HI asymmetries and deficiencies in ALFALFA galaxies

Reshoketswe Thobejane
Supervisor : Prof E. Elson
Centre for Radio Cosmology, University of the Western Cape
Email : 3968498@myuwc.ac.za

Aim

In this work, the aim is to use HI line data from the Arecibo Legacy Fast Alfa (ALFALFA) survey to study the prevalence of HI spectral asymmetries in the context of galaxy environment. From the full ALFALFA sample, this work defines as merger candidates those galaxies that have a neighbour within 25 kpc and 750 km/s. A sample of well-isolated galaxies is also procured. Here, for each sample, distributions of their defining observational characteristics are presented. The goal is to quantify the HI asymmetries in these two galaxy samples in order to generate quantifiable evidence of the environment-induced effects.

Introduction

There's a wide variety of properties/ characteristics galaxies exhibit and the environment in which these galaxies reside in is known to significantly affect these properties. A galaxy's cold gas component (usually a disk for a late-type system) is particularly sensitive to environmental conditions. Neutral hydrogen (HI) makes up the larger majority of a galaxy's gas content making it a sensitive probe for evironmentally induced effects since it is less gravitationally bound to the system. Galaxies are often observed to be HI-deficient if they are located in dense environments such as galaxy clusters, or towards the centres of groups (Denes et al.,2014). Some processes that lead to HI deficiency in a galaxy include tidal interactions, galaxy mergers, interactions with satellite galaxies, flyby interactions as well as ram-pressure stripping. Each of these processes affects the asymmetry of the galaxy's spatially integrated HI profile. Thus, this work also investigates the possibility of a correlation between HI deficiency and HI asymmetry in galaxies.

Data

The data primary data set used in this research is ALFALFA. This catalog contains ~31500 extragalactic HI line sources that were detected by the completed survey out to redshifts z<0.06 (which is equivalent to about 250 Mpc). These include both high SNR (>6.5) detections and ones of lower quality which coincide in both position and recessional velocity with galaxies of known redshift (Haynes et al.,2018). This work howerver, only uses the high SNR 25434 spectra labeled as code 1 by Haynes. The secondary data set used is by Durbala et al. (2020) who provide the stellar mass and star formation rate estimates of the ALFALFA galaxies. DECaLS is also used to generate the optical images of the galaxies.

Sample generation and properties

This study generates a sample of merger galaxy candidates and isolated galaxy candidates in order to compare the quantified HI profile asymmetries of galaxies in dense environments to ones that are in more isolated environments.

- Merger candidates are those that have at least 1 neighbour within 25 kpc spatially and 750 km/s spectrally : This results in 205 merger galaxies.
- Isolated galaxy candidates have no neighbours within 750 kpc spatially and 7500 km/s spectrally : This results in 5406 isolated galaxies.

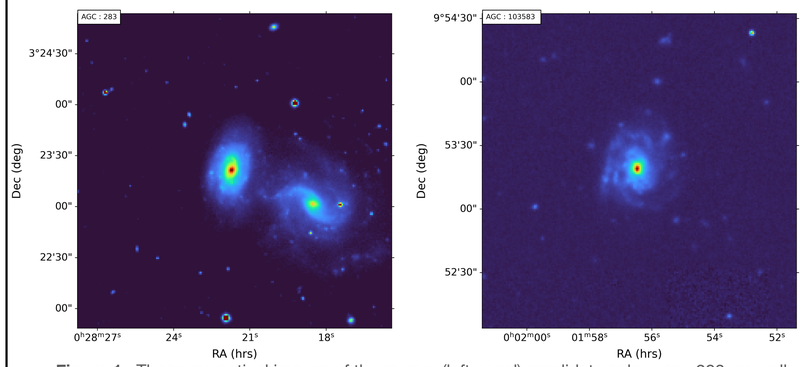

Figure 1: These are optical images of the merger (left panel) candidate galaxy acg:283, as well as the isolated (right panel) candidate galaxy acg:103583 obtained from DECaLS. The merger candidate galaxy shows evidence for a strong interaction with its neighbouring galaxy whereas that of the isolated displays an undisturbed morphology

Figure 2: On the left panel is the qr code of the 3-D distribution of the merger sample. The left panel qr code entails of the properties of the galaxies in each sample. The morphological diversity of galaxies in the merger sample is evident in these properties.

Conclusion

This work finds that on average:

- The merger sample conatins more galaxies with asymmetric HI profiles than the isolated sample. This is in agreement with Bok et al., 2019's result.
- The merger galaxies are more HI deficient than the isolated galaxies.
- There is no correlation between HI deficeincy and asymmetry of galaxies.

