Star Formation in Nearby Galaxies

Prendergast Ladywell School

Steven Faragaianu, Kemal Gazi, Miles Hansell, Ashley Hassell, Charlles Junior, Fritha Price, Jack Tolan, Shirley Wang

Orbyts Fellow: Amara Mighty

Motivation

The study of star formation holds vital significance across numerous domains of astrophysics. This project investigates trends in star formation with global galaxy properties. We also study individual star forming regions to discover where in a galaxy most star formation is happening.

Background Theory

What is a galaxy?

A galaxy is a huge collection of dust, gas, a central black hole, and billions of stars. There are different types of galaxies including spiral and elliptical. Spiral galaxies tend to be more star-forming than elliptical galaxies. We live in a spiral galaxy called the Milky Way.

How are stars formed?

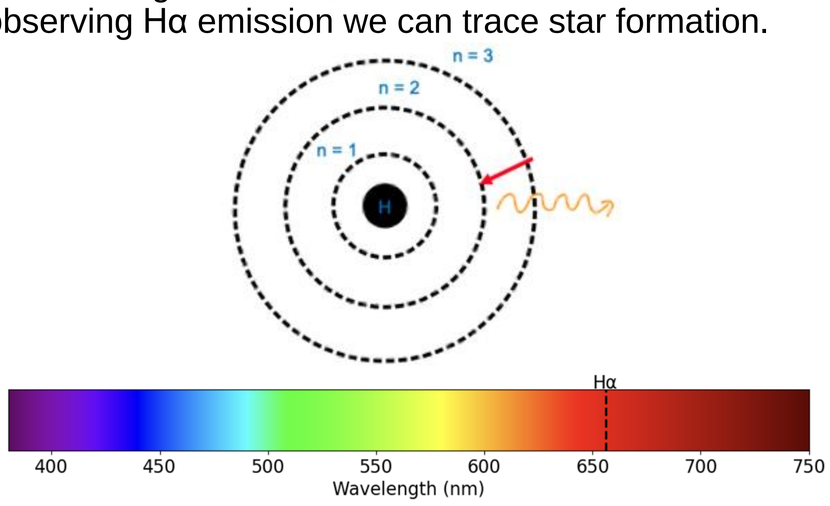
Star formation occurs within a star-forming nebula, a large cloud of gas and dust. The nebula collects more mass until it collapses under its own gravity, forming a protostar. Eventually, the protostar gets hot and dense enough for nuclear fusion to occur, this stops the collapse and forms a stable, main sequence star.

What is required for star formation?

Cold gas is required for regions to become dense enough for gravitational collapse to occur. Cold gas exists in molecular form and we can trace it by looking for specific molecules such as CO.

How do we see star formation?

In the parts of a galaxy where star formation is occurring, high energy ultraviolet radiation from the hot young stars ionise the hydrogen gas in the region. As electrons in in the hydrogen transition from the n = 3 energy level to the n = 2 energy level they emit a photon of wavelength 656 nm, which is called Hα emission. By observing Hα emission we can trace star formation.



What instrumentation is required?

This project made use of data collected by The Multi Unit Spectroscopic Explorer (MUSE) on the Very Large Telescope (VLT) and the Atacama Large Millimeter Array (ALMA).

Conclusions

- Star formation mainly occurs in the spiral arms of galaxies.
- We see star formation in regions with lots of molecular gas.
- Galaxies with more molecular gas are more star-forming.
- More massive galaxies have more star formation.

Methodology

Mapping Hα

We created maps of each galaxy using measurements of the Hα flux. Brighter regions show where the Hα flux is more intense, indicating star formation activity. We were able to isolate and individual star-forming regions. Examples are shown in figure 1.

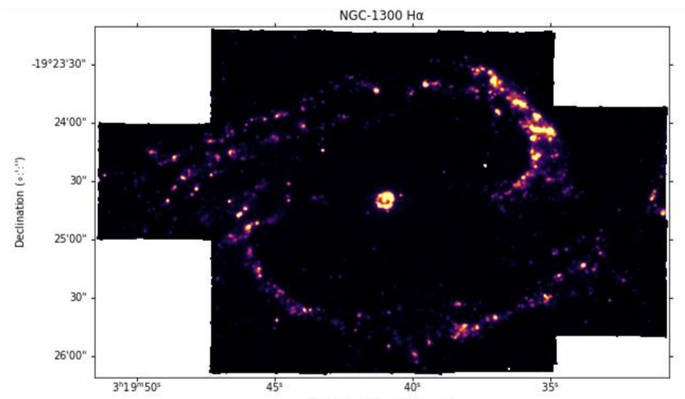


Figure 1: A map of the Hα flux of galaxy NGC1300.

Dendrograms

After identifying the star-forming regions we investigated how they are connected by creating dendrograms using the python package *astrodendro* and data on the intensity of Hα in different areas with MUSE. An example of a dendrogram is shown in figure 2. A dendrogram is a hierarchical tree which shows how star forming regions are connected. The brighter areas are the areas with most Hα known as leaves.

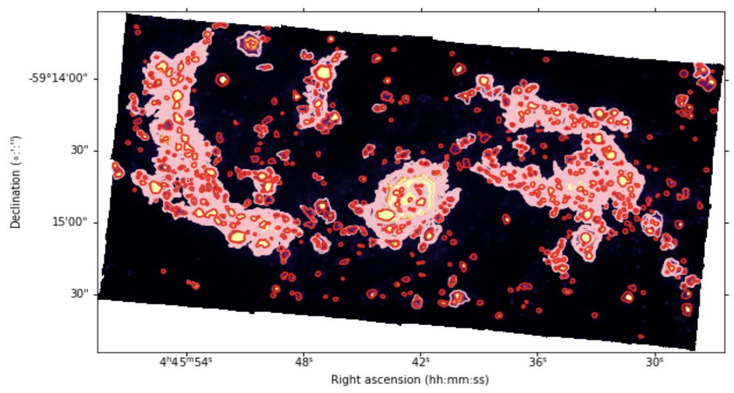


Figure 2: Dendrogram of galaxy NGC 1672. Leaves have a red outline and are surrounded by shaded areas called branches.

