Argelander-Institut für Astronomie

UNIVERSITÄT BONN

The Relation Between Progenitor and Remnant Masses in Double Neutron Star Systems

Masterarbeit zur Erlangung des akademischen Grades

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im Studiengang Astrophysik

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I hereby declare that this thesis was formulated by myself and that no sources or tools other than those cited were used.

Date _____ Signature _____

1. Gutachter: Prof. Dr. Norbert Langer
2. Gutachter: Prof. Dr. Michael Kramer

To my Loved Ones

τί δὴ τοῦτό ἐστι Πυθαγόρας ἐρωτώμενος,
ʿτὸ θεάσασθαιʾ εἶπε ʿτὸν οὐρανόνʾ

When Pythagoras was asked about the purpose
for which humans were created, he said,
"To look upon the heavens"

ACKNOWLEDGMENTS

During my effort for the completion of this Master Thesis many people had stand by me and contributed in one way or another.

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Chapter 1

INTRODUCTION

The cycle of life and death of stars baffled astronomers for many years. The study of stellar structure and evolution continue to be of paramount importance up to this date, since it is crucial to our understanding of various branches of astronomy, e.g. the structure of galaxies, and chemical history of the Universe.

A detailed coverage of the principles of stellar evolution is beyond the scope of this thesis. Moreover, for the interested reader, there are excellent classical textbooks (Kippenhahn et al. 2012; Clayton 1968) covering almost every aspect in the field of stellar astrophysics. Nevertheless, for the sake of completeness, a small introduction to several fundamental notions, tailored to our needs, will be attempted in the next few paragraphs.

Helium stars

A brief explanation of what a helium star is

Formation of Helium stars

A small section explaining how helium stars are being formed

Evolution of single Helium stars

A small section explaining the evolution of single helium stars

Mixing mechanisms

convection, overshooting, thermohaline

Effects of rotation

Rotational mixing

Transportation of angular momentum

Eddington-Sweet circulation etc

Winds and mass loss

Importance of mass loss in the evolution of stellar winds and Wolf-Rayet stars + magnetic braking –¿ connection to angular momentum losses.

Evolution of binary systems

Few words about how most stars form in binary systems, detached, semi-detached and contact binaries

Interaction and orbital parameters

Cases A/B/C etc

Mass transfer

Few words about mass transfer in binary systems (wind mass accretion + Roche lobe overflow)

Common envelope

Explain a little bit in more detail the basics of CE

Angular momentum transfer

Effects of angular momentum transfer + magnetic braking

Gravitational waves

The very basics for GWs and their impact on binary mergers

Stellar transients

Couple of words for the different types of stellar transients and how can we observe them

Classification of Supernovae

Explain in details the difference between core collapse SNe and type Ia and different subdivision

Type Ib/c Supernovae

Explain in details this particular branch

X-ray binaries

HMXB, LMXB, UCXB

Chapter 2

METHODS

Explain shortly what MESA is.

Modules for Experiments in Stellar Astrophysics

Write 2-3 pages of the MESA basics and how it works (Newton iterations etc). Consider possible subsections

Physical assumptions

Mention which physical assumptions we used

Single stars

For single helium stars

Binary systems

For the binary systems

Chapter 3

RESULTS

Mension the mesa reader Python module for the extraction and analysis of MESA data

Single Helium stars

Neutron star + Helium star binaries

Chapter 4

CONCLUSIONS

Write the conclusions we arrived at for all cases and what are they implying for the formation of DNS binaries

Chapter 5

DISCUSSION

Write a page or two for your findings, future work etc

BIBLIOGRAPHY

Clayton, D. 1968, Principles of Stellar Evolution and Nucleosynthesis (McGraw-Hill)

Kippenhahn, R., Weigert, A., & Weiss, A. 2012, Stellar Structure and Evolution, 2nd edn. (Springer)

Tauris, T. M. & van den Heuvel, E. P. J. 2006, in Compact stellar X-ray sources, ed. W. H. G. Lewin & M. van der Klis, 623–665