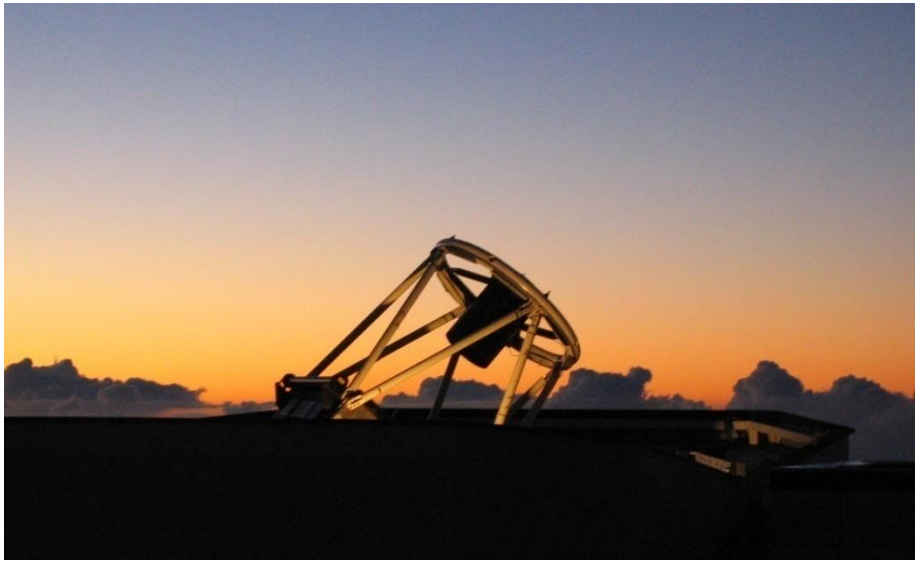
Galaxy Classification

Theory Presentation

The aim of this project will be to introduce students to the concept of varying galactic morphologies.



Using images of galaxies obtained from the Liverpool Telescope, students will classify galaxies according to the Hubble Classification Scheme.

Discussion will be centred around the quality of this classification method.

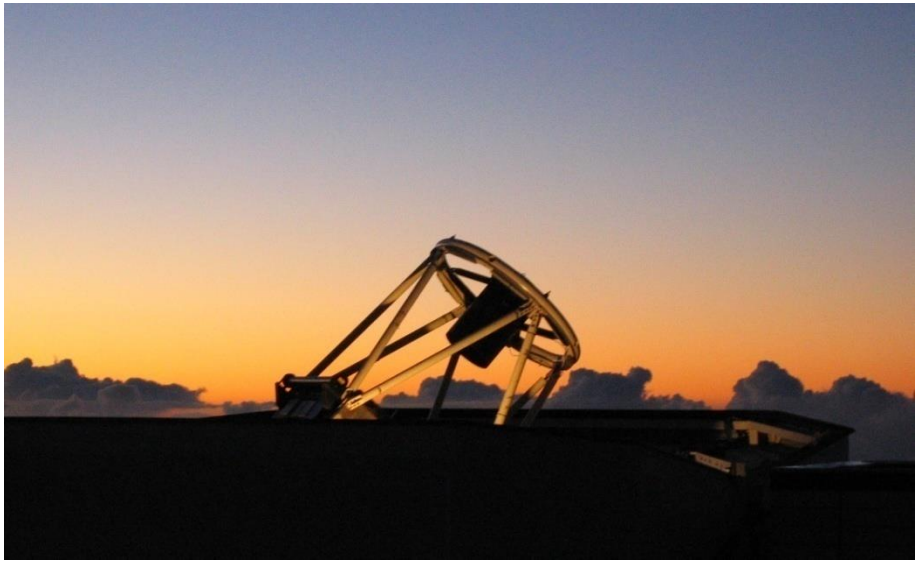
Alternative Theory Presentation

The astrophysics department of Liverpool John Moores University are working on a new galaxy classification scheme.

They would like the opinions of a group of amateur astronomers on current classification methods.

Classify a selection of galaxy images obtained from the Liverpool Telescope using the Hubble Classification Scheme.

