MESA2GADGET
Bridging the Gap between 1D and 3D Stellar Models

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Dartmouth
SAAO & UCT

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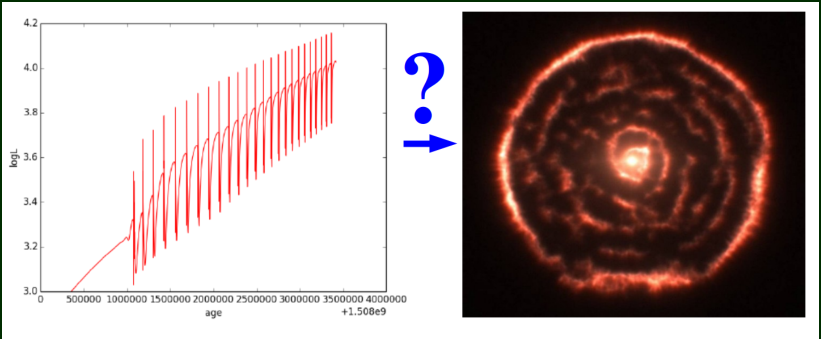
Why?


4.2
4.0
3.8
3.6
3.4
3.2
3.0
logL
0
500000
1000000
1500000
2000000
2500000
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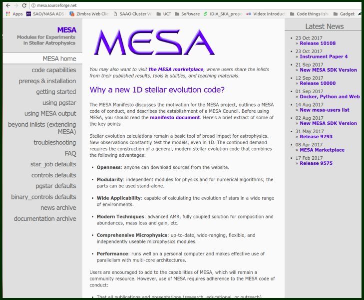
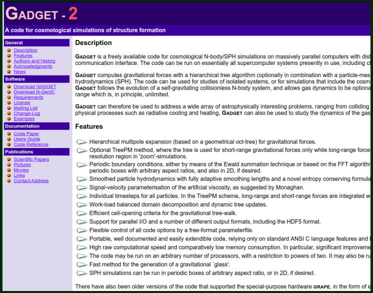
age
+1.508e9
?

Meet the Codes





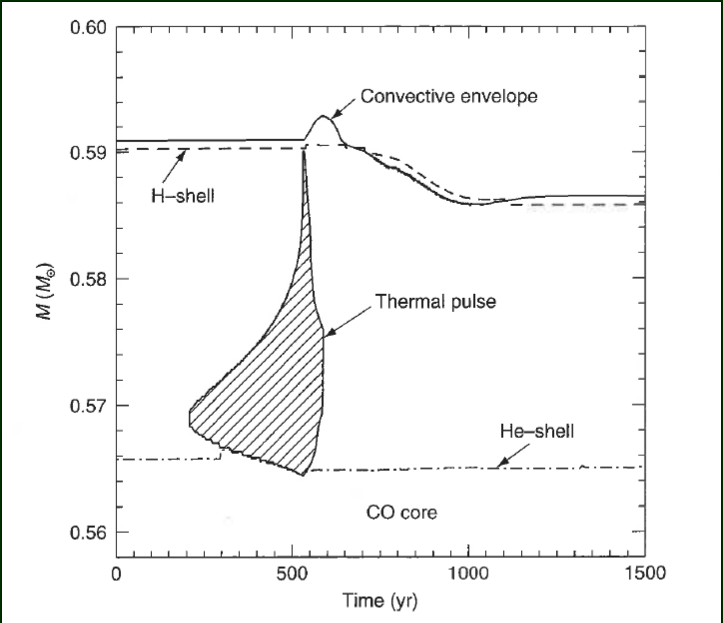
MESA: Modules for Experiments in Stellar Astrophysics

- 1 dimensional stellar structure solver
- highly customizable physical conditions

GADGET: GAlaxies with Dark matter and Gas intEracT

- N-body/SPH
- typically used for galactic and cosmological simulations
- SPH also useful for stellar atmospheres

