The Cambridge STARS Code

A Users Guide

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STARS Operation Manual

Disclaimer
This documentation is pieced together from code introspection, two papers Peter Eggleton wrote, an (incomplete) version of the documentation by Warrick Ball, and the thesis of Jan Eldridge. The authors apologise for any omissions.

Colophon
This document was typeset with the help of KOMA-Script and LaTeX using the kaobook class.
The source code of this book is available at:
https://github.com/fmarotta/kaobook
(You are welcome to contribute!)

Life, forever dying to be born afresh, forever young and eager, will presently stand upon this Earth as upon a footstool, and stretch out its realm amidst the stars.

– H. G. Wells

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1 Introduction

If my calculations are correct, when this baby hits 88 miles per hour...
you're gonna see some serious shit.

Doc Brown

The Cambridge STARS code was first written in 1971, by Peter Eggleton. Since then, several modifications have been made, resulting in the code being sourced in different places, documentation being incomplete, and different parameters being added in different areas. In 2021, an effort was made by Stars and Supernovae, the research group of Associate Professor Jan Eldridge. to unify these sources to modernise the codebase and rewrite the documentation. This document is the result of work by, and the collaborate effort of, several members of that group. In no particular order:

1. Sean Richards (@OrdinaryStarman)
2. Sohan Ghodla
3. Dr Héloïse Stevance (@sydonahi)
4. Assoc. Prof. Jan Eldridge (@astro_jje)

2 Basic User Guide

The story so far: In the beginning the Universe was created. This has made a lot of people very angry and been widely regarded as a bad move.

Douglas Adams

2.1 Installation

Basic installation is straightforward. Create a directory and download the code from GitHub (replace `<USERNAME>` with your GitHub username):

```
mkdir STARS
cd STARS
git clone https://github.com/<USERNAME>/STARS.git
```

2.2 Code files

When downloaded, you will find the following files:

File	Short Description	Long Description location
dat/	Data files for STARS	tbd
obj/	Compiled source files	N/A
src/	FORTRAN source files	tbd
Makefile	Make instructions	Section **??**
run_bs	The run file for STARS	Section **??**
data.bak	STARS main datafile	Section **??**
modin.bak	Model input for STARS	Section **??**

Table 2.1: The structre of the default STARS directory.

2.3 Your first STARS run

In this section, we will evolve a ZAMS model to Helium flash. Provided in STARS is a 1 $M_\odot$ ZAMS model file – modin.bak. At this point, you do not need to worry about the structure of this file (see Section **??**), just know that it contains the structure of the star at 199 different mass coordinates.

We will be evolving a star with $M_{\rm ZAMS} = 10 M_\odot$.

1. First, move modin.bak to modin: `cp modin.bak modin`. It is always advised to keep modin.bak as a backup ZAMS model.
2. Select your desired ZAMS mass. Edit the file data:

```
cp data.bak data
vim data
```

The first 22 lines of data are:

```
 199  40  10  15  15   3   1   0   0   0   0   1
   1   5   1   5   0   0   0   0   0   0   0   0
 100   1   1   1   0 100   0
1.0E-06 1.0E-02 1.0E-07 0.0E+00 0.5E+00
 6  7  0  3  0 80  0  0  0 99
 1  2  4  5  3  9 10 11 12 15  8  7  6  0  0  0  0  0  0  0  0...
 7  8  9 10 11 12 14  4  2  1  3  5  6  0  0  0  0  0  0  0  0...
 4  5  6  7  8  9 10  2  3  1  2  3  1  0  0  0  0  0  0  0  0...
 0  0  0  0  0154  0  0  0 99
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21...
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21...
 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21...
17  2  4  5 18  8  9 10 11 12 13 14 24 25 26 30 16 34
 2  3  4  5  6  8  9 10 17 18 19 20 21 28  7
 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0.80 1.05 9.99 0.00 0.05 0.50 0.15 0.02 0.45 1.0E-04 1.0E+15 3.0E+19
2.00E-02 2.000 0.700 0.173 0.053 0.482 0.099 0.038 0.080 0.072
1.00E+03 0.12E+00 1.00E+03 0.00E-07 0.00E+00 3.00E-01 1.00E-03
1.00E+03 0.00E+00 0.00E+00 1.00E+00 1.00E-04 0.00E+00 0.00E+00
1 1 0.00E+02 1 1.00E+01 0.50 0.00
0 700.0 0   0.0 0.00 0 0 1.00E-02 0.00E+00
0 0.1E+00
```

For now, you do not need to worry about every option. They are explained in Section **??**. Just change IML to 9, RML to your desired ZAMS mass (in this instance, $10 M_\odot$). Change the third number on line 18 to `1.00E+02` ($10\ M_\odot$), and the eighth number on line 2 to `9` (RE-ML).

3. Run the code: `./run_bs`

3 Input & Output

3.1 DATA

tbc

3.2 MODIN

tbc

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Appendix

Cheat Sheet A

B Tips & Tricks

Matrix inversion C