

# The relation between stars and gas in distant galaxies

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Observing any galaxy in the universe will yield the fact that it contains stars and also gas. The dynamics of both can be explored by observing galaxies and collecting spectroscopic data.

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1 Amongst the different types of cosmic  
2 structure within our universe, galaxies can  
2 be seen as the island powerhouses of industry,  
2 and activity. Containing countless stars,  
2 gas, dust, and dark matter [1], it would be  
3 difficult not to express the statement that  
3 the motions of these objects must be linked  
2 in some galactic relationship.

3 By utilising the most powerful tool in as-  
3 tronomy, observation, galaxies, their struc-  
ture and the motions of the objects within  
3 them can be studied to a great depth. As an  
example, if we took optical measurements of  
4 the stellar population, we could use that in-  
formation to estimate the potential age of  
4 the galaxy. We know that redder stars are  
older and bluer stars represent a younger  
set of objects [1]. Or if we wanted to know  
about the material composition or even the  
distance to a certain galaxy, we could split  
the collected light in a spectrograph to pro-  
duce a spectrum. Values of redshift and  
the content of a galaxy can be obtained by  
looking at the absorption and emission lines  
within a galactic spectrum [1].

Gathering and processing this optical and spectroscopic information allows us to build a broad picture of the internal workings of a galaxy. Then with further analysis we can begin to comprehend the intricate re-

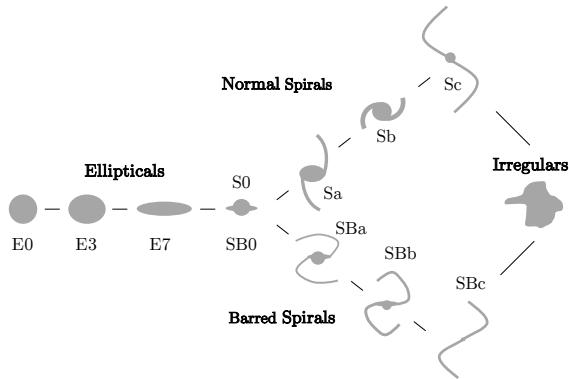
lationships contained within these individual islands [??].

To begin with we must consider a general picture of galaxies, after which we will be able to appreciate and explore the more complex ideas [??].

### a. Galactic classification

As we stated previously, a galaxy can be quite broadly defined as a collection of gas, dust, stars and dark matter. But if we were to observe a large enough sample then we would begin to see that the galaxies can be grouped and classified together.

This categorisation is called the *Hubble Sequence* or the *Hubble Tuning Fork* [1]. From Figure 1 we can see that galaxies can be divided into ellipticals, spirals and irregulars. With ellipticals along the horizontal handle, the two prongs containing normal and barred spirals, and finally irregulars as the third category. The sequence itself does not show the evolution of the galaxies, rather it provides a way to view the different morphologies of galaxies on one plot.



**FIG. 1:** The Hubble Sequence, containing three general groups of ellipticals, spirals, and irregular galaxies. The diagram does not show the evolution of galaxies but their classification. (*This diagram has been adapted from An Introduction to Modern Astrophysics [1].*)

We must ask ourselves then what each grouping represents in relation to the make-up of the galaxy. Alongside the general classification from appearance we can also

explore the component composition of the three types of galaxies.

Take ellipticals, we can see from the Hubble Tuning Fork that they are spherical-like distributions of gas, dust, and dark matter. The stars within them are old red types, the star forming rate is low [1]. [say in section blah blah blah more will be discussed about star forming rates]

Take ellipticals, the distribution of stellar objects within these galaxies are dominated by mainly redder old stars. [??] These types of galaxies coalesce into a spherical-like collection. Comparatively, spiral galaxies are composed of a central bulge which has old stars and a surrounding disk or protruding arms which contain younger stellar objects [1]. Irregular galaxies have no noticeable symmetry and no obvious central nucleus, so they do not fall into either of the other two categories.

By knowing these general characteristics, as we continually improve our observational instruments we can then view deeper into the Universe's past. This means the galactic objects are becoming more and more younger, this is a powerful way for us to build a picture of the evolutionary nature of galaxies and their structure.

### b. Galactic and stellar formation

We introduced the concept that through optical measurements of the stars

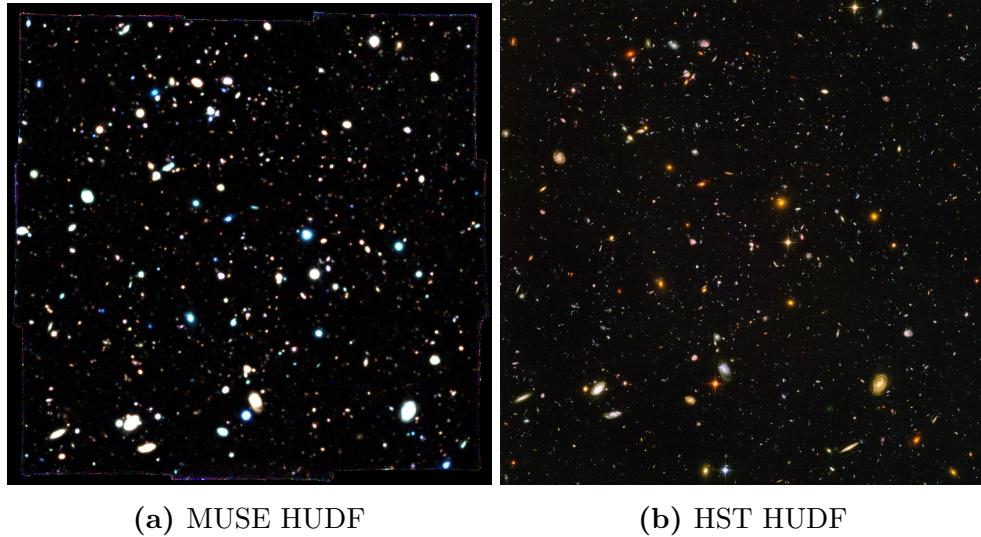
What do I want to say with this? I want to introduce galaxies, the different types of galaxies, how they form, how they can be confused with other types of structure.