TP-AGB Models



Method

- generate MESA density profile
- subdivide into k regions of varying size $(r_u - r_l)_k$ such that the number of particles N is preserved per region and the mass per particle m_p is preserved $\forall k$
  - requires either numerical integration or model fitting to find the mass contained per region, which determines N (or m_p)
- distribute the N particles contained in each region k across the surface of a sphere of radius $r_{\mathrm{mid},k} = \frac{(r_u+r_l)_k}{2}$
  - care is required in selecting a particle distribution method that will minimize computational artifacts $\rightarrow$ HEALPix
- stack these shells: $\forall k, x = x + x_k$ (same for y, z) at $r_{\mathrm{mid},k}$
  - IMPORTANT! must arbitrarily rotate each shell or the particles will be ordered
- send final x, y, z arrays to a Gadget initial conditions (IC) generator
- VALIDATION!
  - Load the ICs! Check: does ρ vs $r_k = \sqrt{x_k^2 + y_k^2 + z_k^2} \forall$ regions k recover the initial radial sampling applied to MESA?

Ohlmann et al., 2017

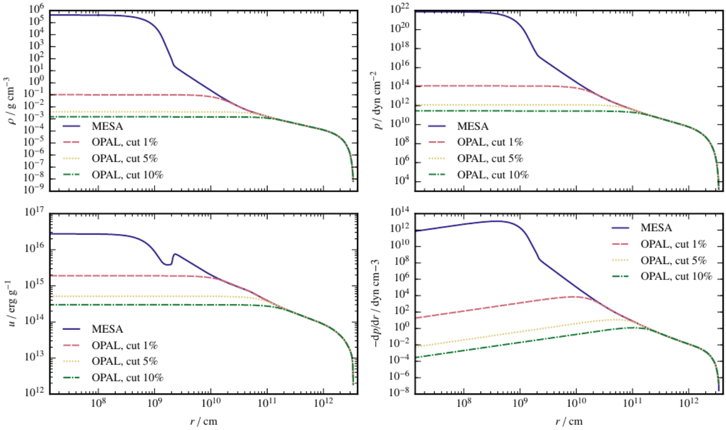
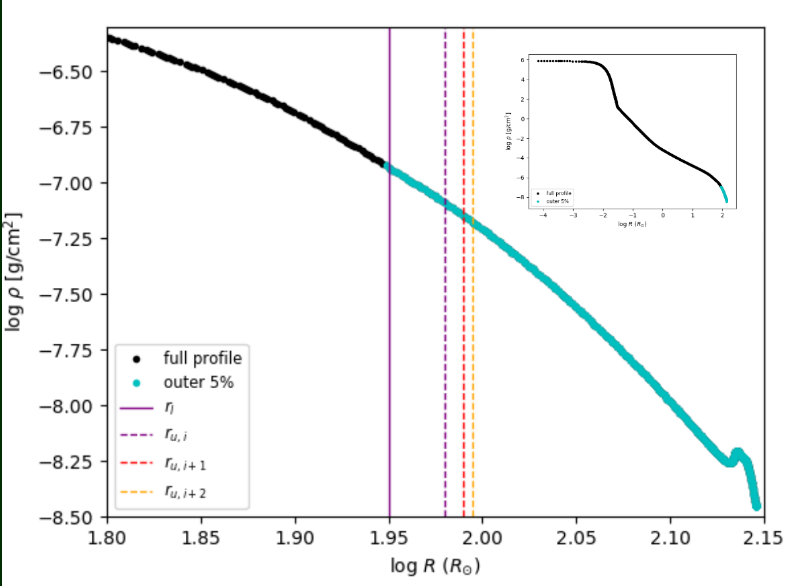
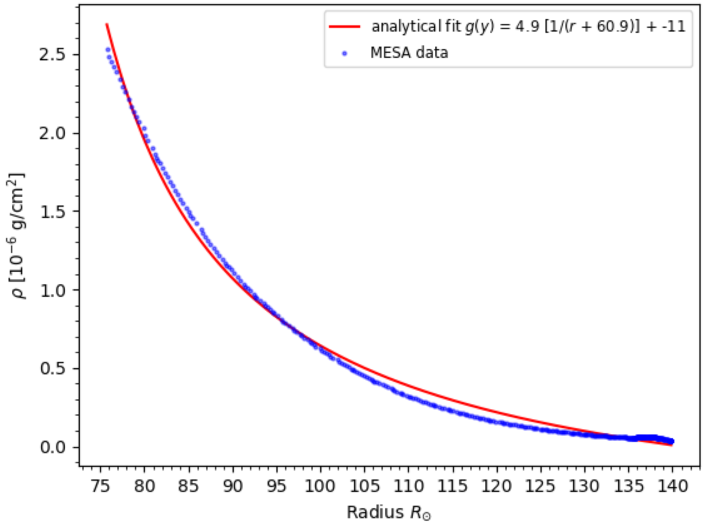


