

Window To The Stars

Robert G. Izzard*, Evert Glebbeek

*Sterrenkundig Instituut, Universiteit Utrecht, P.O. Box 80000, NL-3508 TA
Utrecht, The Netherlands. Email: R.G.Izzard@phys.uu.nl*

Abstract

We present *Window To The Stars*, a graphical user interface to the popular *TWIN* single/binary stellar evolution code, for novices, students and professional astrophysicists. It removes the drudgery associated with the traditional approach to running the code, while maintaining the power, output quality and flexibility a modern stellar evolutionist requires. It is currently being used for cutting edge research and interactive teaching.

Key words: Stars, stellar evolution

1 Introduction

We have developed a graphical user interface, *Window To The Stars* (*WTTS*), to Peter Eggleton's popular *TWIN* single and binary stellar evolution code. We combine a simple interface for input physics with a comprehensive package of two- and three-dimensional graph plotters for immediate analysis of results and production of publication quality plots. *WTTS* is currently being used for both research and teaching at the Universities of Utrecht and Nijmegen. It is written in *Perl* and uses the *GTK2* library, both of which are freely available and portable to all common computing platforms. We have tested it on Linux and Mac OS X and are working on a Windows version. *Window To The Stars* can be downloaded from its homepage at <http://www.astro.uu.nl/~izzard/window/> together with installation instructions, the *TWIN* code and some screenshots.

We describe briefly the *TWIN* code (section 2) then the *Window To The Stars* front-end (section 3). We conclude with a discussion of current use and future plans in section 4.

2 The *TWIN* code

The stellar evolution code used by *WTTS* is a modified version of the *TWIN* stellar evolution code originally developed by Peter Eggleton [1,2]. It uses an adaptive non-Lagrangian mesh which allows stars to be evolved with only 200 meshpoints in a few minutes on a normal desktop computer.

The code has three modes of operation: one to calculate the evolution of single stars and two different ways for binaries, *TWIN* and non-*TWIN*. In *TWIN* mode, the two stars are solved for simultaneously by inverting a single matrix, while in non-*TWIN* mode the code evolves both stars individually and alternates between them at regular intervals.

3 *Window To The Stars* User Interface

WTTS is laid out in a logical progression of tabbed windows which guide the user through the choice of physics, running of the stellar evolution code and analysis of the resulting models. We shall describe each in turn and corresponding screenshots from the evolution of a $3 M_{\odot}$ star can be found in Fig. 1. Further examples and screenshots can be found on the *WTTS* website at <http://www.astro.uu.nl/~izzard/window/screenshots/>.

Options The first steps in creating a series of stellar evolution models are the choices of input parameters and physics. We provide a selection of initial masses from a library of zero-age main sequence (ZAMS) stellar models with a range of metallicities and the ability to load pre-calculated models as a starting model. The physics and initial conditions for stellar evolution are then selected in a series of tabbed menus such that every aspect of the stellar evolution run can be controlled. We have added the ability to load or save a complete set of *WTTS* options, and also to import the original initialisation (*init.dat*) files from the *TWIN* code distribution.

Evolve The bulk of the stellar evolution is done here. There are buttons to start and stop the evolutionary sequence. The *TWIN* log file is also shown and updated automatically during the evolutionary run.

HRD The Hertzsprung-Russell diagram (HRD), which shows $\log L/L_{\odot}$ vs $\log T_{\text{eff}}/K$, is displayed for each star individually or for both stars, and updates as the evolution progresses. The tracks can be labelled with a third

variable, such as central temperature or core mass, and coloured according to the effective temperature.

Structure In this tab structural variables such as age, model number, total mass, core mass, luminosity, radius and abundances are plotted against one another. The plot automatically updates throughout the evolution and many variables can be plotted at once, with the option of logging the axes and choosing data ranges.

Internal It is often desirable to examine the internal details of each stellar model individually or plot the results from a few models in one graph. Successive model information can be overlaid or turned into an animated sequence. Each model can be saved and later used as a starting model for a new evolutionary run (see the *Options* tab description).

