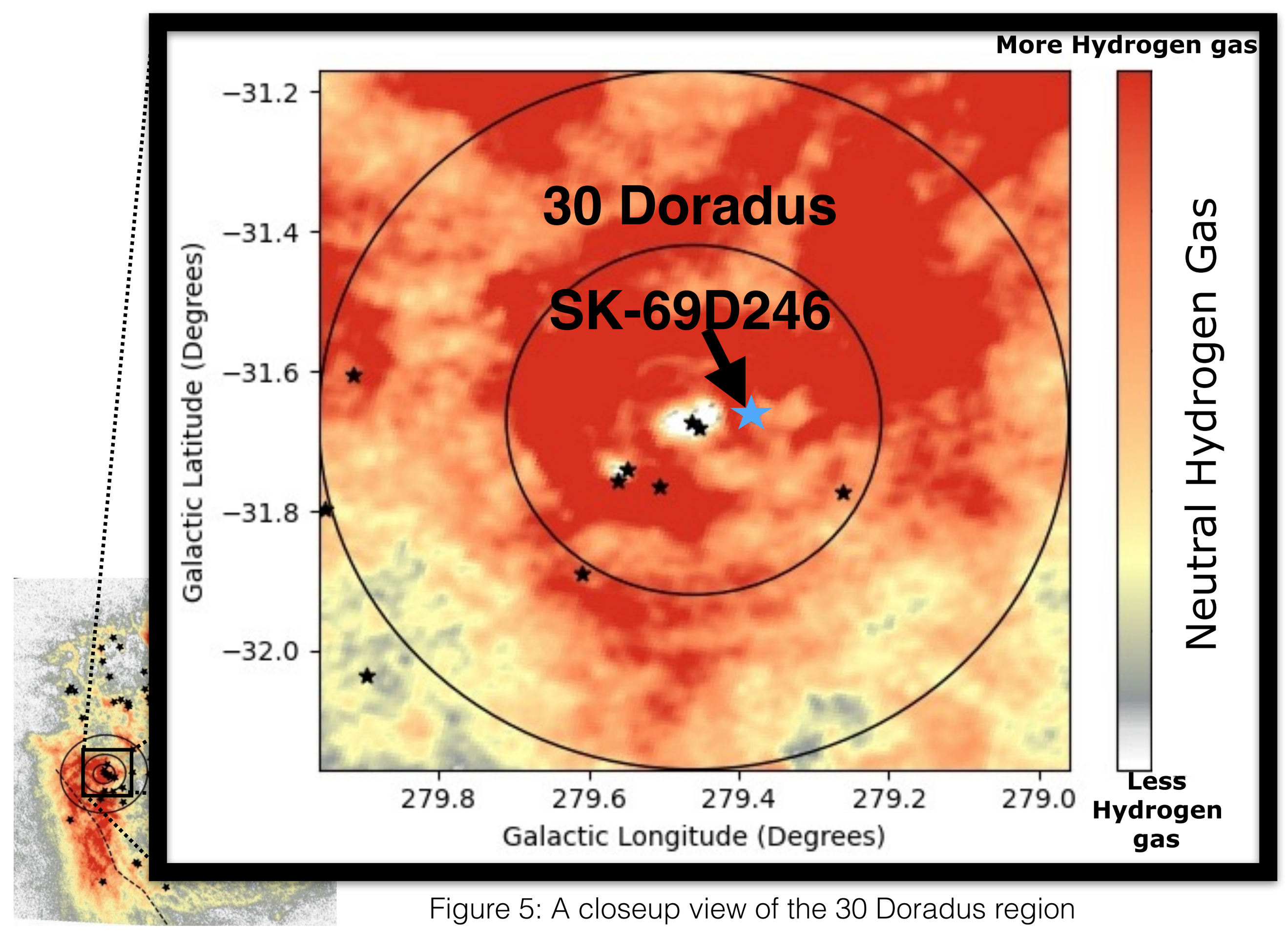
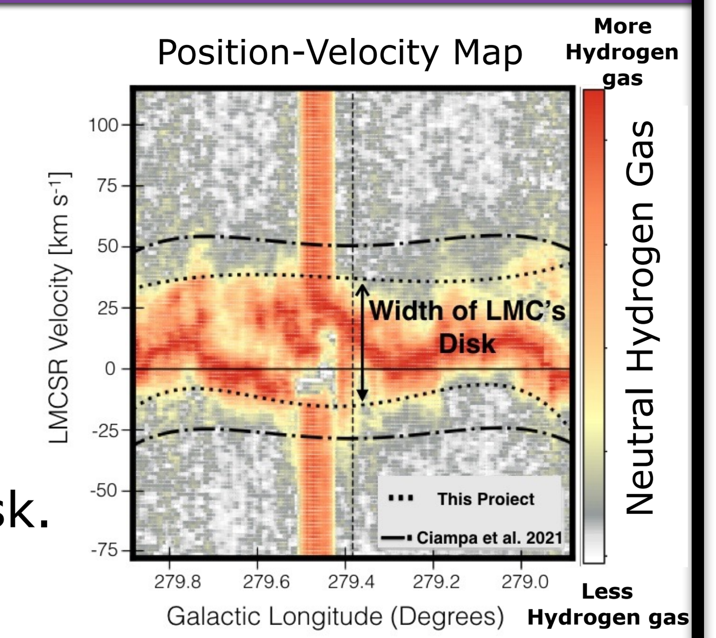