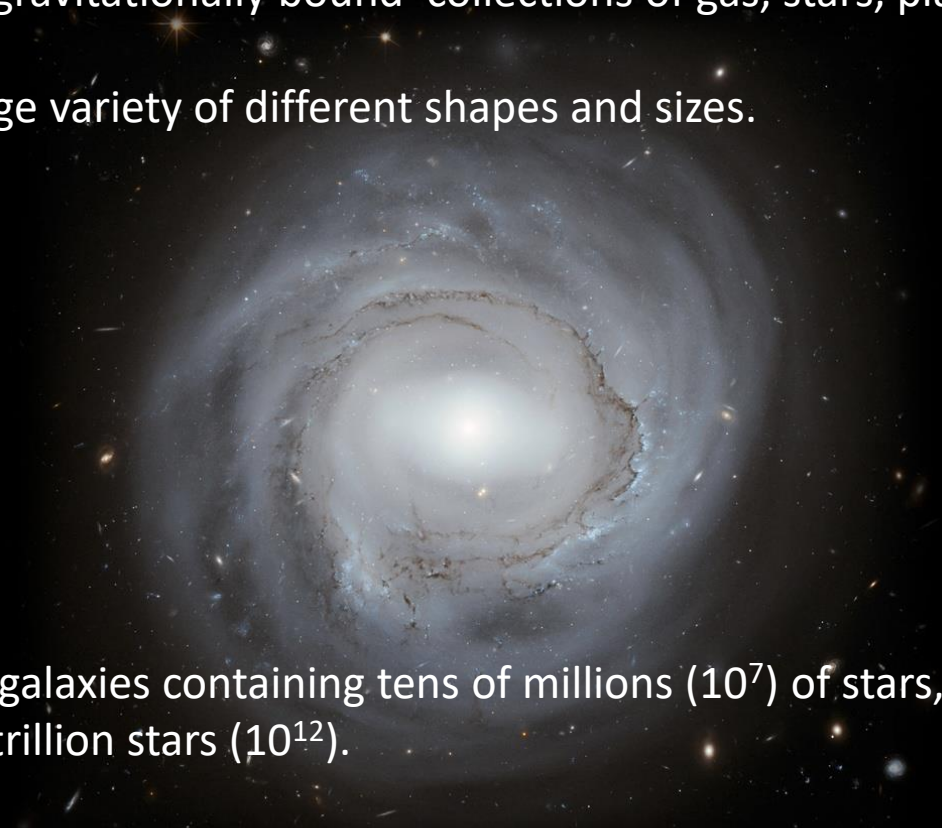
Give your opinions on the quality of this classification scheme and how it can be improved.



Galaxies

Galaxies are huge gravitationally bound collections of gas, stars, planets, ice and dust.

They come in a large variety of different shapes and sizes.



Range from dwarf galaxies containing tens of millions (10^7) of stars, up to supergiants containing up to a trillion stars (10^{12}).

There is more than 100 billion (10^{11}) galaxies in the observable universe.

Image Credit: NASA

Elliptical Galaxies

Elliptical galaxies make up roughly half of the galaxy population.

They have a smooth featureless light distribution and appear elliptically shaped in photographic images.

There is very little star formation going on within them.

They are found near the centre of rich galaxy clusters.

They are gas poor.

