Testing Fully Dynamical Adaptive Mesh Refinement in the Einstein Toolkit

Will It Help our Stars **Explode**?

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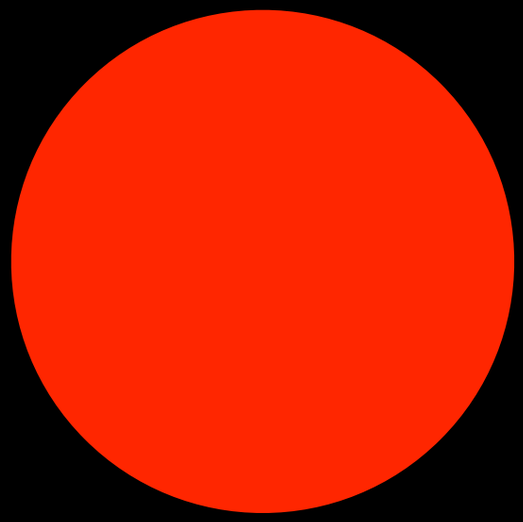
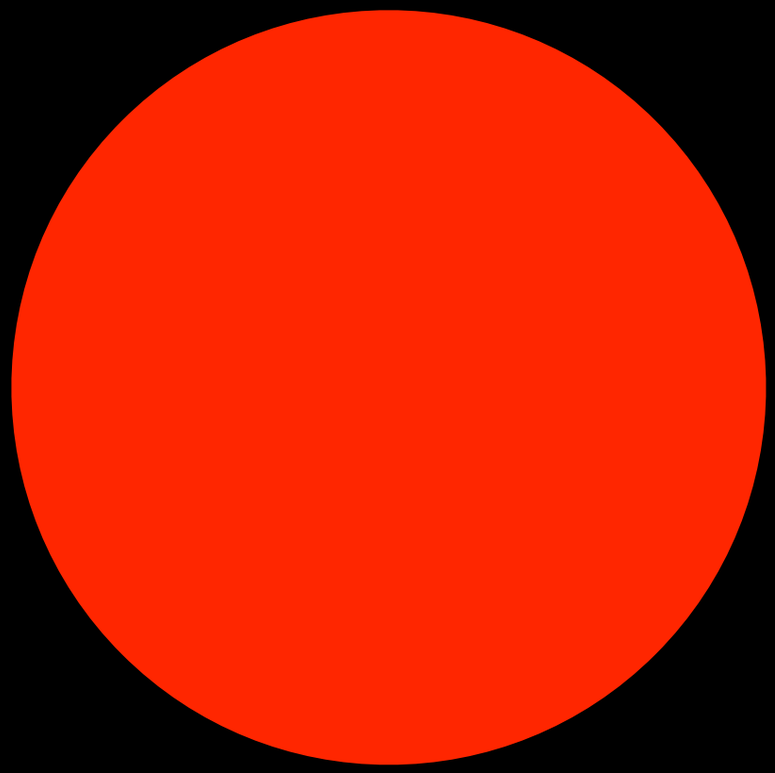
Christian Ott