Measuring asymmetries

This work uses the standard method of measuring asymmetries: asymmetry flux ratio parameter.It is defined by taking the ratio of integrated HI flux on either side of the galaxy's systemic velocity

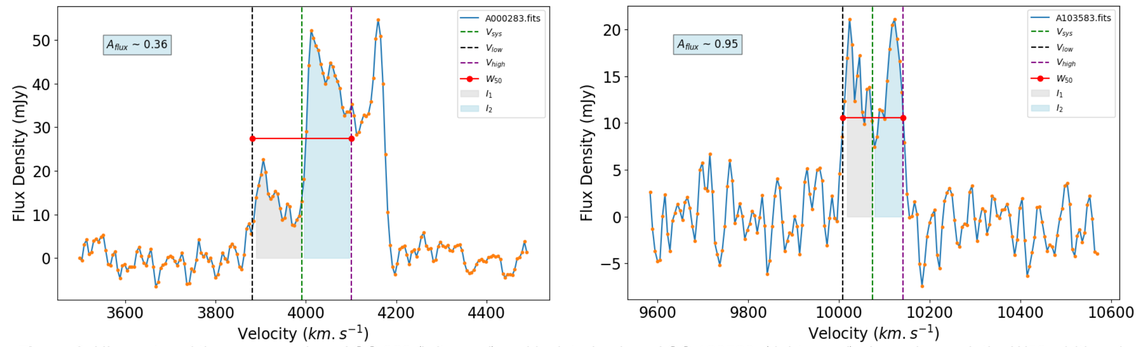

Figure 3: HI spectra of the merger galaxy AGC:283 (left panel) and isolated galaxy AGC:103583 (right panel). In each panel, the W50 widths of the emission lines are indicated by the red horizontal lines and the profile edges (V_{low} and V_{high}) are indicated by the vertical black and purple dashed lines respectively. The flux ratios (A_{flux}) of the galaxies are indicated on the top left corner of each plot. The merger galaxy's spectra (on the left) shows evidence of both this galaxy and its neighbouring galaxy being merged implying a close interaction between these galaxies HI gas.

Results

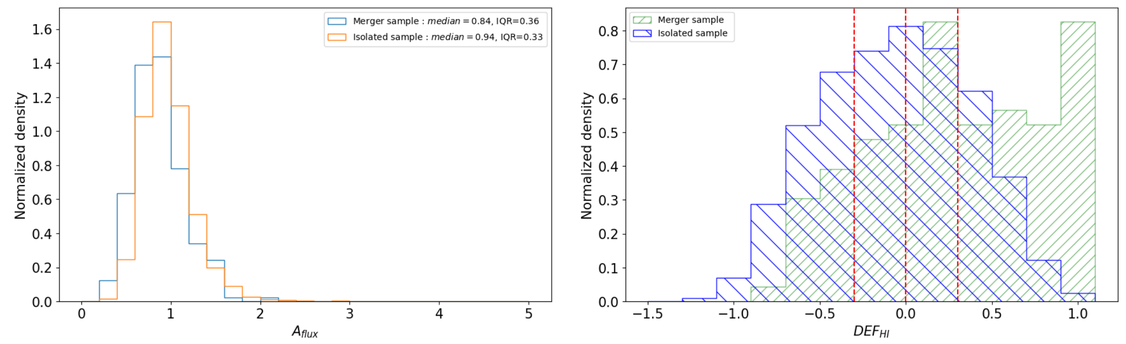

Figure 4: On the left panel are the distributions of asymmetries for the merger and isolated samples. From these distributions, the median asymmetry of the merger sample is ~10% lower than that of the isolated sample.
On the right panel are the distributions of the HI deficiency factors for the merger and isolated samples and from these distributions, the merger galaxies are more HI deficient (on average) than the isolated galaxies.

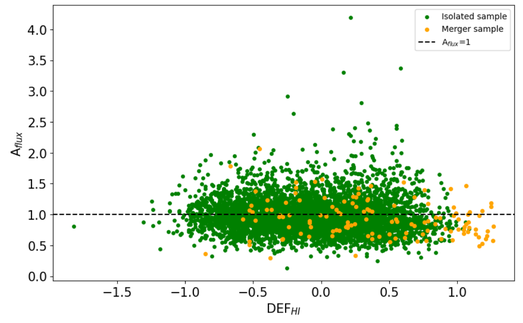

Figure 5: The relation between the asymmetry ratio and the HI deficiency factor of the merger and isolated galaxies.

The HI deficiency of the galaxies is determined using the HI deficiency factor (Denes et al.,2014 and Deb et al.,2023). This factor is defined by the equation:

$$DEF_{HI} = log_{10}M_{HI_{exp}} - log_{10}M_{HI_{obs}}$$

where the first term is the expected HI mass of the galaxy and the second term in the observed HI mass of the galaxy. The deficiency factor is therefore positive for HI deficient galaxies and negative for HI rich galaxies.