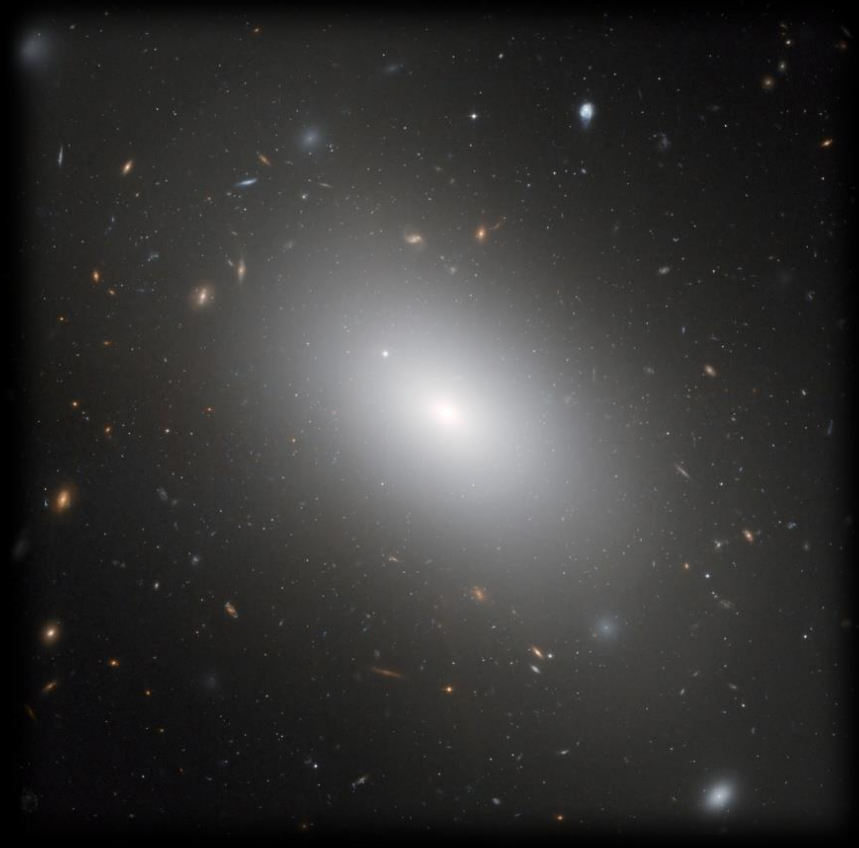


Image Credit: NASA

Spiral Galaxies

The other half of the galaxy population have spiral arms.

Active star formation can be found in spiral galaxies.

Much more isolated than elliptical galaxies.

Dust lanes in the spiral arms are created by previous generations of stars which have died and seeded the galaxy with stellar material.

They are gas rich.

Image Credit: NASA

Barred Spirals

The arms of barred spiral galaxies do not twist all the way into the centre.

Spiral arms are attached at the ends of straight “bar-like” features

It is thought that barred spiral galaxies have a mechanism which channels gas to the centre of the galaxy, possibly to a super massive black hole.

Image Credit: NASA

Lenticular Galaxies

Lenticular galaxies, so called due to their lens shaped morphology, are an intermediate stage between spiral and elliptical galaxies.

Much like spiral galaxies they are disc shaped with a large central bulge, but have no discernable spiral arms.

They have less interstellar matter than spiral galaxies and, like elliptical galaxies, have little ongoing star formation and mostly consist of aging stars.

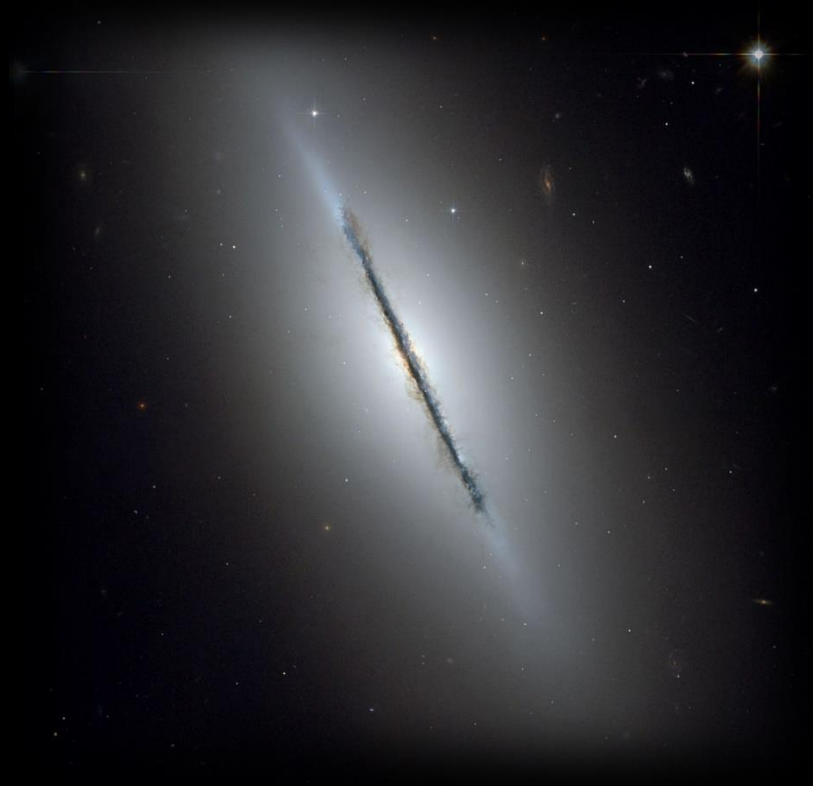


Image Credit: NASA

Irregular Galaxies

Some galaxies do not have a regular shape.