Massive

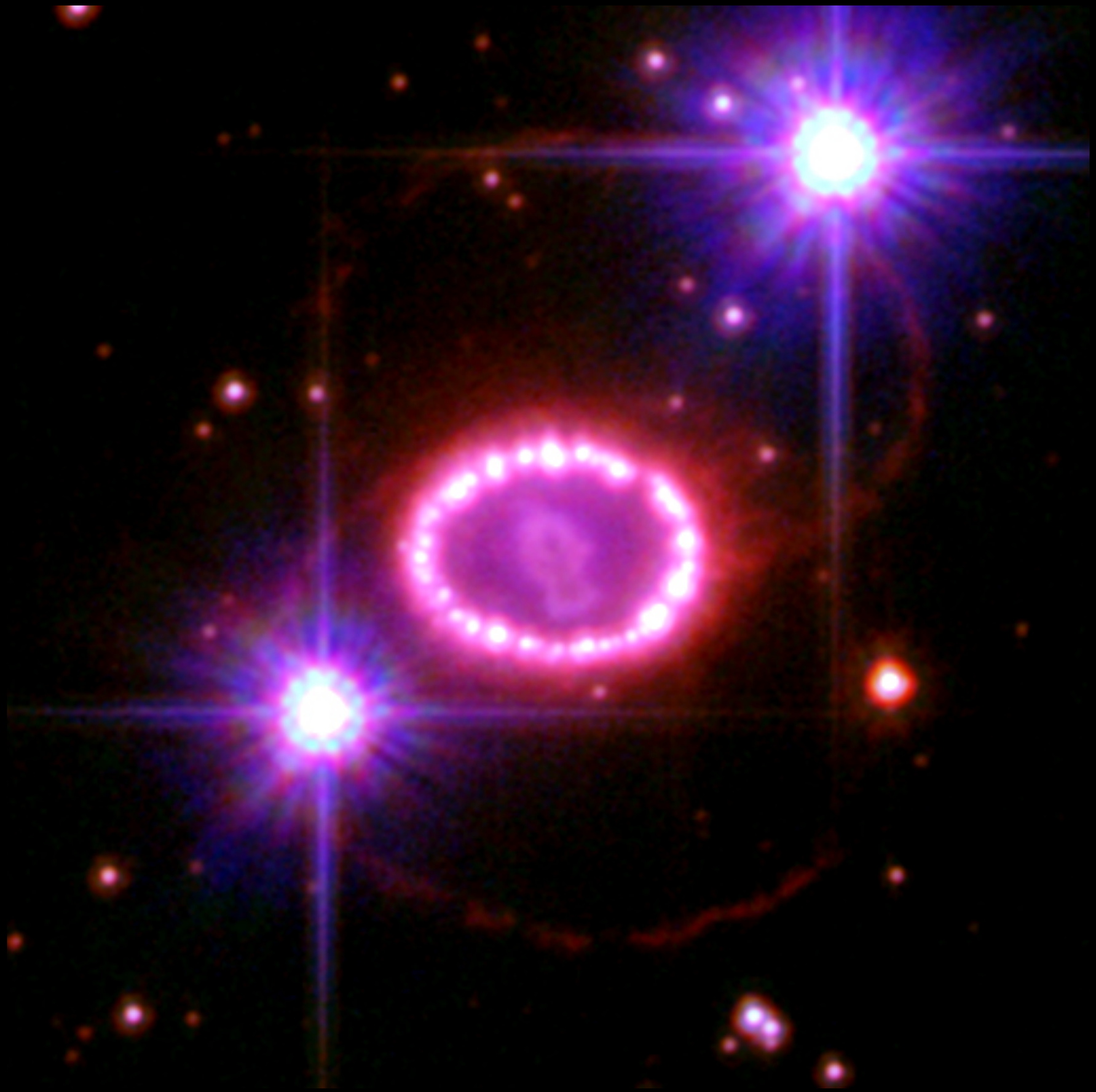


Massive Stars

Massive
Stars
That Explode

Core-Collapse Supernovae are the deaths of **massive stars**

8-100 times the mass of the **Sun**



NASA, ESA, P. Challis, and R. Kirshner (Harvard-Smithsonian Center for Astrophysics)

Optical: NASA/HST/ASU/J. Hester et al. X-Ray: NASA/CXC/ASU/J. Hester et al.

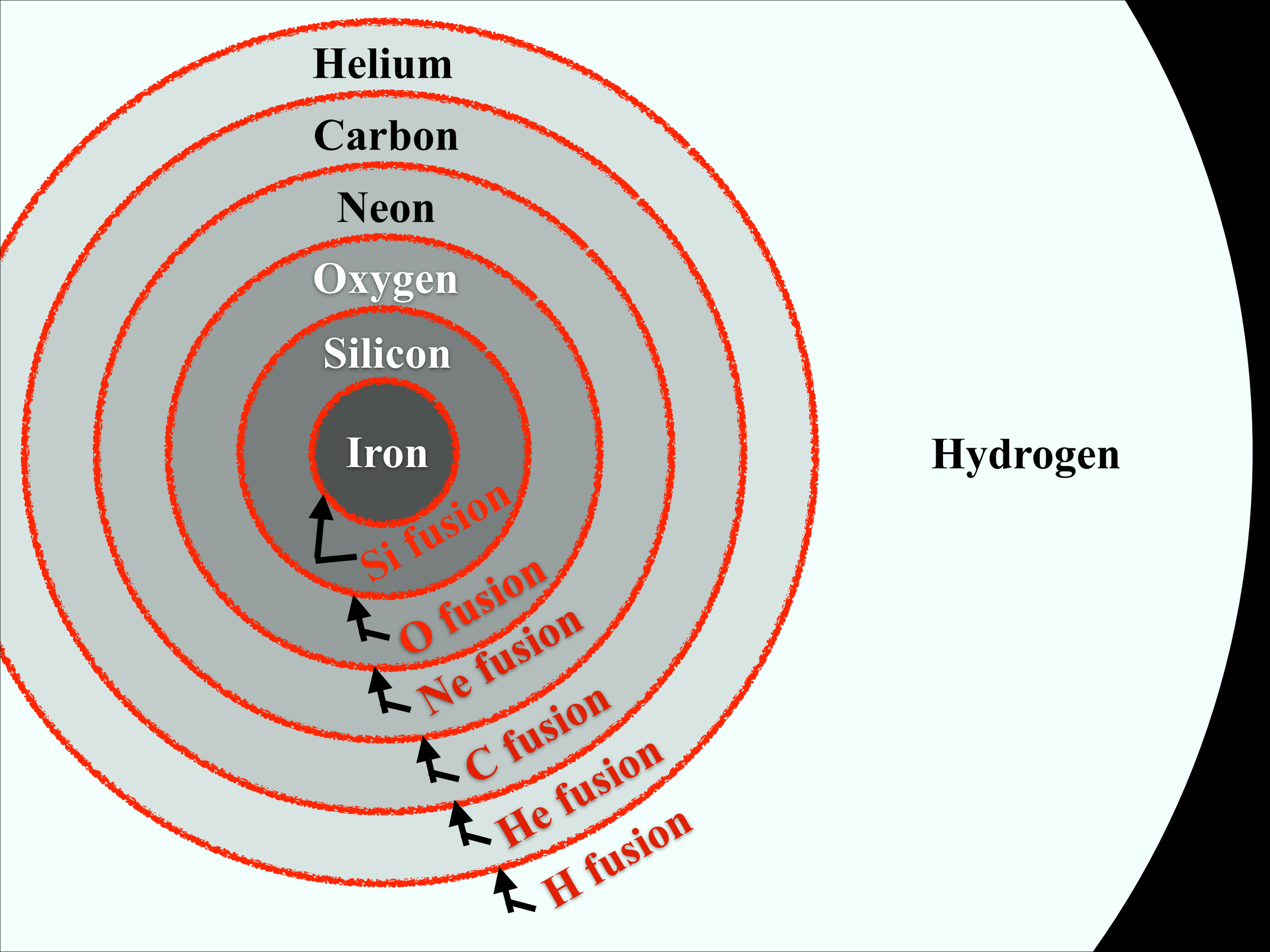
?

