

CEJet

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1 Introduction

2 July 15

2.1 Plan for this week

1. First test run on Stampede2, use CE fiducial (run 143) setup, with the jet turned on. In prep, submit by tomorrow.
2. Fix the initial profile with smooth pressure gradient.
3. Prepare profiles with double or triple the softening radius, to be used for BlueHive tests.

2.2 Run 48 on BlueHive

This was the doubled resolution run from last week, with 4 level AMR and 128 base grids. Momentum is not conserved in the jet (`lcorrect = F`). It has been extended to 20.83 days (90 frames).

Movie edge-on-through-particles:

http://www.pas.rochester.edu/~yzou5/research_data/CEJet/Movie_048/rho/run048_rho_edgeon.gif

Movie face-on:

http://www.pas.rochester.edu/~yzou5/research_data/CEJet/Movie_048/rho_box/run048_rho_box.gif

Movie face-on zoom-in:

http://www.pas.rochester.edu/~yzou5/research_data/CEJet/Movie_048/rho_faceon_300Rsun_1e-12_0.001/run048_rho_faceon_zoom.gif

Figure 1 shows the total mass of the jet material measured from the tracer.

2.3

Run 48 is about the limit of our test runs on BlueHive. With 120 cores, the total run time of 90 frames is within 5 days (4 days 18 hr for run 48). We tried another run with 32 base grid and 7 levels AMR (doubling the resolution of the finest grids), which takes 5 days to get only frame 1.2

2.4 Initial Profile

The original RG profile used for the fiducial run has a problem in its pressure gradient. See the figures. We decided to fix it by integrating the pressure from the modified Lane-Emden equation to both inward and

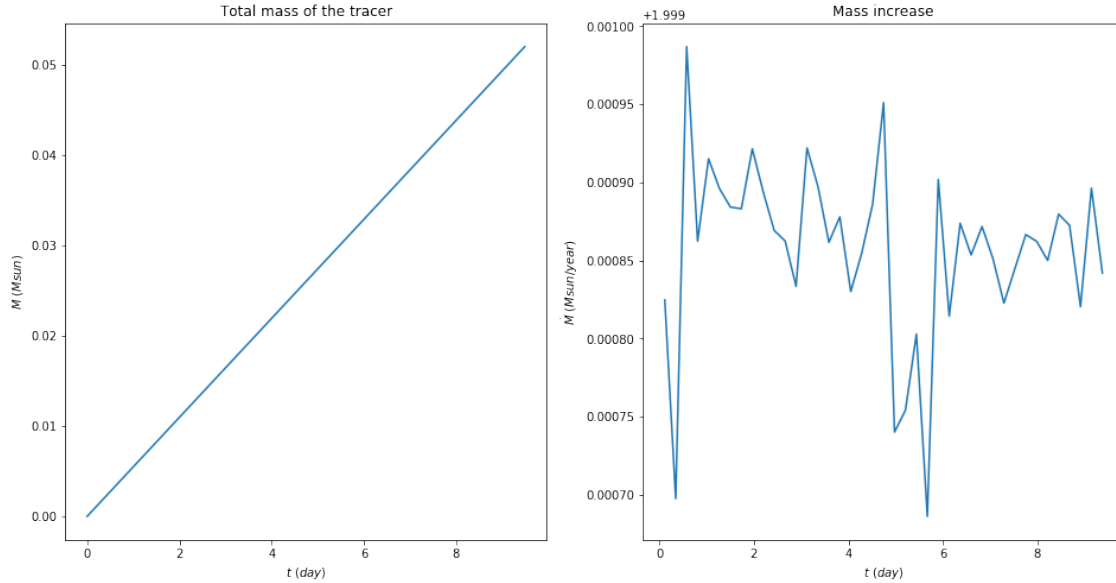


Figure 1: Total mass of the jet material.

outward directions. So the final pressure profile may be slightly different from the MESA profile, but the density profile is made to be agree with the MESA result.