Galaxies can sometimes interact with one another. The resulting gravitational action deforms the morphology of the galaxy.

Galaxies such as these are said to be irregular galaxies.

Image Credit: NASA

Dwarf Galaxies

All different types of galaxies can have dwarf classifications too

This is generally when the galaxy contains fewer than a few billion stars (10^9) – but can be as low as around 100 million

If the galaxy is a dwarf version then the classification scheme uses a lower case ‘d’ in front of the rest of the classification

Image Credit: NASA

The Hubble Classification Scheme

- Developed by Edwin Hubble in 1936.
- Also known as the 'Hubble Tuning Fork'.

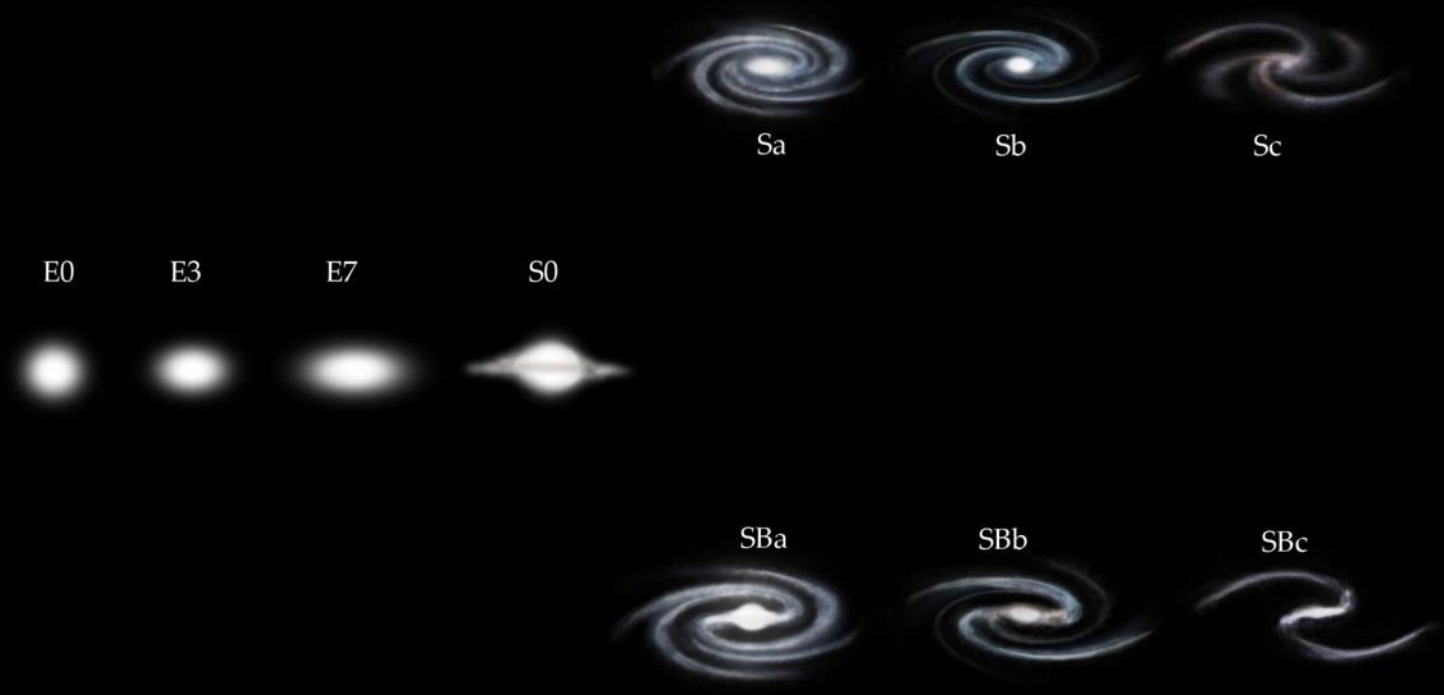


Image Credit: NSO

The Hubble Classification Scheme

Elliptical galaxies are denoted by the letter, E.