Kippenhahn The traditional Kippenhahn plot shows convective regions as a function of mass coordinate and time. We expand on this idea by plotting a mapped 3D surface of any of the stellar evolutionary variables as a function of any two others. In the case of mass-coordinate used as an ordinate, the core mass(es), convective boundaries and nuclear burning zones can be overplotted.

Miscellaneous Other options can be changed here, such as image size, HRD colour contrast and hue, font type and size, plot type (postscript or PNG) etc.

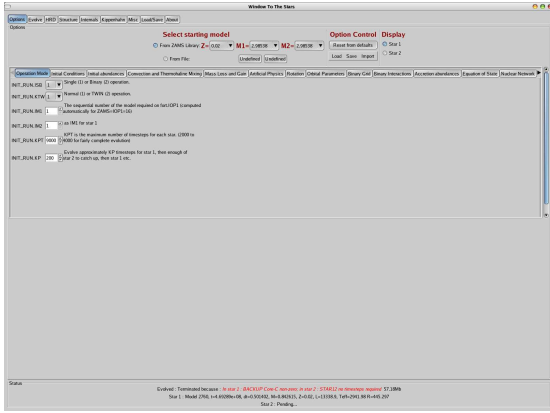
In addition to the main tab window, a status bar is visible at all times, informing the user of the current status (e.g. “Evolving” or “Stopped”) and the physical state of the primary and secondary star.

All images can be saved as either PNG, suitable for web-based projects, or Postscript for publications and talks. Animations are saved as animated GIFs, also compatible with web browsers.

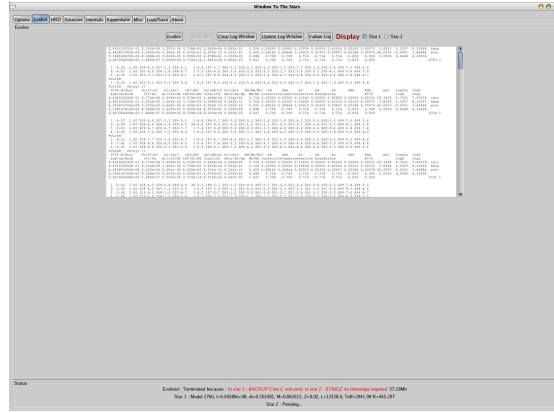
3.1 Installation

We provide detailed installation instructions on our website <http://www.astro.uu.nl/~izzard/windo> as well as an automated installation script which should work with most incarnations of Linux and possibly Mac OS X.

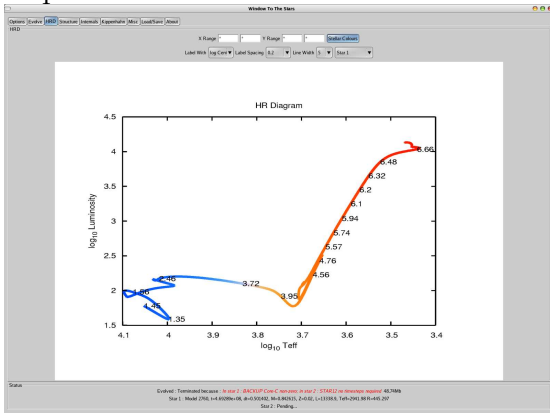
WTTS depends on some free software packages: Perl, GTK2, Perl-GTK, Gnuplot, Imagemagick, Ghostscript and a number of Perl modules (see <http://www.perl.com/>, <http://www.gtk.org/>, <http://www.imagemagick.org>, <http://www.cs.wisc.edu/~ghost/>, <http://www.gnuplot.info/> and CPAN, <http://www.cpan.org>, for Perl modules). All these packages are available for, or are installed by default on, a modern Linux system; we have also had success running *WTTS* on a Mac running OS X. A Fortran compiler is required to build *TWIN*: it is compat-



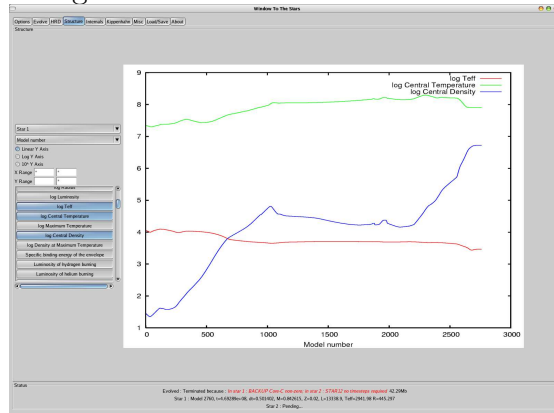
The *Options* tab where physical input is chosen.