3 July 10

1. Read and learn to use the initial profile code
2. Consider rewriting the IDL part in Python
3. Paper to read:
 - (a) Ohmann 2017
 - (b) Moreno Mendez 2017
 - (c) Duffell 2019
4. Install MESA
5. New profile with fixed pressure gradient

BlueHive run 49, 32 base grid and 7 AMR levels

4 July 8

4.1 Plan for runs on Stampede and BlueHive

1. Get one good low resolution test run
 - (a) Stampede – get on the system

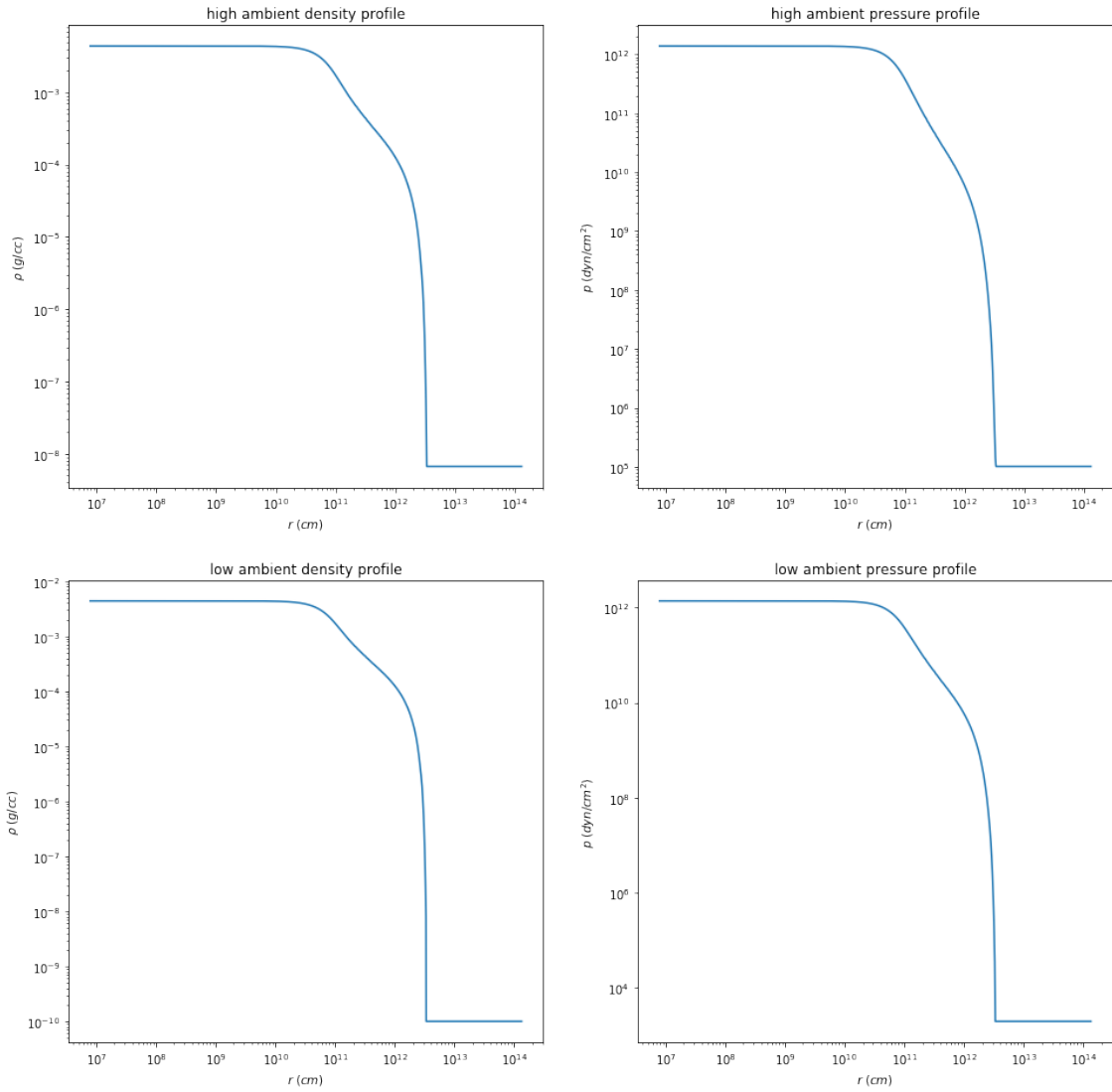


Figure 2: Density and pressure profile with high and low ambient.