The number which follows is related to the galaxies ellipticity.

EO galaxies are near circular.

The most flattened galaxies have ellipticities of e=0.7 (E7).

Lenticular galaxies (between elliptical and spiral) are labelled as SO.

Image Credit: NSO

The Hubble Classification Scheme

The majority of non-barred spiral galaxies can be classed from Sa to Sc.

Sa galaxies have very tightly wound spiral arms and a bright central bulge.

Sb galaxies have less tightly wound spiral arms and a fainter central bulge.

Sc galaxies have loosely wound spiral arms and a smaller, fainter central bulge.

Image Credit: NSO

The Hubble Classification Scheme

Barred spiral galaxies are classed in the same way as non-barred spiral galaxies.

SBa galaxies have tightly wound spiral arms and a large central bulge.

SBb galaxies have slightly looser wound spiral arms and a fainter central bulge

SBc galaxies have very loosely wound spiral arms and a faint galactic bulge.

Image Credit: NSO

Prediction

With a well defined classification scheme, such as the Hubble Tuning Fork, it should be possible for astronomers to catalogue galaxies according to their morphology.

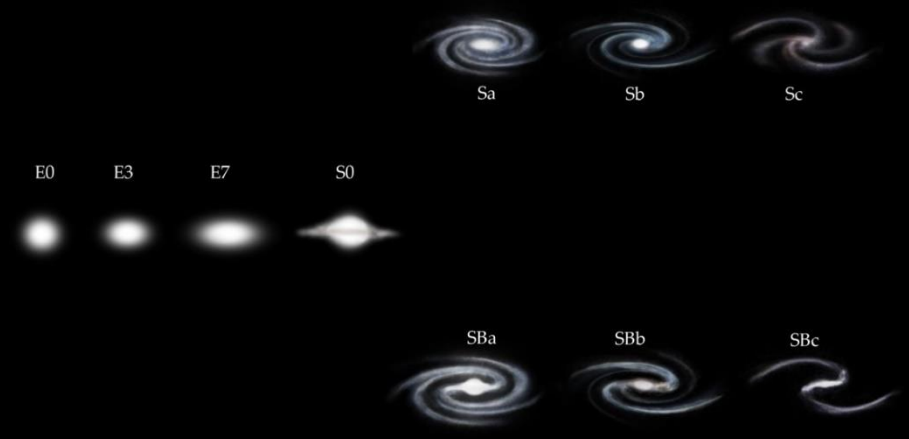


Image Credit: NSO

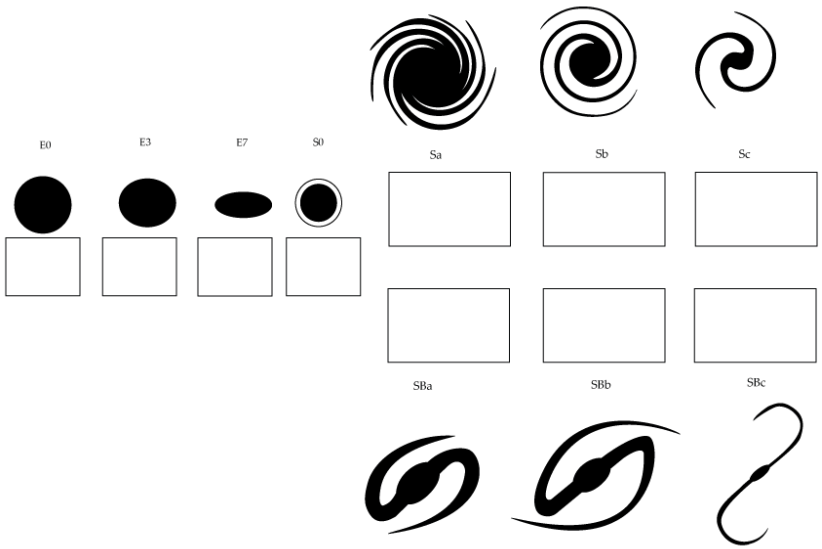
The Experiment

Each student is given a copy of the Hubble Tuning Fork worksheet.

