Chapter 1

Introduction

1.1 General introduction

In the field of observational astronomy and astrophysics, the formation and evolution of stars remain fundamental to many questions concerning the structure and evolution of galaxies in the universe (McKee & Ostriker, 2007). Stars, which are the basic building blocks of galaxies, evolve over time, in a cycle far longer than human life times, yet, due to the number of stars in the Galaxy, it is possible to examine stars in each phase of their life cycle. Different tools and observables are used in order to study stars, from their earliest formation, throughout their evolutionary cycle.

Variable stars in general can contribute greatly to the understanding of different aspects of stars, therefore, they can be used as valuable tools in probing the subjects of stellar structure and stellar evolution, where important information can also be acquired on star formation. A variability search, as conducted in this study, is prone to reveal many different variable sources in the region under investigation. Variable stars can be seen as stars that show any form of light variation, which can be irregular, while periodic stars are a subgroup of all variable stars with periodic intensity changes. The different types of variable stars can in turn reveal different aspects of stellar structure and their evolutionary phases.

Stellar clusters are favourable regions for conducting studies regarding stellar structure and evolution due to the fact that the sample of stars contained in the cluster shares similar properties which include age, initial composition, distance and mass range (Lata et al., 2011). The above mentioned properties can, therefore, also be determined with better accuracy for cluster stars than for field stars, which emphasises the importance of cluster observations (Mermilliod, 1981).

1.2   Motivation and problem statement

In order to probe the properties of cluster stars mentioned above, large amounts of data need to be treated and processed, using different techniques which will be explained in the succeeding chapters.

The main motivation behind this study is to search for a specific type of pulsating periodic star of the class β Cephei, in the two southern open clusters of NGC 6204 and Hogg 22. According to Pigulski et al. (2002), a higher occurrence of β Cephei stars are found in young southern open clusters compared to open clusters in the northern hemisphere. This can be the result of a higher metallicity content in the southern open clusters due to the metallicity gradient in the Galaxy, where the observed clusters from the southern hemisphere are located closer to the galactic centre with a higher metallicity that is expected for smaller galactocentric distances (Pigulski et al., 2002, Maciel & Costa, 2010).

The observations were done with the newly setup $16''$ telescope of the North-West University which will be described in more detail in Chapter 3. The final telescope setup was completed shortly before the onset of observations for this study. The observations were done over a period of 14 nights which resulted in a fairly large data set, consisting of more than 2000 image frames.

A weak point in the initial setup was the fact that no auto-guiding system was installed yet which created some difficulties in field stabilisation. Although it did not affect individual images, it affected long period tracking of the target field. Due to the large data set obtained with the new telescope system and the field corrections that needed to be made, the task of automating the data reduction process and the extraction of all periodic sources from the data were included in the aim of the study. This called for the creation of a reduction and photometry pipeline for the particular telescope setup, which needed to incorporate corrections on problems experienced during data acquisition. These comprised of image rotation due to camera removal and large shifts in the observational field due to unguided observations. The proposed pipeline, therefore, needed to include the reduction, photometry and variability extraction procedures which will be explained in more detail in Chapter 3. This study will therefore be directed towards the processing and analysis of cluster data with the intent to automate the process of data reduction and analysis.

The task of finding periodic variable stars, like the β Cephei stars under study, in open clusters relies on the process of comparing all stars with a non-variable star in each image. In a variability study like the present, data can be taken over many nights, where a typical image of open cluster data may contain thousands of stars. Before