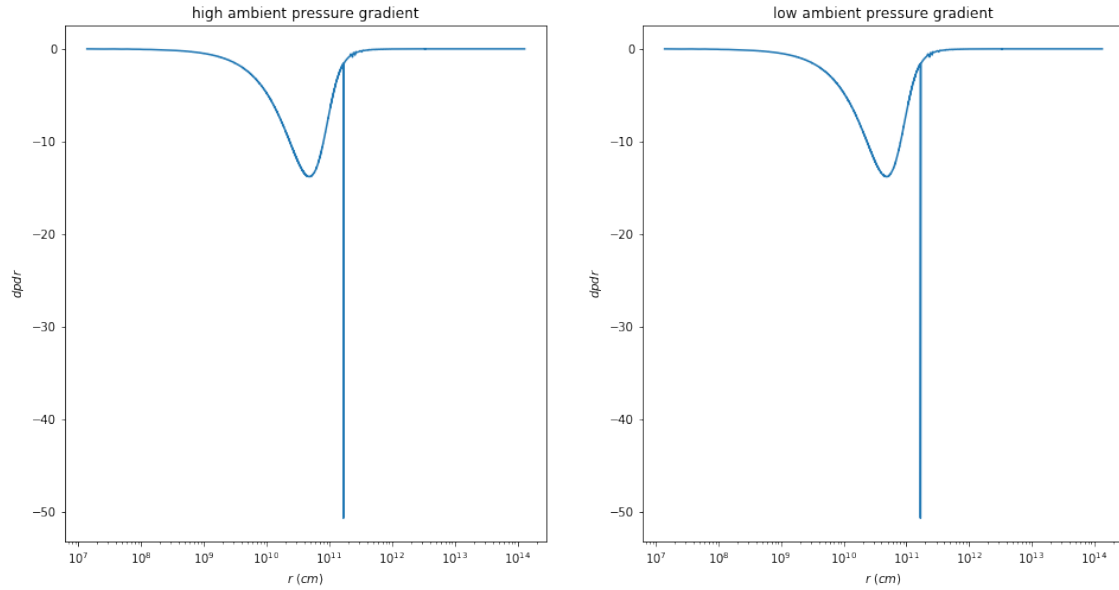


Figure 3: Pressure gradient of the RG profile

(b) analyze this, make sure everything is as expected.

2. Explore parameter space using test runs

- (a) separations
- (b) ambient
- (c) restart frame (from run 143)
- (d) jet parameter
 - i. jet radius
 - ii. \dot{M}_{jet}
 - iii. θ
 - iv. Temperature
 - v. r_{surface}
 - vi. Q ,

3. test / production runs on Stampede

4.2

1. Fiducial run 143

2. New

- large initial separation, a
- lower ambient
- possibly correct initial profile
- possibly improve refinement

3. Tests

- use larger softening radius
- small lbox
- Higher AMR level, lower base resolution

4.3 Run 48 on BlueHive

Doubling the resolution from previous, with 4 level AMR and 128 base grids. Starting at the surface of the primary.

5 July 1

5.1 From last week: 3 test runs planned

4 levels of AMR with 64 base grid resolution. Each run is planned for 10 days in simulation time, and takes about 2 days to complete on BlueHive.

Run 45 - low ambient, small separation

Secondary starts right against the primary envelope: $a_0 = 49 R_\odot$.

Use lower ambient density and pressure profile: $\rho_{\text{amb}} = 1e - 10 \text{ g/cc}$, $p_{\text{amb}} = 1961 \text{ dyn/cm}^2$.

Run 46 - high ambient, small separation

Secondary starts right against the primary envelope: $a_0 = 49 R_\odot$.

Use ambient profile as the CE fiducial run (run 143): $\rho_{\text{amb}} = 6.67e - 9 \text{ g/cc}$, $p_{\text{amb}} = 1e5 \text{ dyn/cm}^2$

This and the first run will compare the effect of ambient material over the jet. Also a comparison with the CE fiducial run.

Run 47 - low ambient, large separation

Start with the secondary farther out: $a_0 = 98 R_\odot$ (meant to do $72.5 R_\odot$, but I messed up), and use lower ambient profile.

5.2 Issue: unstable primary, 2 tests without jet

Secondary starts right against the primary envelope: $a_0 = 49 R_\odot$. Use lower ambient density and pressure profile: $\rho_{\text{amb}} = 1e - 10 \text{ g/cc}$, $p_{\text{amb}} = 1961 \text{ dyn/cm}^2$.

test 1 - low ambient, small separation

no mass in the secondary ($M_2 = 0$),

but the two particles are given the same initial velocity as the orbiting case.