Fig. 4. Comparison of density (*upper left*), pressure (*upper right*), internal energy (*lower left*) and derivative of pressure (*lower right*) for a 2 $M_{\odot}$ RG with a ~0.4 $M_{\odot}$ He core. Shown is the original profile from the MESA stellar evolution code as well as approximate profiles for cut radii of 1%, 5%, and 10% of the total radius. The approximate profiles were computed using a polytropic index of $n = 3$ for the interior part.

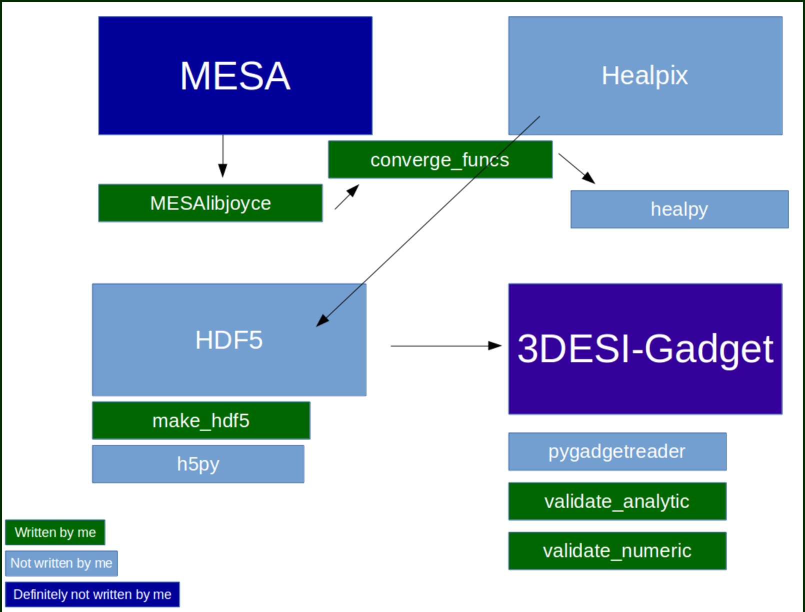


full profile
outer 5%
r_l
$r_{u,i}$
$r_{u,i+1}$
$r_{u,i+2}$
log ρ [g/cm²]
log R (R⊙)