Molecular Gas

We created a map us of CO and Hα. We selected the regions in the ALMA CO observations where the density of the gas is high. These regions of dense gas are called molecular clouds. We then look at the Hα data and layer it over this CO data regions so that we can see how the positions of the two correlate.

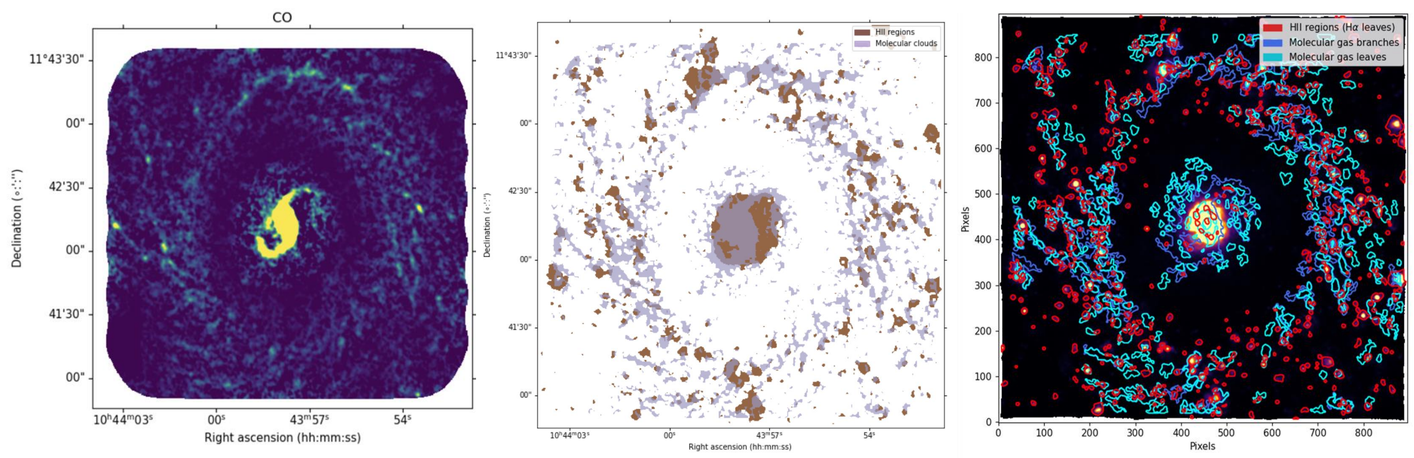


Figure 3: Maps of galaxy NGC3351. The left plot is a plot of the CO density, the middle plot is an overlay of Hα emission with CO density. The right plot is a combined dendrogram of CO and Hα regions.

Luminosity Functions

The luminosity of a galaxy is a measure of its brightness, which indicates how much energy the star is radiating. A luminosity function shows the distribution and number of bright regions that a galaxy contains and tells us about the star formation activity. We made plots of luminosity functions for each of our galaxies and looked for trends with specific variables.

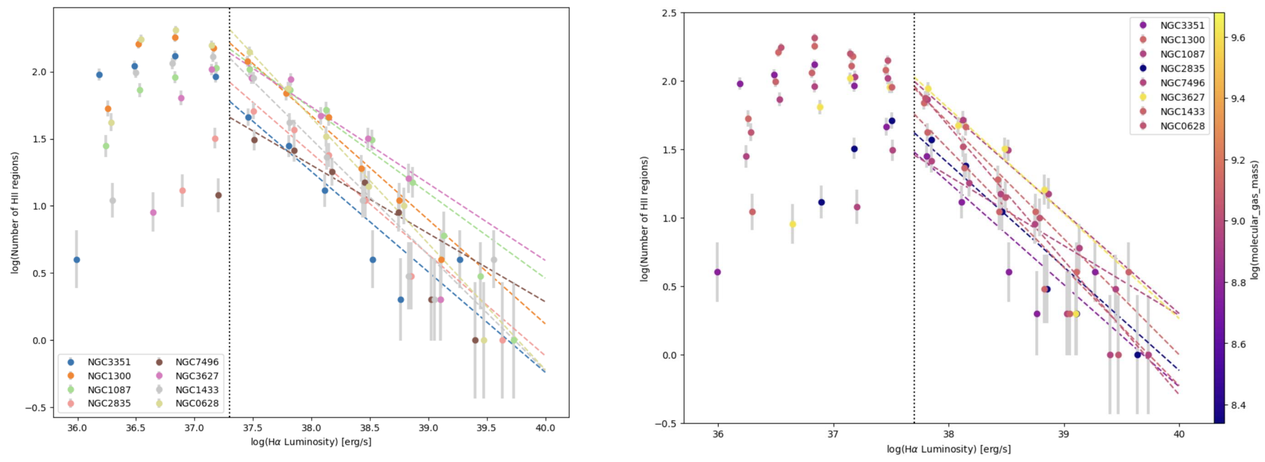


Figure 4: The plot on the left shows the luminosity functions of all galaxies in this study. The plot on the right shows the luminosity functions of all galaxies colour-coded by molecular gas mass.

By analysing our luminosity functions we can see that the galaxy with the most star-forming regions is NGC3627. There is trend with molecular gas mass showing that galaxies with a higher molecular gas mass have more star formation activity.