See the primary blows up in the opposite direction of its motion:

test 2 - low ambient, small separation

with secondary ($M_2 = 0.978 M_\odot$),

this is like Run 45 without the jet.

Same effect observed in the orbiting case:

a zoomed-in view:

5.3 From group meeting: How to stabilize the primary in low resolution?

try:

- density dependent viscosity (hard way, back plan)
- [modify the initial profile data with larger softening radius.](#)

-
- try a non-rotating primary – in `problem.data`, set the position of particle 1 to be fixed.

about `r_jet`:

How wide the nozzle is at the top.

Depends on resolution, which also affects the ramp pressure of the jet.

Calculate what pressure we need to keep the jet from being quenched.

6 June 24

Working on branch `ticket_442`.

6.1 Questions to answer for jet project

1. How does the jet affect the morphology of the envelope?
2. How does the jet affect the ejection of the envelope?
3. How does the jet evolve, does it get quenched?
4. What is the dependence of these questions on when the jet gets turned on?
5. What is the dependence on accretion rate?
6. Opening angle?

6.2 movies from test run 44

Starting with secondary right against the primary envelope. No secondary mass. Jet mass loss rate at 2 M_{sun} /year, and radial velocity 430 km/s (Keplerian).

- density-edge-on
- temperature-edge-on
- density-face-on

6.3 3 test runs planned for this week

4 levels of AMR with 64 base grid resolution. Each run is planned for 10 days in simulation time, and takes about 2 days to complete on bluehive.

1. Run 45 Secondary starts right against the primary envelope: $a_0 = 49 R_{\odot}$.
Use lower ambient density and pressure profile:
 $\rho_{\text{amb}} = 1e - 10 \text{ g/cc}, p_{\text{amb}} = 1961 \text{ dyn/cm}^2$.
2. Run 46 Secondary starts right against the primary envelope: $a_0 = 49 R_{\odot}$.
Use ambient profile as the CE fiducial run (run 143):
 $\rho_{\text{amb}} = 6.67e - 9 \text{ g/cc}, p_{\text{amb}} = 1e5 \text{ dyn/cm}^2$.
This and the first run will compare the effect of ambient material over the jet.
Also a comparison with the CE fiducial run.
3. Run 47 Start with the secondary farther out:
 $a_0 = 72.5 R_{\odot}$, and use lower ambient profile. There is also a CE run without jet to be compared.

6.4 Some parameters to explore

- Initial separation (a_0) (ref. Shiber+2019)
 - 49 R_{sun} , right against the primary envelope. Jet might be quenched after the secondary enters the envelope.
 - 72.5 R_{sun} , start farther out, longer time for the jet to evolve (although farther means lower mass loss rate if we use accretion rate to determine the mass loss of the jet).
 - 109 R_{sun} , Roche distance of our system.
- Jet mass loss rate
 - From CE paper 1, the secondary can have extremely high accretion rates of 0.2 - 2 $M_{\text{sun}}/\text{year}$. This rate corresponds to 100 - 1000 times the Eddington rate for a MS star, or $1e4 - 1e5$ times for a WD. Currently we are using the upper limit (2 $M_{\text{sun}}/\text{year}$). For a more physical value, we plan to compare between 1 vs 100 times Eddington rate of a WD (100 times WD rate would be Eddington rate for a MS).
 - Check out the Xsede proposal for more suggested tests.
- Jet radial velocity
 - Federrath+2014 suggests using Keplerian velocity at the surface of the star.
 - In the current test runs, this is computed using initial mass of the secondary ($0.978 M_{\odot}$), and 1 solar radius. So,
$$\text{jet_vrad} = \text{sqrt}(G * M_2 / R_{\text{sun}}) = 430.75 \text{ km/s}$$
- Jet radius, distance from the secondary particle within which the jet is initialized. 64 cells (70.4 R_{sun}) for now. Federrath+2014 also tested this effect, and suggests using 16 or 32 cells.
- Refinement radius (compare to the orbit). See CE paper 1 fig. 3, and paper 2 appendix fig. C1.
- Refinement shapes and qTolerance.