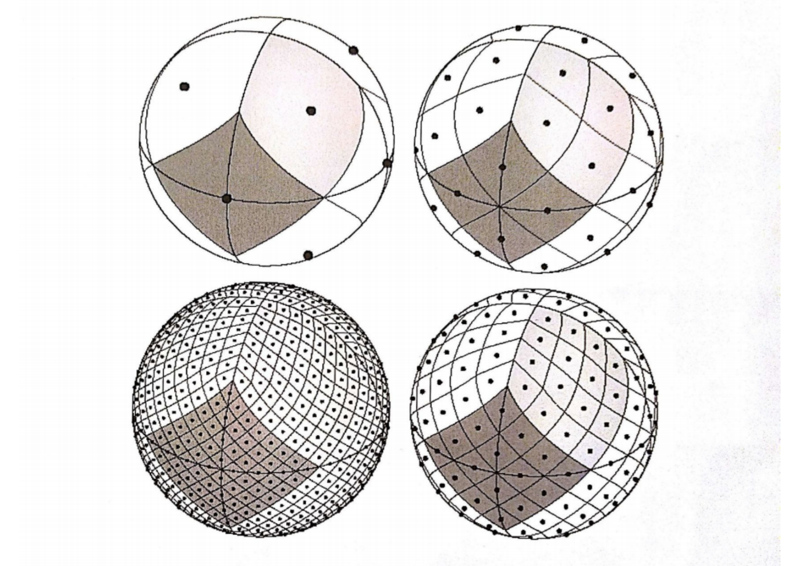


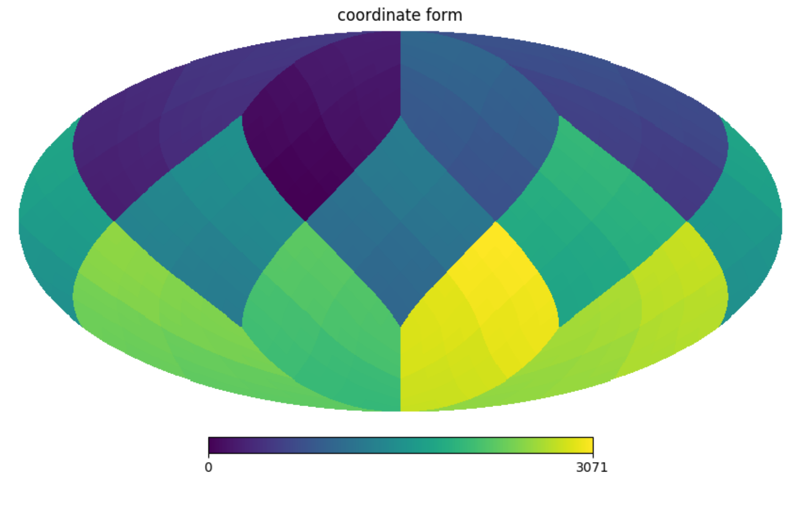
analytical fit $g(y)$ = 4.9 [1/(r + 60.9)] + -11
MESA data
ρ [10^{-6} g/cm^2]
Radius $R_\odot$
0.0
0.5
1.0
1.5
2.0
2.5
75
80
85
90
95
100
105
110
115
120
125
130
135
140

Workflow

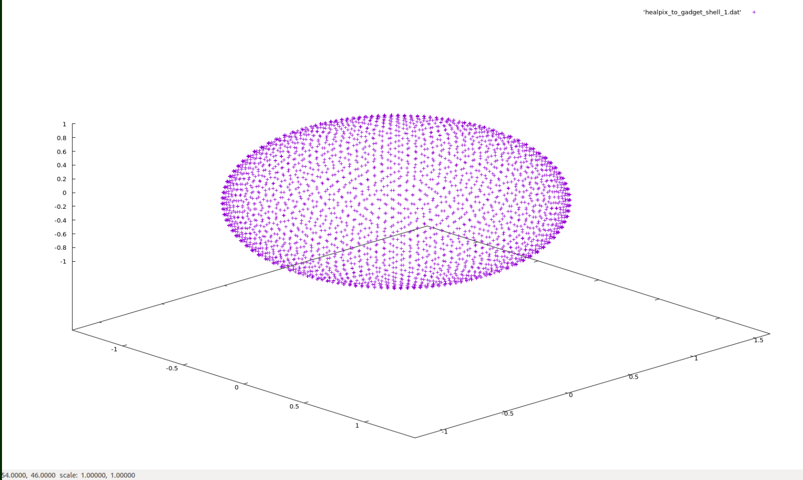

MESA
Healpix
converge_funcs
MESAlibjoyce
healpy
HDF5
3DESI-Gadget
make_hdf5
h5py
pygadgetreader
validate_analytic
validate_numeric
Written by me
Not written by me
Definitely not written by me

