University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Science

of

AUSTIN DAVIS

BSc (University of Victoria, 2014)

"Convective Boundary Mixing in Simulations of Massive Stars"

Department of Physics and Astronomy

Wednesday, April 12, 2017
9:30 A.M.
Elliott Building
Room 161

Supervisory Committee:
Dr. Falk Herwig, Department of Physics and Astronomy, University of Victoria (Supervisor)
Dr. Jody Klymak, School of Earth and Ocean Sciences, UVic (Member)
Dr. Katherine Prestridge, Department of Physics and Astronomy, UVic (Outside Member)

External Examiner:
Dr. Henning Struchtrup, Department of Mechanical Engineering, UVic

Chair of Oral Examination:
Dr. Ben Nadler, Department of Mechanical Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The turbulent convective mixing in the late stage evolution of the core of massive stars is not well understood. In the last few hundred years of a massive stars life, convective cores and shells form is close proximity. Whether or not the convective regions can interact and change the evolution of the star is dependent on the amount of material that can be mixed across the boundary. One-dimensional (1D) codes that simulate the lifetime of stars rely on models with free parameters in order to model the convection. The free parameter determining the strength of the mixing across the boundary of a convection zone is undetermined for the majority of convective boundaries.

A three-dimensional (3D) simulations of the O-shell in a $25\mathrm{M}_\odot$ stellar model with Z = 0:02 is summarized with a focus on determining the diffusion coefficient that would be necessary in a 1D stellar evolution model to reproduce the spherically averaged composition profiles. The diffusion coefficient was then fit with the exponential decaying convective boundary mixing (CBM) model and the free parameter, f_{CBM}, was determined. The sensitivity of the late time evolution of the core in a $25\mathrm{M}_\odot$ 1D stellar model at Z = 0:02 with respect to variation in the value of f_{CBM} was tested. The Goal of this work was not to determine what values of f_{CBM} the stellar model should have, but to investigate the differences in the structure as a result of changing the f_{CBM} values. Past the onset of convection in the first C shell, the values of f_{CBM} change the structure of the star significantly, promoting dredge-ups that mix material from the core to the top of the C shell. The presupernova structure was investigated with a focus on the compactness parameter, $\xi_{2.5}$. The models show significant non-linear variation in $\xi_{2.5}$ with respect to f_{CBM}, where $\xi_{2.5}$ spans a range of (0:12; 0:35). The abundances near collapse of the models were also investigated. It was found that Ne ash that was entrained into the C shells through dredge-ups and shell mergers was transported high enough in the star to be ejected by the supernova explosion.