

## The relation between stars and gas in distant galaxies

Jacky Cao

Level 4 Project, MPhys Theoretical Physics

Supervisor: Dr. Mark Swinbank

Department of Physics, Durham University

Submitted: November 5, 2018

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.

Abstract abstract abstract abstract abstract abstract abstract abstract abstract abstract  
abstract abstract abstract abstract abstract abstract abstract abstract abstract ab-  
stract abstract abstract abstract abstract abstract abstract abstract abstract ab-  
stract abstract abstract abstract abstract abstract abstract abstract abstract ab-  
stract abstract abstract abstract abstract abstract abstract abstract abstract ab-  
stract abstract abstract abstract abstract abstract abstract abstract abstract ab-

# Contents

## 1. INTRODUCTION

## 1. Introduction

- a. Galaxy classification
- b. Data
  - 1. Hubble Ultra Deep Field
  - 2. MUSE

## 2. Analysis

- a. pPXF

### 3. Discussion

## 4. Conclusions

## Acknowledgments

## References

```
prepost
```

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

- By utilising astronomy's most powerful tool, observation, galaxies, their structure and the motions of the objects within them can be studied to a great depth. For example if we took optical measurements of the stellar population, then we could use that information to estimate the potential age of the galaxy. [ref] Or if we wanted to know about the material composition or the distance to that galaxy, we could split the collected light in a spectrograph. [ref]

Gathering and processing this optical and spectroscopic data allows us to build a broad picture of the internal workings of a galaxy. However this picture would not be complete unless we had a general understanding of galaxies themselves.

### a. Galaxy classification

If we observed a large enough sample of galaxies then we would begin to see that

some of them can be grouped together, this categorisation is called the *Hubble Sequence* or the *Hubble Tuning Fork*. With a horizontal handle and two prongs, the sequence itself does not show the evolution of the galaxies, rather it provides a way to view the possible different types of galaxies on one graph. [REF and show an example of the sequence - find some data and plot it? or images of galaxies?]

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.

## b. Data

Duis eget tellus tortor. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. In tellus nulla, sodales eu pulvinar at, accumsan quis magna. Nunc sed lacus diam. Nam enim mauris, imperdiet ut egestas quis, tincidunt at odio. Ut viverra nulla at libero dictum aliquet. Suspendisse lacus lacus, imperdiet nec elit nec, ullamcorper facilisis ex.

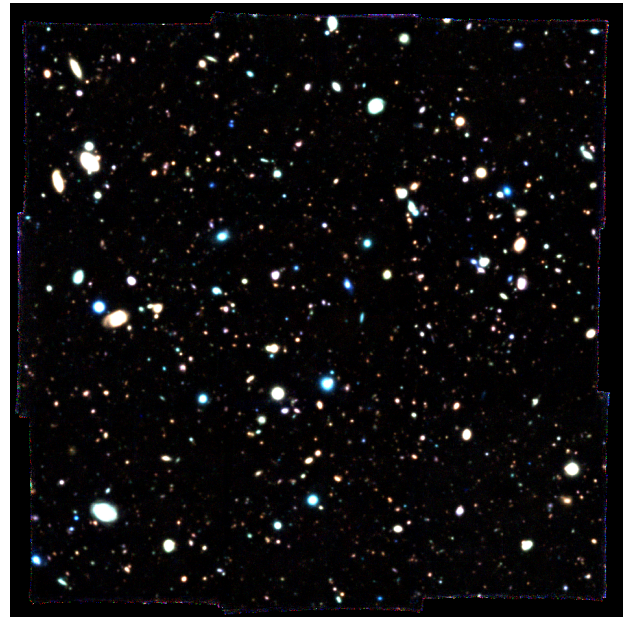
### 1. Hubble Ultra Deep Field

Proin sit amet mauris tincidunt, consectetur nisi ultrices, dapibus elit. Nullam vitae faucibus odio, pharetra ultrices tortor. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos.

### 2. MUSE

To obtain spectroscopic information on the Hubble UDF objects, the Multi-Unit Spectroscopic Explorer or MUSE was employed. This instrument is

what is MUSE, where it is on the VLT, problems, limitations of MUSE - why it is useful...etc



**FIG. 1:** A colour image of the Hubble Ultra Deep Field created using MUSE spectroscopic data. The wavelength range was split into three components, which were then collapsed to create the three colour bands (R, G, B).

For every pixel the median value was found from the reduced spectroscopic data. [I NEED TO ADD THE ACTUAL OPTICAL IMAGE FOR A COMPARISON]

## 2. ANALYSIS

### a. pPXF

Duis eget tellus tortor. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. In tellus nulla, sodales eu pulvinar at, accumsan quis magna. Nunc sed lacus diam. Nam enim mauris, imperdiet ut egestas quis, tincidunt at odio. Ut viverra nulla at libero dictum aliquet. Suspendisse lacus lacus, imperdiet nec elit nec, ullamcorper facilisis ex.

## 3. DISCUSSION

Duis eget tellus tortor. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. In tellus nulla, sodales eu pulvinar at, accumsan quis magna. Nunc sed lacus diam. Nam enim

mauris, imperdiet ut egestas quis, tincidunt at odio. Ut viverra nulla at libero dictum aliquet. Suspendisse lacus lacus, imperdiet nec elit nec, ullamcorper facilisis ex.

#### 4. CONCLUSIONS

Donec finibus, tellus sit amet luctus sodales, lectus ante accumsan ligula, at condimentum lorem justo a sapien. Phasellus vel tortor vitae metus lacinia efficitur ac vel ex. Aenean eget congue leo. Aliquam cursus mauris sit amet arcu dignissim, vel condi-

mentum nisi sodales.

#### Acknowledgments

(OPTIONAL) The author would like to thank...

#### References

- [1] Bradley W. Carroll and Dale A. Ostlie. An Introduction to Modern Astrophysics. Pearson, 2nd edition, 2007.