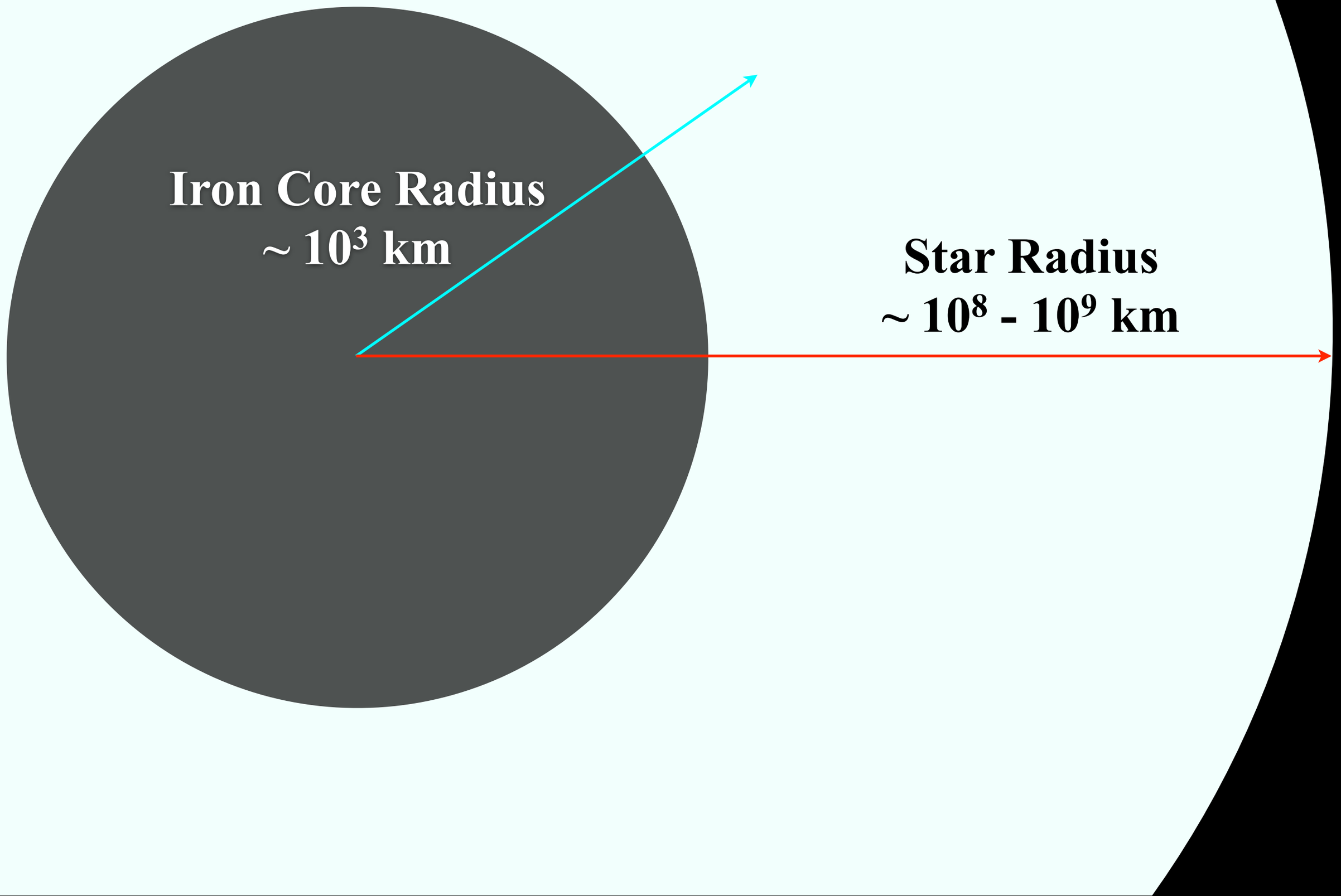
stars we simulate

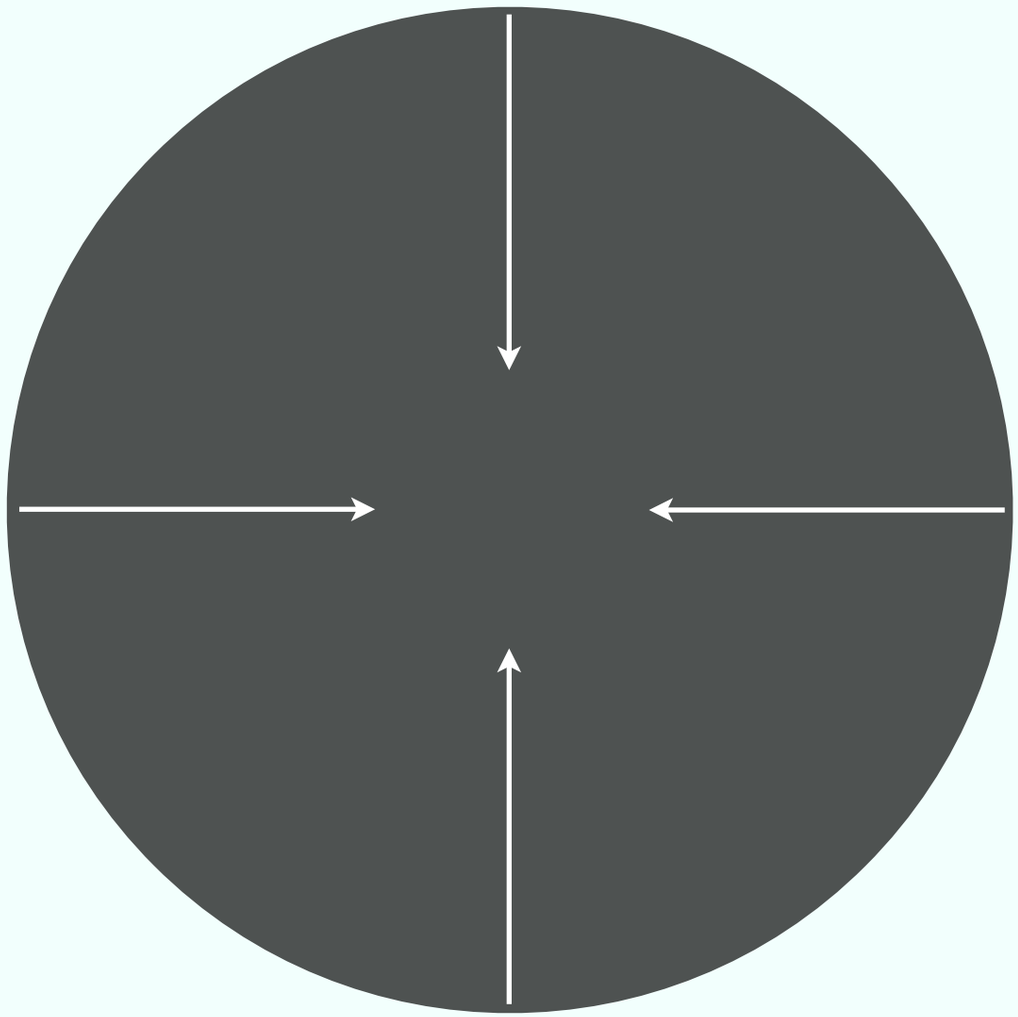
won’t explode

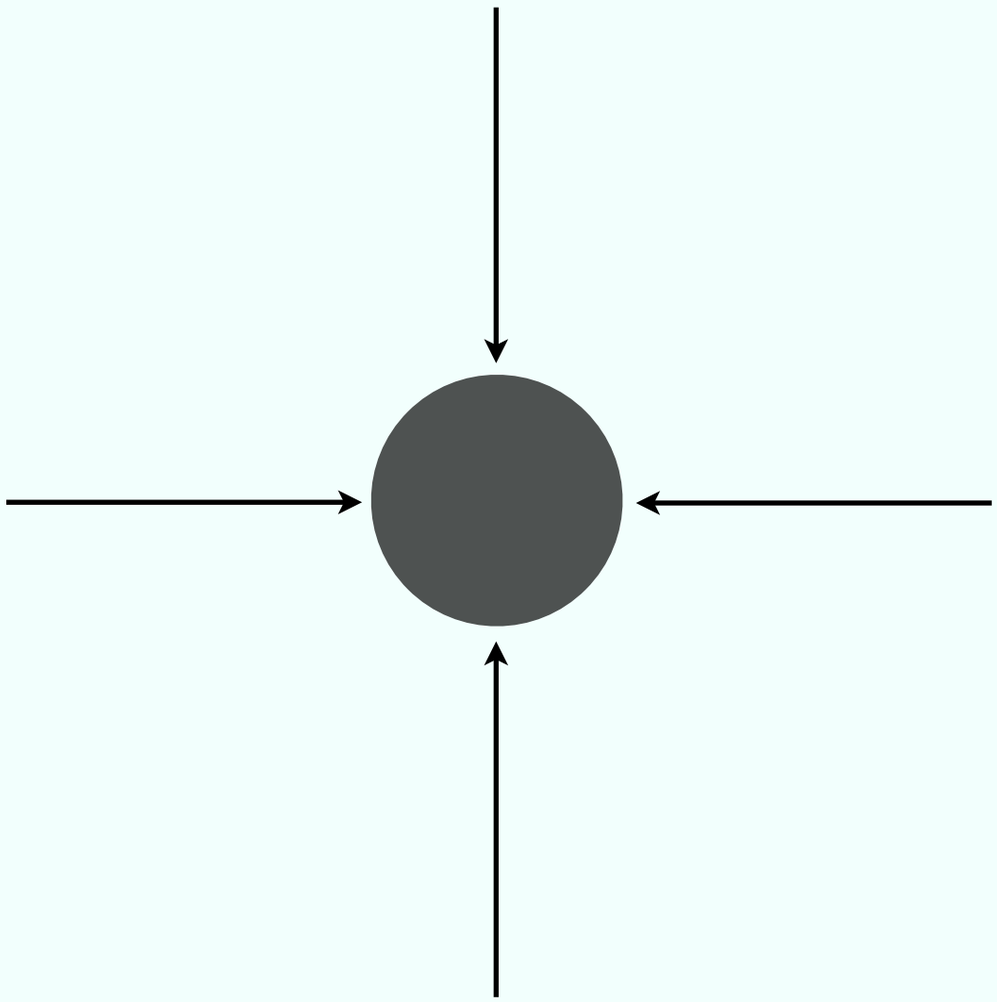
