

# Galaxies

Michael McEllin

## 1 Introduction

The most distant object you can see with the naked eye is the *Great Nebula in Andromeda* also known by its Messier catalogue number as M31. It was Edwin Hubble during the night of October 5-6 1923 who by observing variable stars in M31 of a known light output established beyond doubt that M31 was a separate galaxy to our own - a whirlpool of 100,000,000,000 stars and at a stroke completely changed our view of the scale of the Universe.

Since then the study of galaxies and the way they evolve over time has been at the forefront of astronomy. While much of the life cycles of stars are now fairly well understood, there are many aspects of galaxy behaviour that we still do not fully understand. (How galaxies come to form so quickly after the beginning of the Universe is one of the major research topics in modern astronomy.)

This project is an investigation of the *morphology* of galaxies, and aims to ask what we can learn about galaxies just by looking at photographic images. However, it will be more than just looking at the type of photographs you may have seen taken by space telescopes such as Hubble. We will perform a scientific investigation by using photographs taken through different coloured filters, which will allow us to see when stars of different ages tend to occur in galaxies.

## 2 Resources

There are two ways in which we can obtain photographic images of the required quality:

- *The Sloan Digital Sky Survey* is a long running project based around a robotic telescope with a 2m diameter mirror that automatically scans the sky every night, recording thousands upon thousands of high quality photographs covering the entire northern sky in multiple colours. All the photographs are stored in a public database.

- The Faulkes Telescopes are two research class robotic telescope (again with 2m mirrors), one based in Australia, one in Hawaii, that are available for UK school students to use for astronomical investigations. You plan observations and request the computer controlled telescopes to carry them out on your behalf, collecting the data over the Internet some time later.

It is, of course, extremely exciting to plan and carry out your own observations with a powerful instrument that many professional astronomers would happily get their hand on. However, it does come with some difficulties: learning to use complicated instruments takes time, and there are false steps along the way. In previous years some students *have* successfully carried out observations with Faulkes, but it would be fair to say that they did not get as many photographs as they originally planned, and some teams did not get any successful observations at all. We hope to be able to give more guidance this year, but do not underestimate the effort involved.

On the other hand, all the Sloan photographs are already there, waiting to be retrieved. All we have to do is learn how to do it. Bear in mind that this is a system that is really designed for use by professional astronomers, so they assume certain levels of background knowledge from their users (for example, how to look up the sky coordinates of interesting objects in astronomical catalogues). We should, however, be able to provide you with all the guidance required. (Dr McEllin, your mentor, has a PhD in astronomy and a lot of experience with computers.)

In both cases we will also need to learn how to useful extract information from photographic images. In general this means turning parts of the images into numbers and probably plotting graphs. We will need to use a number of special computer programs to do this, so the project will involve learning how to drive these applications.

### 3 Investigations

You may like to examine the following questions - but it is perfectly fine if, after doing preliminary reading, you decide that there are more interesting problems that can be investigated. (Do, however, discuss this with the mentor who may be able to tell you whether you are planning to take on a problem that you have a realistic chance of examining in the time available.)

Questions for initial background reading:

- How do we know the distance to galaxies? How far away are they?

- How big are galaxies? (How many stars do they contain?)
- How old are the stars in galaxies?
- Are there different types of galaxies?
- Are stars being born currently in galaxies?
- How do we find out where stars are being born?
- How do we measure the positions of objects on the sky?
- How are astronomical objects of interest collected in catalogues, and which catalogues should we look at for our investigations?
- What does the colour of a star tell us?

Observational Questions:

- How many different types of coloured filters can we typically use on astronomical telescopes?
- How do the colours change across the different types of galaxy?
- What may this be telling us about the places stars are forming?