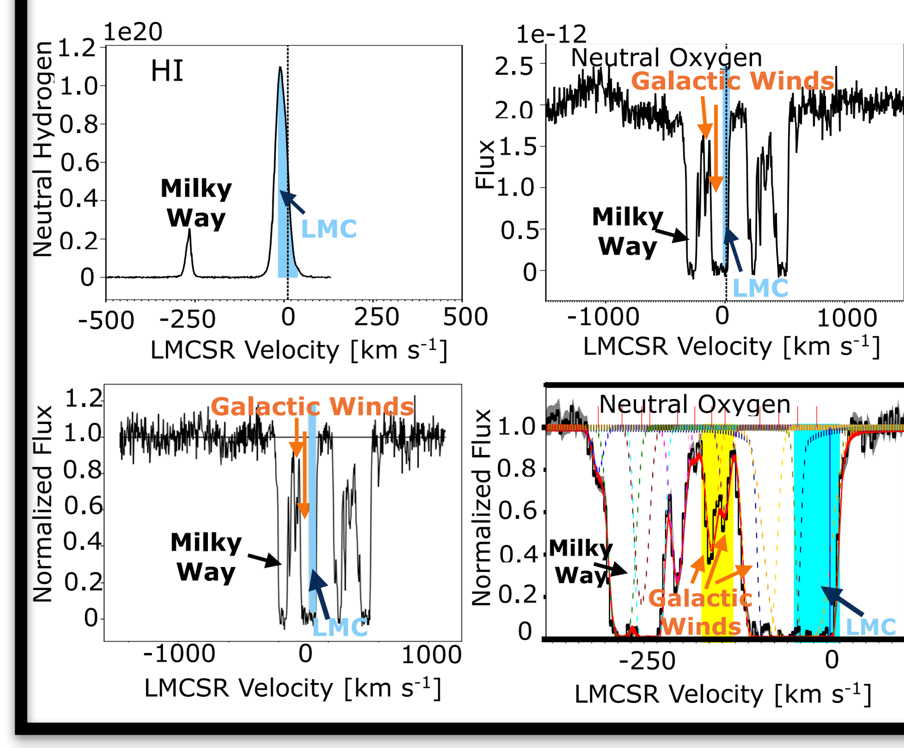
Figure 5: A closeup view of the 30 Doradus region

Inside the LMC, there is a highly active starburst region known as 30 Doradus. This region has a multitude of older stars that are exploding and creating turbulence in the region. We are beginning our investigation into the LMC's galactic winds by studying 5-10 sightlines close to the center of 30 Doradus. We showcase sightline SK-69D246 as an example.

Characterizing the Winds

We utilize the GASS observations to trace the motions of the neutral hydrogen gas. We created position-velocity maps to explore how the neutral hydrogen varies kinematically across the LMC. We calculated the central velocity and widths of the spectral lines' emission to find the average kinematic boundary of the disk.





To determine the properties of winds, we will fit the ion transitions with Voigt[4] profiles. These fits will provide information on how much gas is between us and the background star, how fast the wind is moving, and its kinematic width.

Future Work

These are our future project goals:

- Estimate the ionization state of the gas inside the galactic winds and the kinematic properties of the outflow
- Determine large- and small-scale properties of the wind
  - Distribution of the gas
  - Outflow rate
  - How much light from the background stars is being absorbed at specific wavelengths
- Identify how much the starburst region 30 Doradus contributes to the LMC's galactic winds

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One of our closest galaxy neighbors is expelling 85 million Suns' worth of gas. These outflows are called galactic winds. Bright stars inside the galaxy shine their light through the galactic winds allowing us to decipher the properties of the outflows. We are using observations of the stars' light to determine how much gas is outflowing, how fast it is traveling, and its temperature.

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