Overview

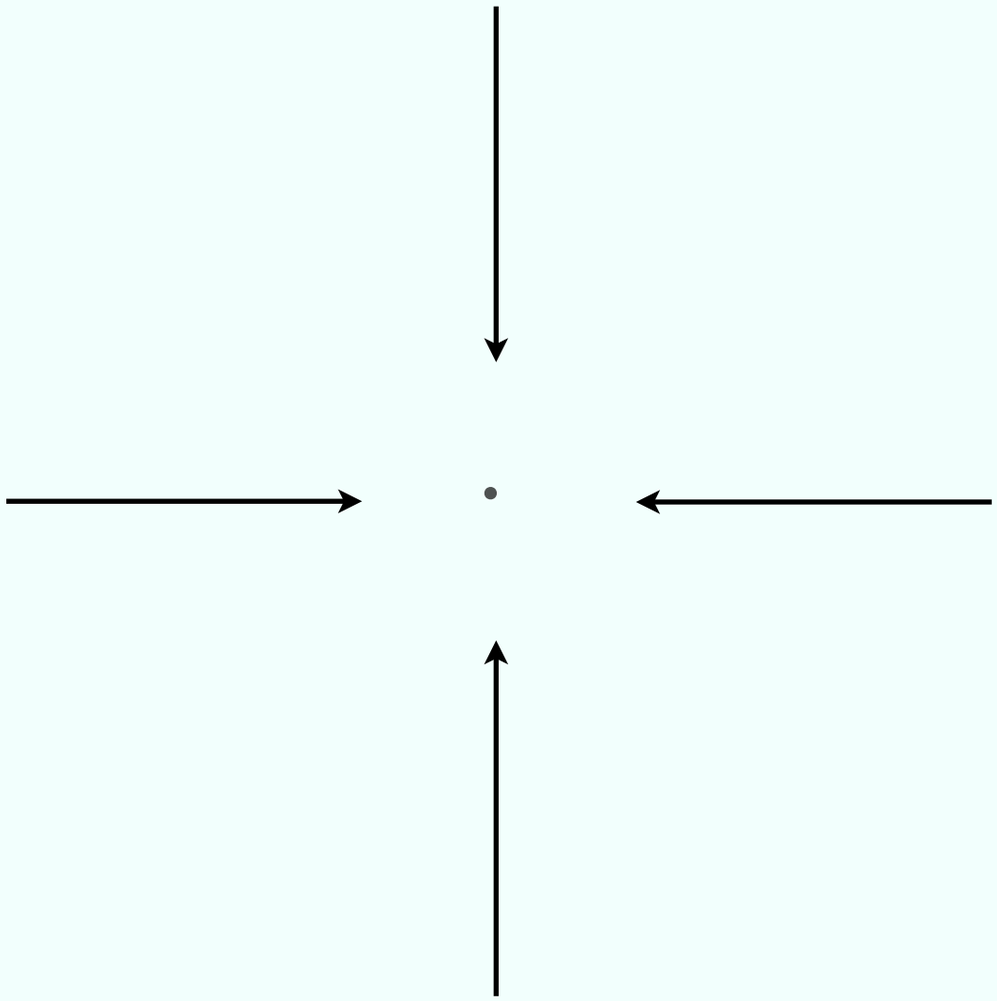
1. What Happens in an Exploding Star
2. Adaptive Mesh Refinement
3. Results of Application
4. Conclusions
5. Future Work


Helium
Carbon
Neon
Oxygen
Silicon
Iron
Si fusion
O fusion
Ne fusion
C fusion
He fusion
H fusion
Hydrogen