### c. Data

askjdnaksld

#### 1. HUDF and MUSE

To obtain spectroscopic information on the Hubble UDF objects, the Multi-Unit



**FIG. 2:** (a) A colour image created from the MUSE spectroscopic data of the HUDF. The wavelength range was split into three equal regions and then collapsed to create three bands (R, G, B). A final colour image was produced by combining these separate frames together. (b) The optical HUDF as captured by the Advanced Camera for Surveys instrument on the Hubble Space Telescope [2].

Spectroscopic Explorer or MUSE was employed. This instrument is

what is MUSE, where it is on the VLT,  
asdasd

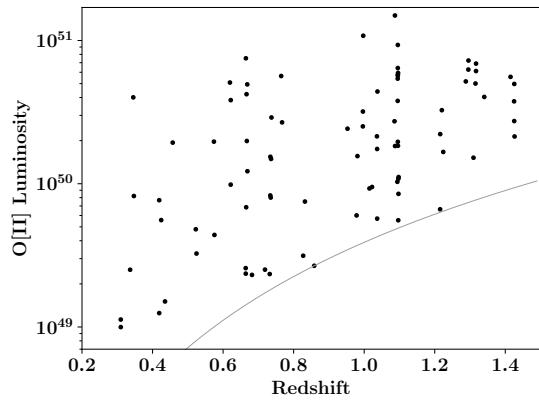
problems, limitations of MUSE - why it is useful...etc

#### a. Cube extraction

## 2. ANALYSIS

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asdasd

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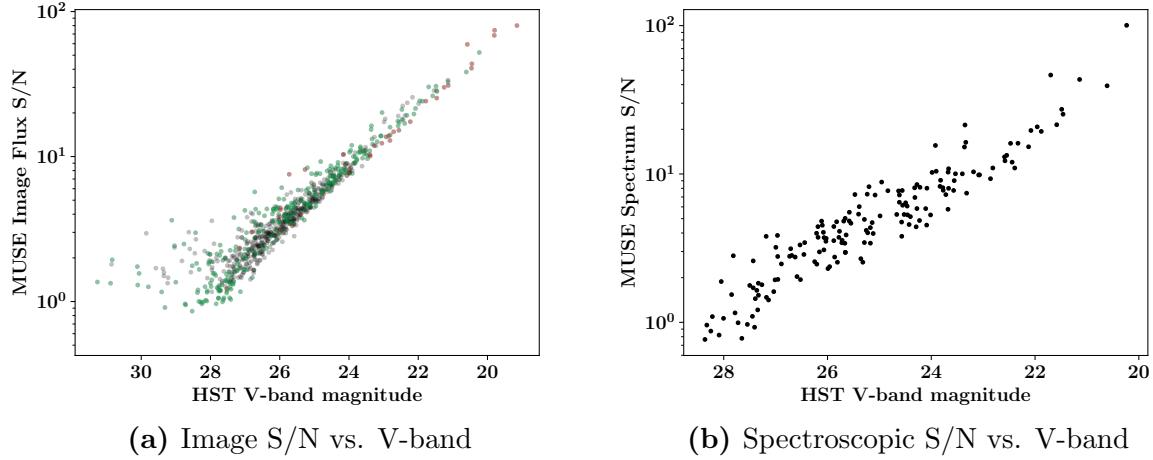
**FIG. 4:** Graph showing the calculated luminosity for the O[II] doublet plotted against redshift. Data points are plotted as well as a model line representing the lower-limit of the flux from the sample. [???]a

#### b. pPXF

## 3. DISCUSSION

## 4. CONCLUSIONS

In conclusion, through extensive data and statistical analysis it can be said that the dynamics of stars and gas in galaxies are ... (?)



**FIG. 3:** (a) The signal-to-noise of the image flux for every object in the MUSE collapsed image plotted against their respective V-band magnitudes from the HST catalogue. The red points represent those with redshifts  $z < 0.3$ , and the green points are a chosen sample of 300 points as defined by the sextractor probability that they are not stars. (b)

### Acknowledgments

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Pearson, 2nd edition, 2007.

- [2] NASA, ESA, S. Beckwith, and HUDF Team. Hubble Ultra Deep Field. <https://svs.gsfc.nasa.gov/30946>, May 2018. [Online; accessed 5th November 2018].

### References

- [1] Bradley W. Carroll and Dale A. Ostlie. An Introduction to Modern Astrophysics.