The galaxies are then displayed in turn in the classroom.

Students will then mark on the worksheet which class they believe each galaxy falls into.

Once all the galaxies have been shown, the results of the student's opinion on each of the galaxy images can be collected and discussed.



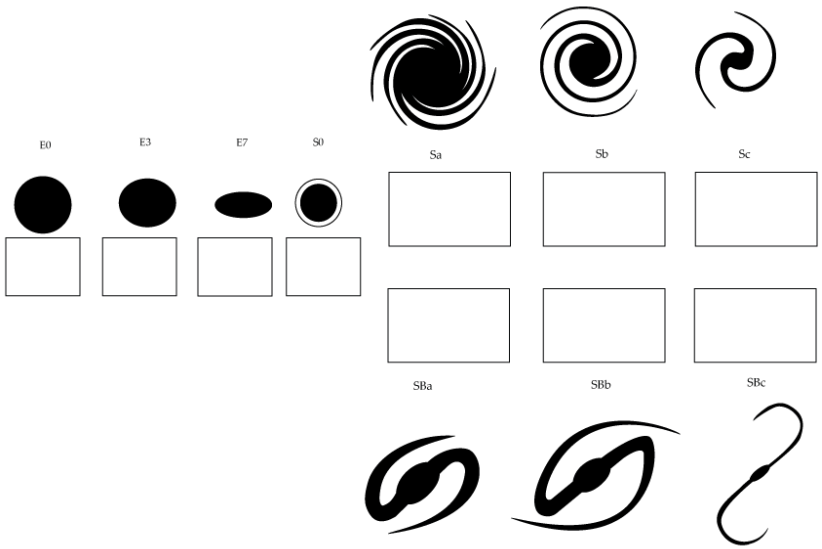
Prediction Compared to Results

How good is the agreement for each galaxy?

Have the students unambiguously classified all of the galaxies?

Are there some galaxies which are disagreed on more than others?

Does the most commonly attributed class for each galaxy agree with the classification supplied in the results ‘Galaxy List’ Excel file.



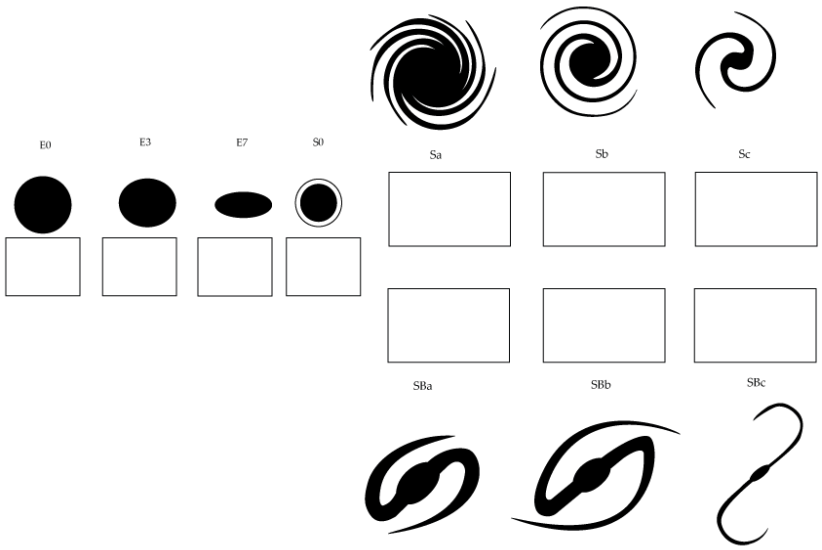
Discussion Compared to Results

Can galaxies be unambiguously classified using the Hubble classification scheme?

What difficulties were encountered when classifying the galaxies from the images provided?

Is a more detailed classification scheme necessary?

In what way could the classification scheme be improved?



Questions, Exercises and Tasks

The de Vaucouleurs system is an alternative galaxy classification scheme. How does this differ from the Hubble Classification Scheme?

One of the galaxies in the supplied images was an irregular galaxy. Classify this image using the de Vaucouleurs system.

What class of galaxy is our own galaxy, the Milky Way?

Why is it difficult to make clear conclusions about the morphology of the Milky Way?