

Ay190 – Worksheet 08
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Date: February 5, 2014

1

The `toV_RHS` function is simply our system of two ODEs and it returns an array of $[\frac{dP}{dr}, \frac{dM}{dr}]$ for pressure P , mass M , and radius r .

Then, `toV_integratefe` integrates `toV_RHS` using a defined method (either forward Euler or RK2,3,4 for our cases). It returns $[P, M]$.

We then divide our star into a grid (in our case, 1000 points) and give boundary values. We define our pressure, radius, and mass as arrays of zeros of length `npoints`, the number of points in our grid. The zeroth values of these arrays are our central values. Setting up a large radius `max` (much larger than the radius of a dwarf star) gives us a safety net for calculation. We also fill in the polytropic EOS inversion to find density as a function of pressure. Our loop proceeds by intervals of dr or h .

We also set up a termination and iteration criterion for our code by defining a cutoff pressure, `press_min`, that identifies the surface of our star. We loop over our grid. If our pressure is less than the cutoff pressure, we go back one loop and define that gridpoint `nsurf` as our surface. Otherwise, we continue, upgrading the n th item in our pressure, mass, density arrays corresponding to the n th grid point.

Our adiabatic index is $4/3$, the value for a relativistic gas, degenerate or not. Indeed, a dwarf star is relativistic gas.

2

I add an RK-2 integrator. I have to rewrite the first element of our `toVRHS` function, which returns an array of [pressure, mass], into density using the polytropic equation of state.

I'm not sure how to check convergence rate, but RK2 should converge twice as fast as forward Euler.

I calculate RK-3 and RK-4 as well, similarly to RK-2. To our level of precision, the results are identical

3

I plot density, pressure, and mass rescaled at their central, central, and total values, respectively. I use the `twinx()` function of `matplotlib` to add an additional y-axis. I don't use a logarithmic scale; a linear scale shows the evolution clearly for our case.

See Figure 1.

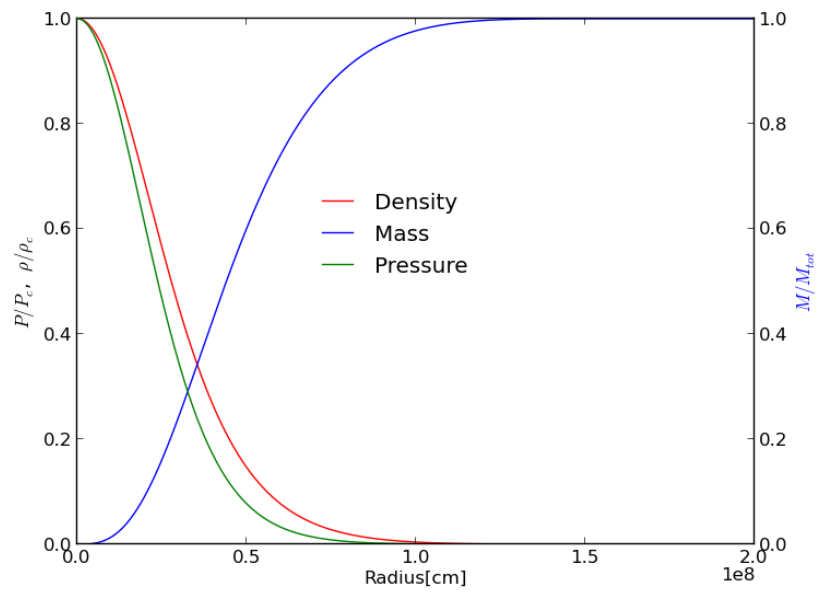


Figure 1: Scaled Pressure, Mass, Density