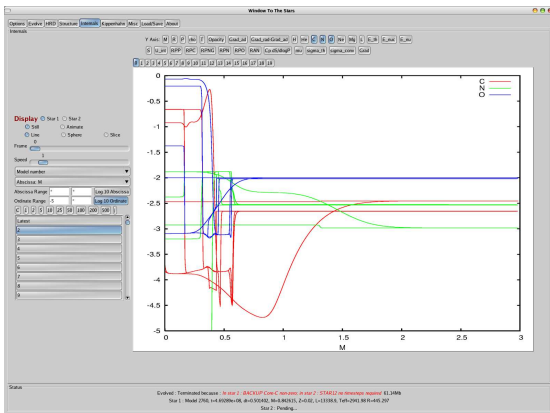
The *Evolve* tab follows the *TWIN* log file.



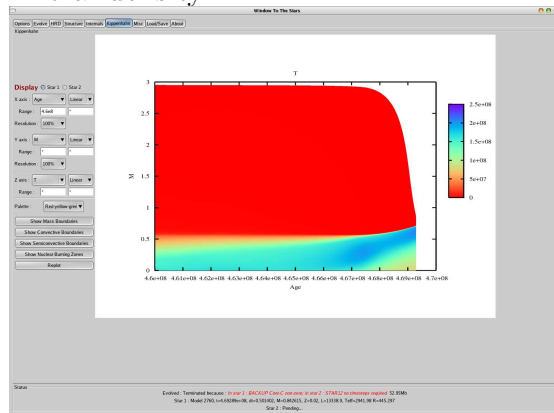
The *HRD* tab, labelled by log central density.



The *Structure* tab showing surface and central temperature, and central density.



The *Internals* tab showing CNO abundances for one in every 500 models.



The *Kippenhahn* diagram tab showing temperature as a function of mass coordinate and age.

Fig. 1. Example screenshots of the various tabbed windows showing the evolution of a $3M_{\odot}$ solar metallicity star (a total of 2760 stellar models).

ible with the GNU *g95* compiler (<http://g95.sourceforge.net/>), which is free and portable, as well as Intel's not really free compiler. We have also made some binary executables of *WTTS* and *TWIN* available on our website, for Linux *i386* (32-bit) and *x86_64* (64-bit) systems.

4 Conclusions and Future Plans

Window To The Stars provides everybody, from novices to experts, with a powerful yet uncomplicated stellar evolution tool. Its graphical interface circumvents the need for manual hacking of tables of cryptic numbers. It is capable of evolving stars and analysing the results, with output of publication quality. The focus is on physics, not computing. While *WTTS* has reached an advanced level, we plan numerous improvements, most notably the ability to transparently use different stellar evolution codes with the same graphical user interface.

Paul Groot of the University of Nijmegen is the first person to use *WTTS* in a stellar evolution course, and he describes his experience so far as “extremely positive”. The 2007 stellar evolution course at Utrecht University will include exercises based on *WTTS*. We already use *WTTS* to analyze our work on stellar accretion and mergers.

References

- [1] P. P. Eggleton. The evolution of low mass stars. *MNRAS*, 151:351, 1971.
- [2] P. P. Eggleton and L. Kiseleva-Eggleton. The Evolution of Cool Algols. *ApJ*, 575:461–473, August 2002.

Acknowledgements

RGI would like to thank everyone who contributed to this project, especially his in-laws for boring him into starting the project and Cecilia and Stefan for feeding him during a stay in Heidelberg, where *WTTS* grew up. RGI and EG are supported by the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO).