Red Supergiant Stars within the Local Group

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Abstract

Red Supergiant stars represent the most luminous stars in the infrared sky. Their intrinsic luminosities combined with the low dust extinction observed in this regime makes these objects very attractive to study in the near-IR. Added to this is the fact that RSGs are necessarily young objects, therefore these stars are tracers of recent star formation in extra-galactic systems. As the next generation of telescopes will be optimised for study in the near-IR, it is clear that in the coming years RSGs will play a prominent role in the way which astronomers probe the local universe and out to larger distances with space-based observations. Therefore, bettering our understanding of these objects now and developing the tools which will allow us to take full advantage of the suite of instrumentation which will become available in the near future is vital. This thesis aims to further the understanding of RSGs by focusing on photometry and spectroscopy at near-IR wavelengths.

I describe the implementation of the J-band analysis technique which is used to derive stellar parameters using near-IR spectra of RSGs. This implementation is tested on a variety of synthetic and real spectra and is shown to work well across a broad range of input spectra.

Using this implementation of the analysis routines I esimate stellar parameters for 14 RSGs in NGC 2100, a young massive star cluster in the Large Magellanic Cloud. I estimate the chemical and dynamical properties of this star cluster and find that this cluster has must have expanded owing to stellar evolution on a slow timescale.

Using the analysis routines described, 11 RSGs in NGC 6822 are observed with the new K-band multi-object spectrograph (KMOS) and have stellar parameters estimated. The data reduction process with KMOS is described in detail, in particular where the reduction has been optimised for our data. The metallicity

of these stars is compared to previous estimates and is shown to be in good agreement.

KMOS spectra of RSGs in NGC 55 is presented and stellar parameters are derived for these stars. These results are compared to previous estimates in this galaxy and the spatial distribution of the chemical abundances is assessed.

Using the metallicity measurements made within these three galaxies I estiamte the local mass-metallicity relationship using RSGs. I compare this relationship to other estiamtes from within the local group and comment on the calibration of the high-redshift mass-metallicity relationship.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

Parts of this work have been published in **?**.

(*Lee. R. Patrick, March 2016*)

Acknowledgements

I would like to thank myself for getting all of this work done ...

Contents

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Chapter 1

Introduction

Completeness: 85%
This estimation is based on the work done in the first year report.

Description:
The introduction will be split into three main sections:

1. The life and death of massive stars
Where I will outline the physical processes of the birth, the evolution from the onset of hydrogen fusion and finaly the death of massive stars focusing in particular on the Red Supergiant phase of stellar evolution

2. The Physical Properties of Red Supergiants
I will detail the properties of RSGs from Galactic studies and outline our present understanding of what a RSG is and some of their characteristic features e.g. mass loss rates.

3. The Chemical evolution of galaxies
In this section I will give an account of how galaxies build up their present abundances via star formation and feedback. I will describe the mass-metallicity relationship and how RSGs will play a role in furthering our understanding of this relationship.

Chapter 2

J-band Sythentic Spectral Fitting

Completeness: 60%
My implementation of the J-band spectral fitting technique is in the final stages of testing and has performed well in a variety of tests. More testing still remains before I can use this implementation confidently on a new data set.

In tandem to developing this implementation of the technique I have also documented my progress which will serve as the bones of this chapter.

Description:
This chapter will describe in detail the process by which one can estimate stellar parameters based on near-IR spectra of Red Supergiant stars. I will document the progress to date using this technique and describe how my implementation will allow an independent check to results which have been obtained using other implementations of the same technique.

I will focus in particular on the differences between my implementation and those in the literature.

Chapter 3

Red Supergiants in NGC 2100

Completeness: 60%
The observations and data reduction for this section are complete. I am currently polishing the analysis for this chapter and a have a draft of a paper almost ready.

Description:
This chapter will describe KMOS observations of 14 RSGs in NGC 2100.

I will describe the cluster and outline the connection between YMCs and GCs and the potential for constraints on GC properties by studying YMCs.

I will estimate the dynamical and chemical properties of NGC 2100 and comment on the evolution of young clusters in general.

Chapter 4

KMOS Observations in NGC 6822

Completeness: 95%
This work is published in Patrick et al. (2015, ApJ, 804, 14) and has been adapted and expanded into a thesis chapter

Description:
This chapter describes the observations of RSGs in NGC 6822 a local dwarf irregular galaxy. This chapter details the observations obtained with KMOS and the data reduction process as well as what has been optimsied in this process for our observations. Target selection is based on that described in a previous chapter

The analysis for this section is that described in a previous chapter.

The results of this chapter are that we obtain stellar parameters for 11 RSGs in this galaxy and quantify the lack of stellar metallicity gradient within this galaxy. We show that our results compare well to previous estimates of stellar metallicity from young stars and HII regions in this galaxy. Using a simple chemical evolution model we show that the present-day metallicity can be explained in terms of the simple closed-box chemical evolution model which is remakrable give the morphology of this galaxy. Finally we compare the stellar parameters derived in this study with all those derived using the same technique in different environments. We show that there appears to be no significant variation of temperature of RSGs with respect to metallicity, in direct contrast with recent evolutionary models.

Chapter 5

Red Supergiants in NGC 55

Completeness: 30%
The observations for this section are complete and the data reduction is currently being optimised.

Description:
This chapter will outline KMOS observations of 20 RSGs in NGC 55. I will descibe the work I have done in preperation for these observations.

I will discuss the optimisations which have been made for this data set and describe the challenges of obtaining the best possible data from a set of challenging observations.

I will comment on the spatial distribution of the chemical abundances in this galaxy and discuss a potential metallicity gradient previously suggested in the literature.

Chapter 6

Calibrating the Mass-metallicity relation with RSGs

Completeness: 0%

Description:
This chapter will be a compilation of the three science chapters I have where I will estimate the mass-metallictiy relatioship using RSGs.

I will compare this with other estimates of the MZR in the local universe and identify which of the high-z calibrations best match our local measurements.

Chapter 7

Conclusions

Completeness: 0%

Description:
This chapter will provide the concluding statements to my thesis.

Appendix A

The First Appendix

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