Iron Core Radius
~ 10^3 km
Star Radius
~ 10^8 - 10^9 km



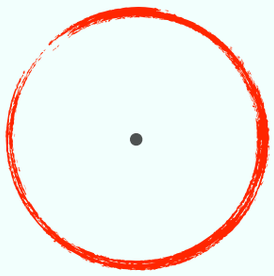


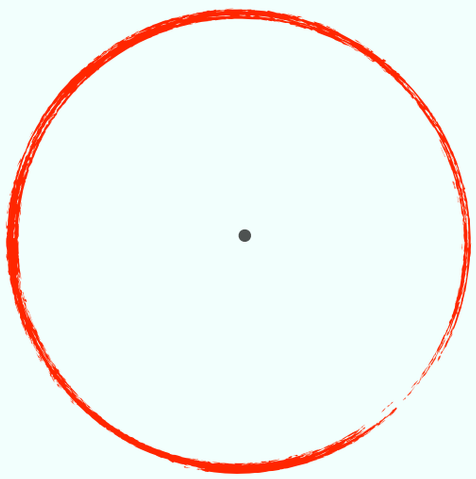


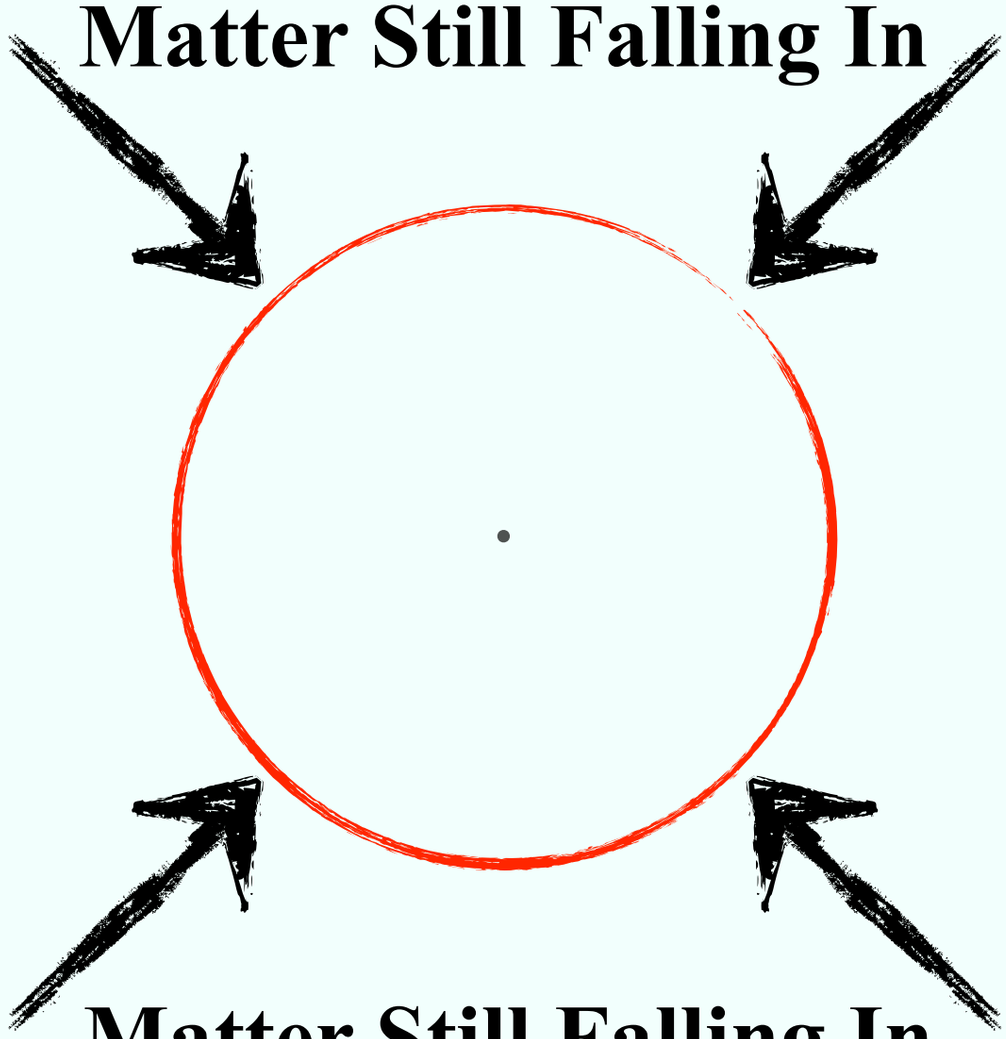
Proto-Neutron Star Radius

~ 10 km

H

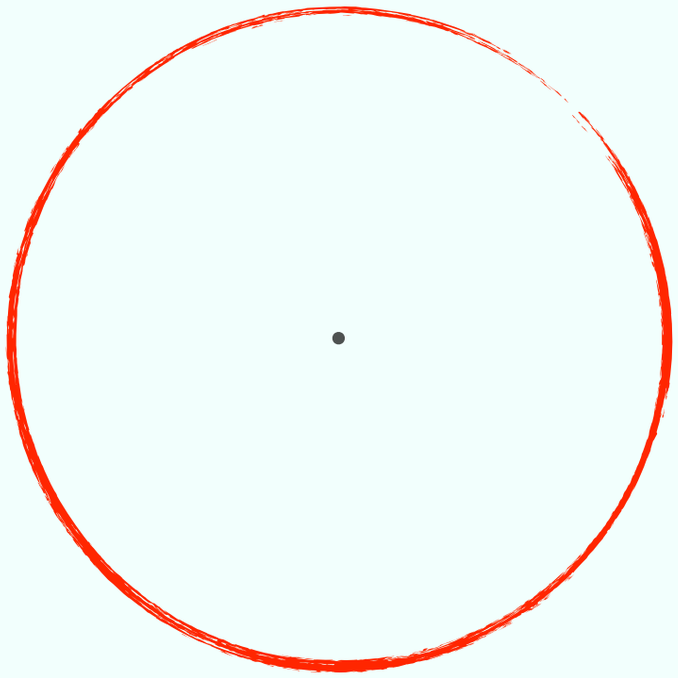





