Massive Stars

Workshop

Getting Started

In this workshop we want to study at a set of massive stars models of massive stars of solar composition that have been evolved from pre-mains sequence to onset of core collapse. You can find the data files and python source code for the analysis tools at

https://2sn.org/Download/ANITA20/

There you will find the following directories:

- `python` - the python source code

- `abuset` - composition data that can be used for some plots, e.g., for comparing to solar abundances or abundance ratios.

- `s12`…`s29` - data files for start with initial masses of $12\,\mathrm{M_\odot}$ to $29\,\mathrm{M_\odot}$

The star directories contain files of the form

- `s12.cnv.xz` - output file for Kippenhahn Diagrams

- `s12#A` - "Dump" files - snapshots at various times.

the code provided for this workshop has been (somewhat) tested to run on Python 3.7; Python 3.8+ should work as well.

Additional packages that may be needed can be found at

https://2sn.org/python3/

but these may differ slightly form the ones provided for the workshop, and some may only run with extra python packages.

To run the Python code, I recommend to download/unpack all files as provided for the School to a subdirectory `ANITA20`. Start IPython in the `python` sub-directory or set `PYTHON_PATH` environment variable to include this directory.

```
>>> %pylab
>>> ion()
```

To load Kippenhahn diagram data file, e.g., first load the data and the make plots:

```
>>> import convdata
>>> import convplot
>>> c = convdata.load('/home/test/ANITA2020/s25/s25.cnv.xz')
>>> p1 = convplot.plot(c, logtime=-8.2, solar=True)
>>> p2 = convplot.plot(c, logtime=-8.2, radius=True)
```

You may browse the `convplot.py` file for more options.

To load the dump files and access the data you can use:

```
>>> from kepdump import load as D
>>> d = D('/home/test/ANITA2020/s25/s25#A')
>>> d.tn
>>> d.dn
>>> d.abu.c12
>>> d.abu.h1
>>> d.abu.he4
```

You can use these values to make plots; note that for technical reasons the array values `0` and `-1` do not contain useful data for zone-centred values, the index `-1` is not used for zone interface values except for transport quantities such as diffusion where indices `0`, `-1`, and `-2` should not be used.

You may look at https://2sn.org/kepler/doc/edit/index.html for definition/names of some of KEPLER quantities saved in dumps, or at the `kepdump.py` for extra derived quantities of the python module.

There is some limited support for drawing standard KEPLER structure plots directly from the dump files for quick review:

```
>>> from kepler.dumpplot import plot as P
>>> d = D('/home/test/ANITA2020/s12/s12#A')
>>> P(d)
>>> P(d, 1)
>>> P(d, 3)
>>> d.parm[443]=3
>>> P(d, 3)
```

Various further quantities and features will be discussed during the workshop as is of interest.

Suggested Tasks

Maybe best would be to work in groups at a table of four. Coordinate with other groups to ensure you look at models of different mass. We could try for each group to give a quick 1-2 minute summary of what they found – so, make table or keep plots; we could use *Google Docs* for the presentations.

Task 1a

Plot Kippenhahn diagram as function of log of time till core collapse. Note that the last model in the `cnv` files is about $0.25\,\text{s}$ before core bounce.

Task 1b

Plot Kippenhahn diagram as function of linear time. How does the picture compare?

Task 1c

Identify the different burning phases – core and shell burning – from lecture. you may use the dump files, as in question below, to guide you.

Task 1d

Plot Kippenhahn diagram as function of *radius*. What to you conclude about the burning and shells?

Task 2+

The dump files labelled `A`...`P` are snapshots at various evolution phases of the star. Try to identify what they may signify. You may compare with time axis from the Kippenhahn Diagrams.

Task 3*

Make a $T_\text{c} - \rho_\text{c}$ diagram (both axes logarithmic, use density for x-axis). Indicate the the different burning phases and times until core collapse.

Task 4*

Compare neutrino luminosity and photon luminosity of the star at different evolution stages.

Task 5

All Groups Work (last 5-10 minutes), build 4 groups of 10 people with one rep from each of the earlier working groups How do your models all compare, what is common, what is different, what is peculiar?