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.

Abstract abstract

Contents

1. INTRODUCTION

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

By utilising the most powerful tool in astronomy, observation, galaxies, their structure and the motions of the objects within them can be studied to a great depth. As an example, if we took optical measurements of the stellar population, we could use that information to estimate the potential age of 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 produce 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 relationships 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 early Hubble type ellipticals along the horizontal handle, the two prongs containing normal and barred spirals (the later Hubble types), and 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.

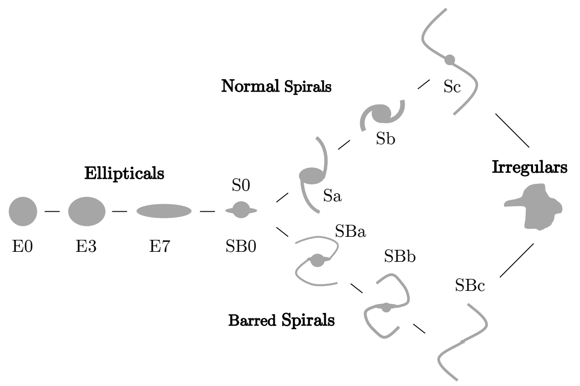

Figure 1: The Hubble Sequence, a diagram containing three general groups of ellipticals, spirals, and irregular galaxies. A pictogram and the classification name is shown for each of the main types from each galaxy group. The sequence does not show the evolution of galaxies but their classification.
(*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 basic component composition of the three types of galaxies.

Take ellipticals, we see from the Hubble Tuning Fork that they are spherical-like distributions. In fact they range from virtually spherical (E0) to highly flattened (E7) collections of gas, dust, and dark matter [2]. Observing the stars within them we find that the majority of them are older, red coloured stars. This may be due to the fact that early on in the creation of the ellipticals, a considerable proportion of the gas could have went into the formation of stars, thus viewing these galaxies now we find that their stars are older types [1]. This could also explains the lack of disks which can be otherwise seen in the spiral galaxies, with not enough material they would not form.

Comparatively, we can class spiral galaxies as being composed of a central nucleus which has a surrounding disk of material. This disk itself has denser regions which can coalesce and form the protruding arms around the main bulge [1]. The later type spirals (Sc and SBc) have arms which are more loosely wound than their earlier types (Sa and SBa) [2]. With more available gas and dust [1], we would assume that spirals in their various forms will have more opportunities to form new stars than ellipticals.

We find that it is within the arms of spiral galaxies that new stars are born. This spiral structure provides the gravitational field required to move and transport angular momentum outwards. Older and less massive stars in the galaxy produce a gravitational field which eventually leads to the shocking of the interstellar gas [3]. As a result the density of the gas in the arms increase and certain regions then collapse to form new young, blue, and massive stars.

Spiral galaxies therefore have a mix of ages in terms of their stellar population. The spiral arms containing young stars whilst the nucleus is similar to the elliptical galaxies where the population is older

(a) MUSE HUDF (b) HST HUDF

Figure 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 [4].

[1, 3].

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 to 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

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2. ANALYSIS

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to introduce galaxies, the different types of galaxies, how they form, how they can be confused with other types of structure.

c. Data

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1. *HUDF and 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

a. Cube extraction

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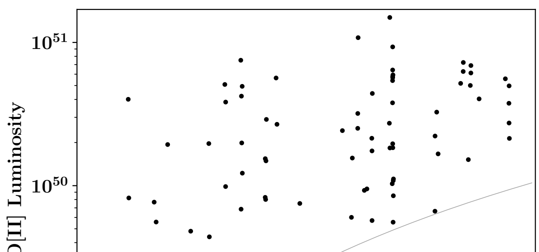

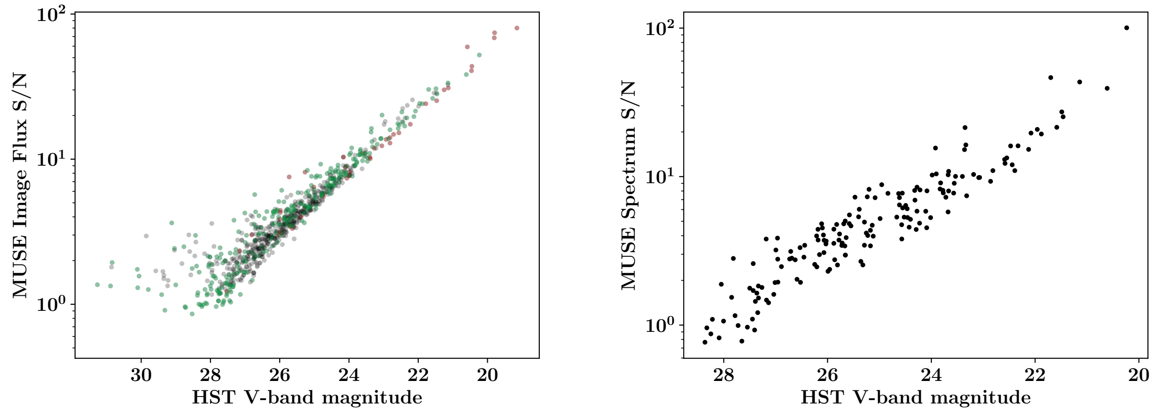

(a) Image S/N vs. V-band **(b)** Spectroscopic S/N vs. V-band

Figure 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)

Figure 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

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b. pPXF

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3. DISCUSSION

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4. CONCLUSIONS

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

Acknowledgments

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References

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[2] Partrick Moore and Robin Rees. Patrick Moore's Data Book of Astronomy, pages 357 – 362. Cambridge University Press, 2011.

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