Matter Still Falling In
Matter Still Falling In

Stalled Shock Diameter

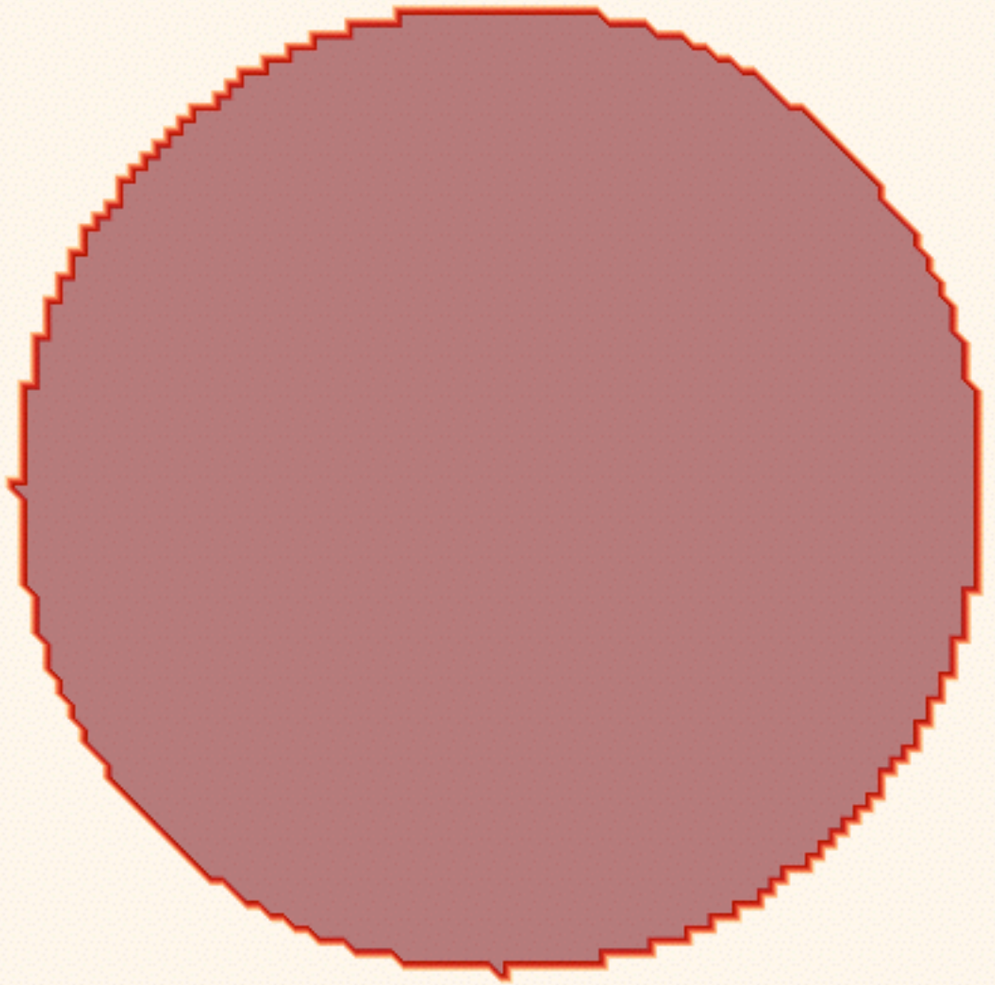
~ 100 km

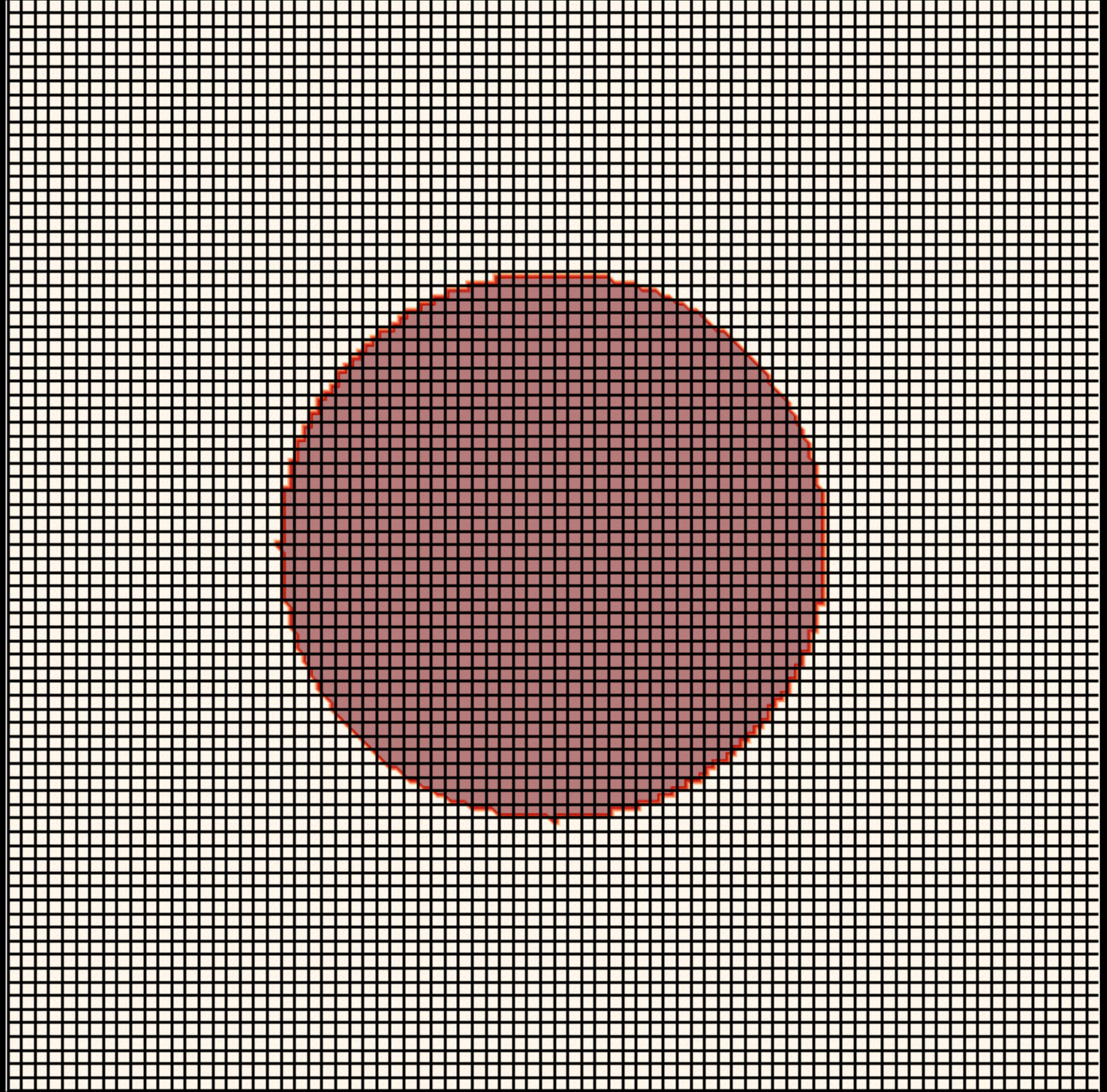


Ott, C. D., Abdikamalov, E., Mösta, P., et al. 2013, ApJ, 768, 115 Animation: Steve Drasco

