Simulating Stars 2018

Novae Lab 2: Exploring the parameter space of novae

Having run our first nova model in Lab 1, we'll now expand the range of white dwarf mass and accreted compositions to see the influence on the nova lightcurve.

Part 1: Stable burning

Nuclear burning on white dwarfs isn't always unstable. At high accretion rates, the burning stabilizes. Wolf et al. (2013, ApJ 777, 136) used MESA to calculate a sequence of stably-burning accreting white dwarf models. We've included these models with the files for this lab – they are in `stable_burning_models.tgz` (you can also find them on the MESA Marketplace at `http://mesastar.org`). The models cover a range of white dwarf masses from 0.51 to 1.36 $M_\odot$.

- First choose a white dwarf mass from those available in the stable-burning models in the range 0.51 to 1.1 $M_\odot$. Copy the model to your work directory, edit your inlist to use the new model, and then check that if you accrete at a high rate the burning is stable. You may need to experiment with the rate a bit, but something in the range 3×10^{-7} to 3×10^{-6} $M_\odot$ yr^{-1} should work.
- Once you see stable burning, lower the accretion rate until you see unstable burning begin. Report the mass accretion rate of the last stable burning model you find $\dot{M}_{\rm stable}$, and the temperature and pressure at which the hydrogen burns in that model.

Part 2: Unstable burning across the parameter space of mass and metallicity

We discussed in the lecture that it is likely that the layer of accreted H/He is polluted by metals from the underlying white dwarf, either between novae as the layer builds up or during the nova itself. Published calculations often simulate this by adding extra metals to the accreting material. We'll do this here, adjusting the total amount of hydrogen and helium such that the ratio Y/X is fixed.

When running many different parameter variations, it can be useful to automate things. We've provided a python script `driver.py` that automatically generates an inlist for MESA based on a template `inlist_flash_template`. You can use this to run one model or many models iterating over different parameters. The script generates the inlist and then, if the run is successful, stores the `history.dat` and final model, and makes a movie of the run using the `.png` files generated by pgstar.

- Use the same mass as in part 1, but now choose a metallicity in the range 0–0.5. Set the values of Z, $\dot{M}$ and M in `driver.py`, and then run it in the terminal by typing `python driver.py` . Run the model at a high accretion rate again to find the stable-burning solution at your chosen Z.
- Now explore lower accretion rates where the burning is unstable. For each value of $\dot{M}$, calculate the following:
  - the recurrence time and ignition mass
  - the maximum temperature and pressure reached in the H burning region
  - the lightcurve of the nova
  - the rate at which the white dwarf mass is changing

  Note that if you change accretion rate by a large amount, you'll probably run into convergence issues with the model. If that happens, try taking a smaller step.

We will collect the results for different M_{WD} and Z from each group to compare at the end of the session.