the non-variable stars can be identified in the field, some of the stars must be cross-correlated in different images in order to account for translation and rotational effects which will simplify repeated photometry greatly as well as consistent numbering of stars in the cluster data. These problems then emphasise the importance of automation of the search process of periodic sources in large data sets.
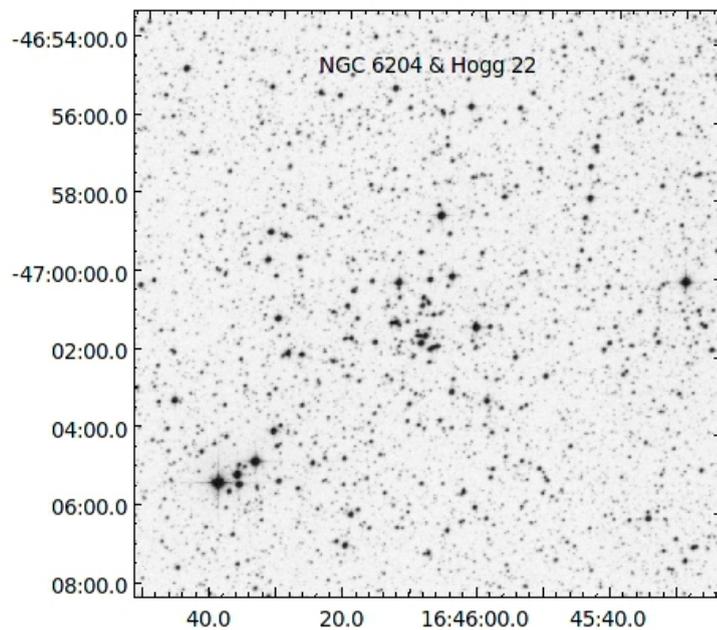
1.3 Region of study

FIGURE 1.1: DSS image showing the region of study: NCG 6204 and Hogg 22

The region of NGC 6204 is not very well documented in the literature, compared to other clusters which are more easily observable from the northern hemisphere. However, in a study done by Forbes & Short (1996), a number of stars from both clusters were identified, which will also be used to compare results obtained from this study.

NGC 6204 and Hogg 22 are two southern open clusters located within 6 arc minutes of one another in the constellation of Ara. This close angular proximity made it possible to observe these two clusters simultaneously. Figure 1.1 shows the the two clusters, where NGC 6204 is in the centre of the figure and Hogg 22 in the lower left hand corner. The centre of the frame in figure 1.1 is at the coordinates $\alpha = 16^h 46^m 08^s$, and $\delta = -47°00'44''$ (J2000), (galactic coordinates: $l = 338.902$, $b = -1.572$). NGC 6204 is believed to be the oldest cluster of the two at a distance of 0.8 kpc while the much younger Hogg 22 is more distant at 2.8 kpc. A discrepancy in documented distances for NGC 6204 can be explained due to the fact that these two clusters were presented as a single group of

stars. In a study done by Humphreys (1978), it was indicated that NGC 6204 contained 2 O type stars and presented a distance of 2.5 kpc for NGC 6204, whereas Forbes & Short (1996), showed an earliest spectral type of B8.

These two young clusters display a highly scattered nature which is also evident from young clusters containing Cepheid pulsating stars (Forbes, 1986). It is believed that Hogg 22 may contain stars of spectral type as early as O6.5, which makes it a good candidate for the calibration of absolute magnitude-spectral type for massive stars (Forbes & Short, 1996).

The question of which stars belong to which cluster resulted in Forbes & Short (1996) conducting a detailed photometric study of these two clusters before any stellar evolution studies could be done. In the present study the focus will in particular be on pulsating B-type stars, which will include β Cephei and Slowly Pulsating B stars (SPB).

1.4   Chapters to follow

A short summary of what to expect in the following chapters:

- **Chapter 2 : Theoretical background** A brief background on the processes of star formation and their evolutionary cycle, including the structure of stars and the properties of galactic open clusters, will be presented in this chapter. The class of B-type pulsating stars with the focus on two sub-type stars which are the β Cephei and Slowly Pulsating B stars and the classification thereof will be discussed. The theoretical background on these stars with the focus on β Cephei stars will also be provided in this chapter.

- **Chapter 3 : Data acquisition and reduction** This chapter will be used to explain some important concepts in the process of acquiring the data for this type of study as well as to introduce the instrumentation used to obtain the data. A detailed overview and explanation of the steps followed in the data reduction pipeline will also be provided in this chapter.

- **Chapter 4 : Results and discussion** The data reduction will lead to the process of photometry on the data, where the results will be provided in this chapter and will also indicate the variability of these pulsating stars.

- **Chapter 5 : Summary and conclusions** This chapter will include the summary together with the conclusions made from the data analysis. Recommendations and possible improvements of this study will also form a part of this chapter.