HEALPix: Hierarchical Equal Area iso-Latitude Pixelization




coordinate form
0
3071

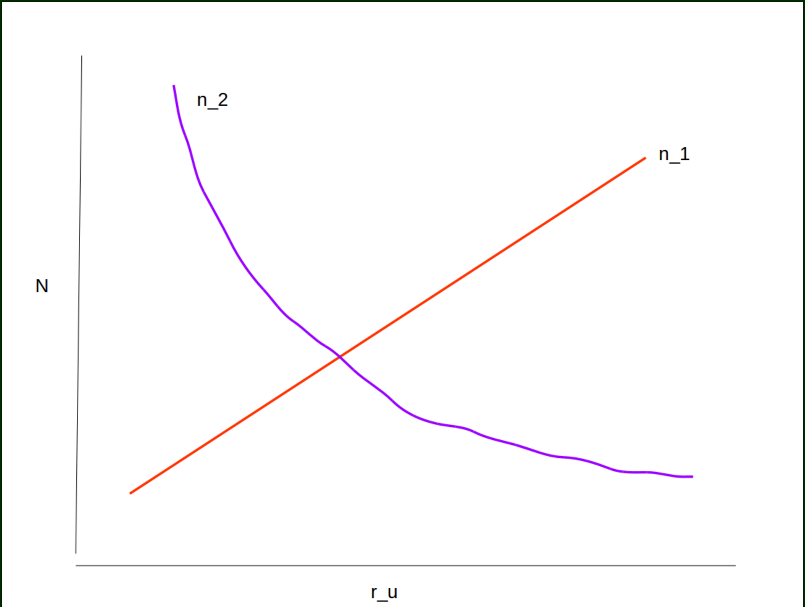
HEALPix distribution for arbitrary shell k



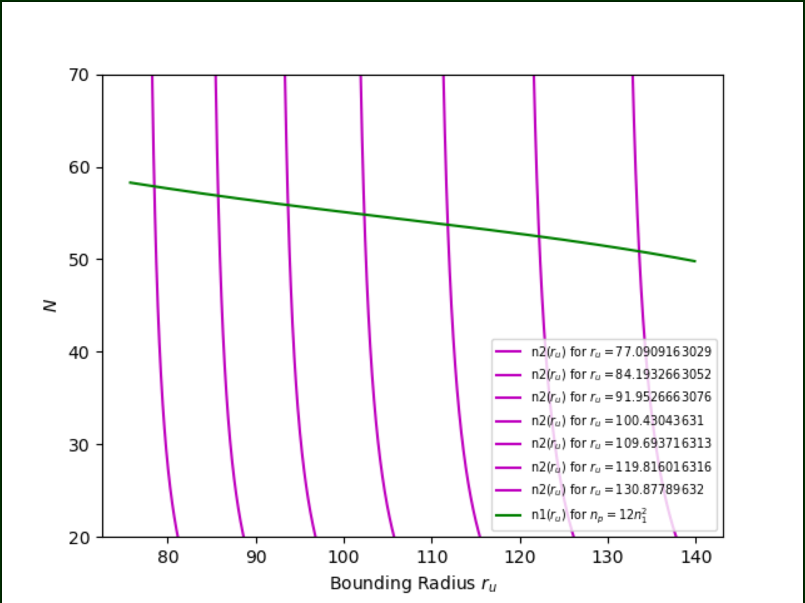
Convergence Criteria: $n_1(r_u)$ and $n_2(r_u)$

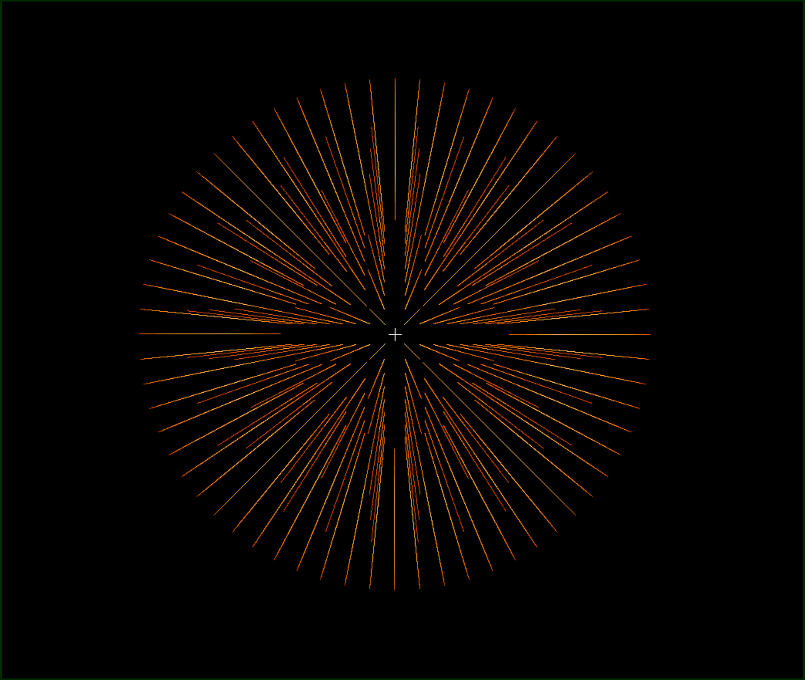
- Method: Impose two independent constraints and force their equality
- HEALPix tessellates a sphere into $12n^2$ quadrilaterals for $n \in \{2^x\}; n, x \in \mathcal{Z}$
- Let n_1 s.t. $n_p = 12n_1^2$, where $n_p = \frac{M_{\text{shell}}}{m_p}$, with n_p the number of particles per shell
- Then $n_1 = \sqrt{\frac{M_{\text{shell}}}{12m_p}}$, where $M_{\text{shell}} = M_{\text{shell}}(r_u, r_l)$
- Now, let each quadrilateral have width $r_u - r_l$. The surface area of that quadrilateral is $(r_u - r_l)^2$
- Simultaneously, the total surface area of the shell k is $4\pi r_{\text{mid}}^2 = 4\pi \frac{(r_u+r_l)}{2}^2$
- HEALPix requires $12n_2^2$ partciles and $12n_2^2$ quadrilaterals via 1 particle per region constraint. Hence, $(r_u - r_l)^2 12n_2^2 = 4\pi \frac{(r_u+r_l)}{2}^2$ which gives $\rightarrow n_2 = \sqrt{\frac{\pi}{12} \frac{r_u+r_l}{r_u-r_l}}$.
- Because n_1 is a monotonically increasing function of r_u and n_2 is monotonically decreasing, $\exists r_u$ s.t. $n_1 = n_2$*
- *IGNORING all other constraints on M_{shell}

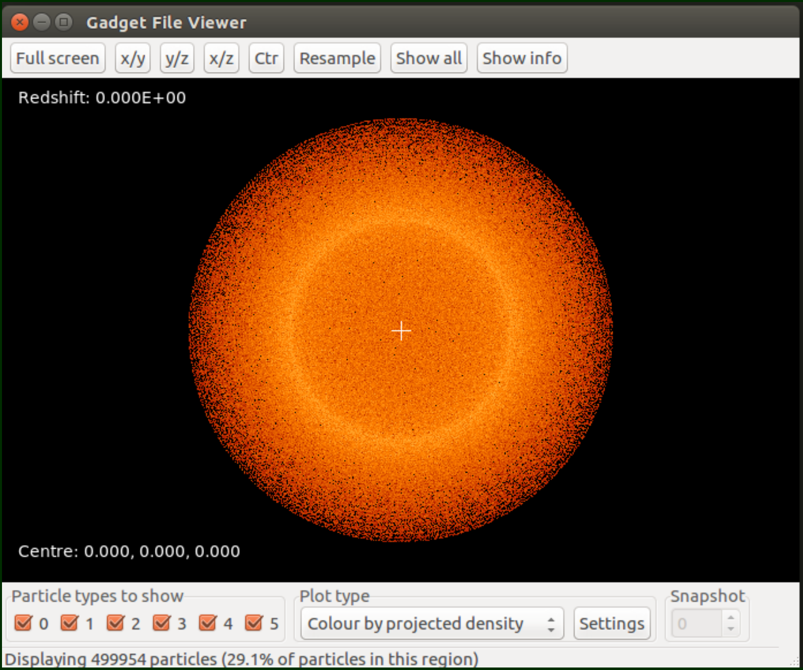
For fixed r_l and increasing r_u

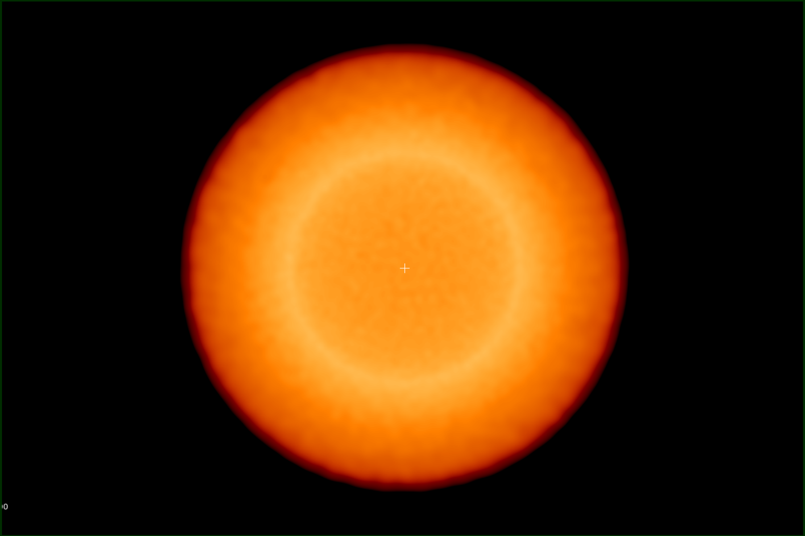


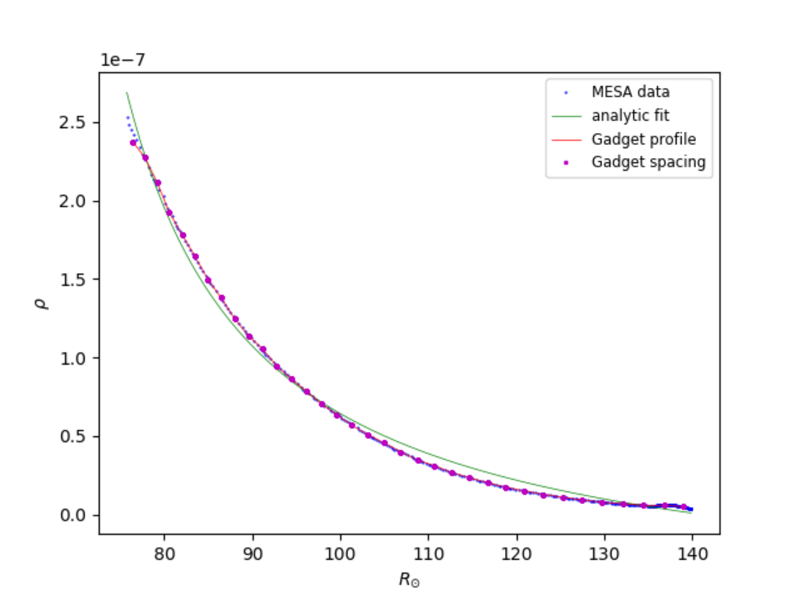
Convergence



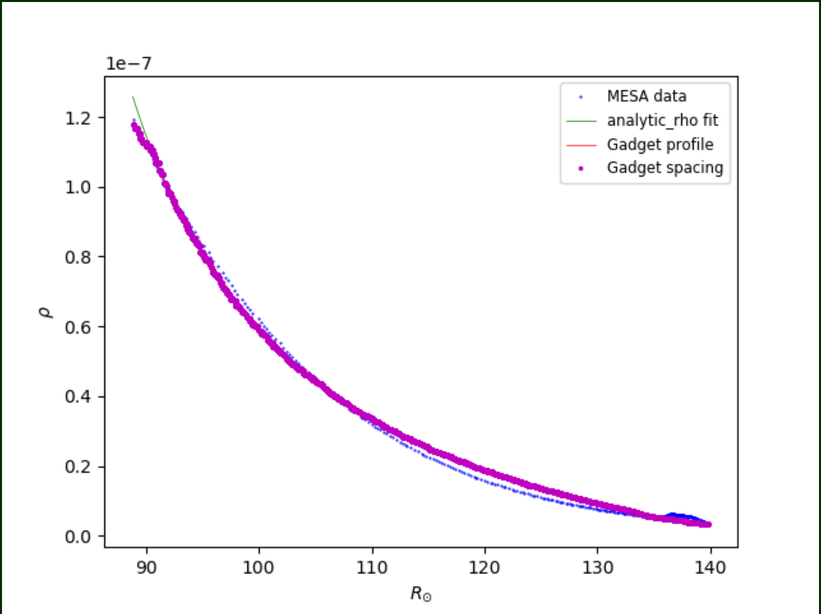



Gadget File Viewer
Full screen
x/y
y/z
x/z
Ctr
Resample
Show all
Show info
Redshift: 0.000E+00
Centre: 0.000, 0.000, 0.000
Particle types to show
0 1 2 3 4 5
Plot type
Colour by projected density
Settings
Snapshot
0
Displaying 499954 particles (29.1% of particles in this region)



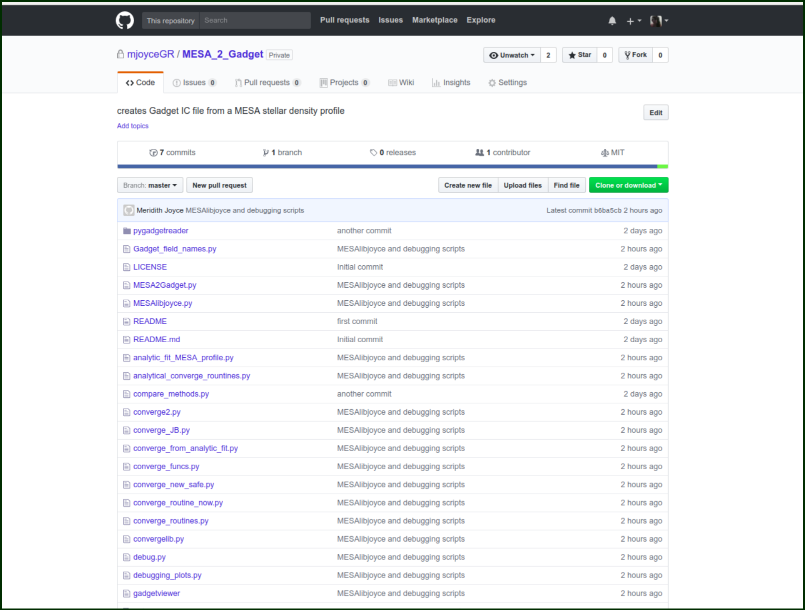


1e−7
2.5
2.0
1.5
1.0
0.5
0.0
ρ
80
90
100
110
120
130
140
$R_\odot$
MESA data
analytic fit
Gadget profile
Gadget spacing



1e−7
MESA data
analytic_rho fit
Gadget profile
Gadget spacing
ρ
0.0
0.2
0.4
0.6
0.8
1.0
1.2
90
100
110
120
130
140
$R_{\odot}$

Coming Soon...


This repository
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Issues
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Explore
mjoyceGR / MESA_2_Gadget
Private
Unwatch
2
Star
0
Fork
0
Code
Issues 0
Pull requests 0
Projects 0
Wiki
Insights
Settings
creates Gadget IC file from a MESA stellar density profile
Edit
Add topics
7 commits
1 branch
0 releases
1 contributor
MIT
Branch: master
New pull request
Create new file
Upload files
Find file
Clone or download
Meridith Joyce MESAlibjoyce and debugging scripts
Latest commit b6ba5cb 2 hours ago
pygadgetreader another commit 2 days ago
Gadget_field_names.py MESAlibjoyce and debugging scripts 2 hours ago
LICENSE Initial commit 2 days ago
MESA2Gadget.py MESAlibjoyce and debugging scripts 2 hours ago
MESAlibjoyce.py MESAlibjoyce and debugging scripts 2 hours ago
README first commit 2 days ago
README.md Initial commit 2 days ago
analytic_fit_MESA_profile.py MESAlibjoyce and debugging scripts 2 hours ago
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