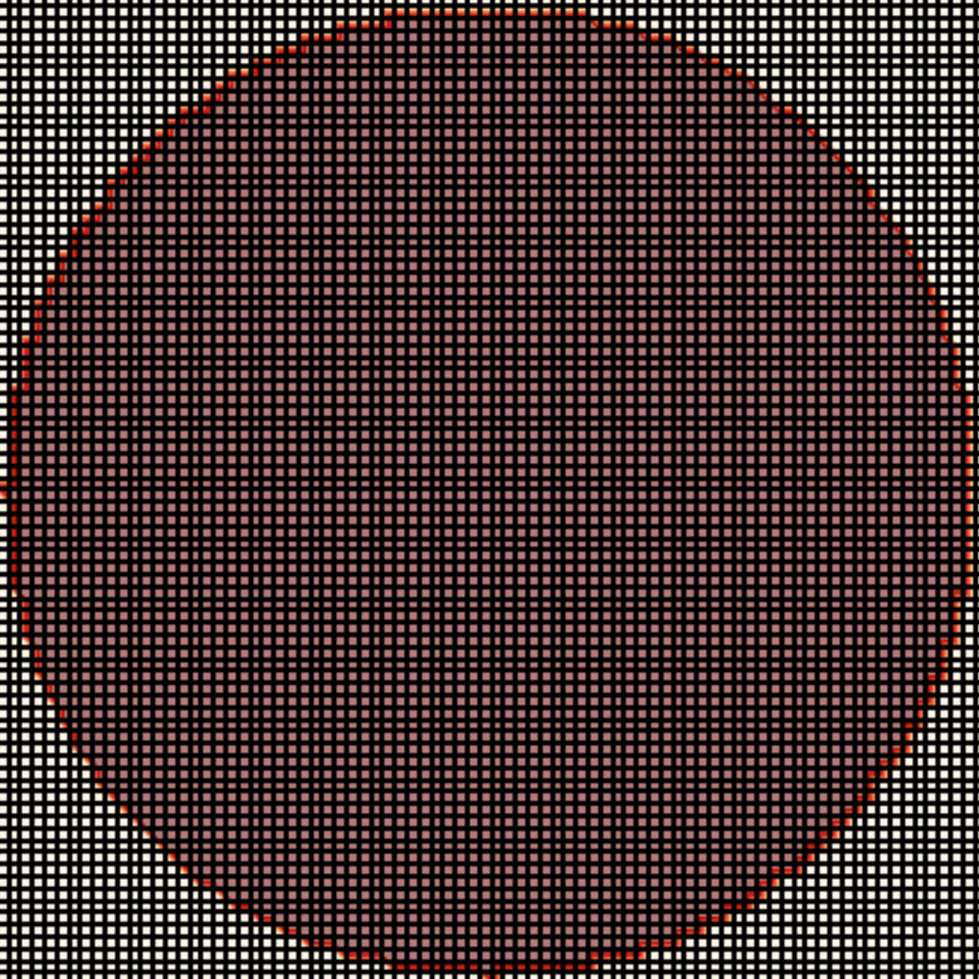
Super Dense Matter Ball

~ 15 km

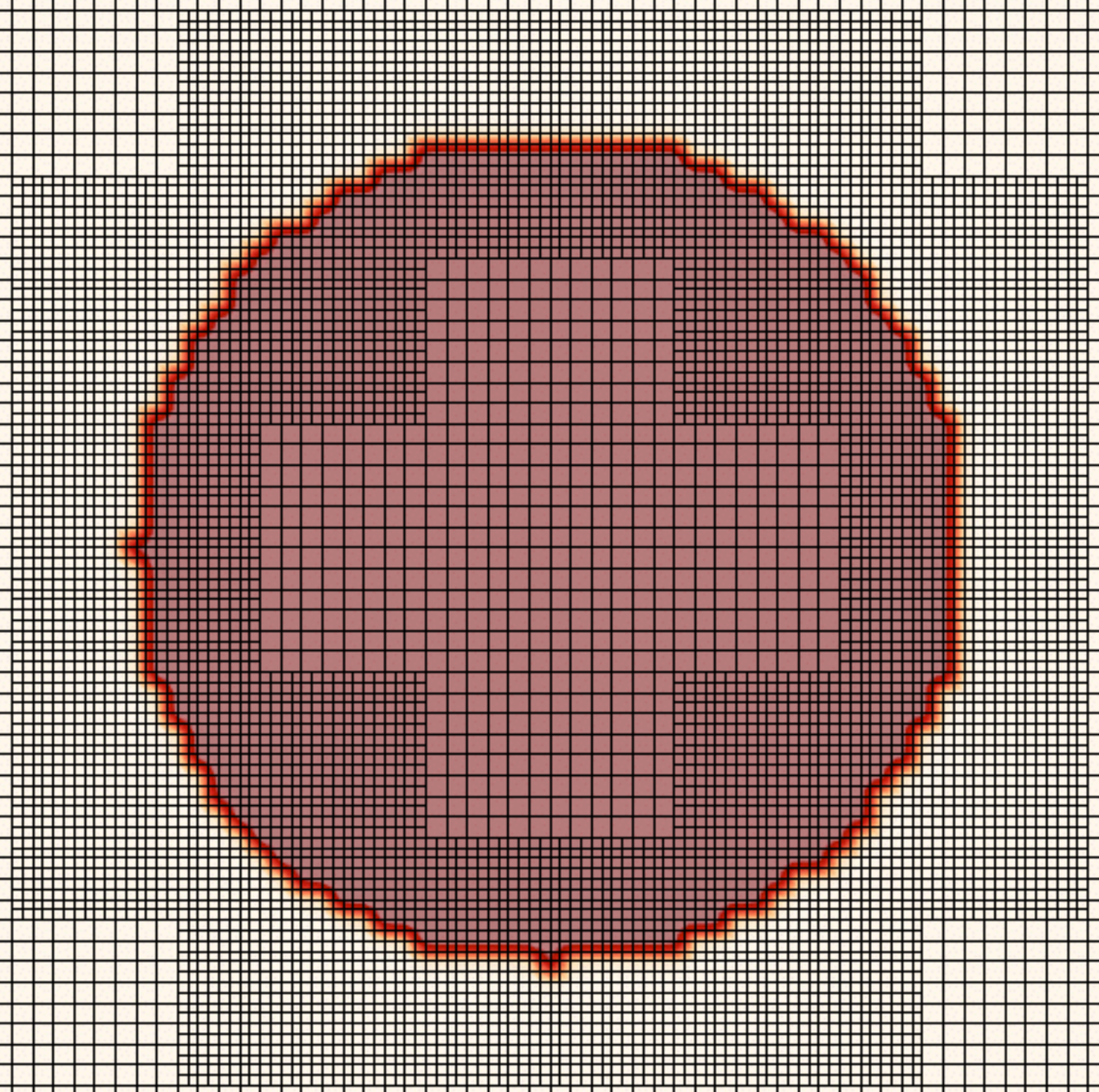


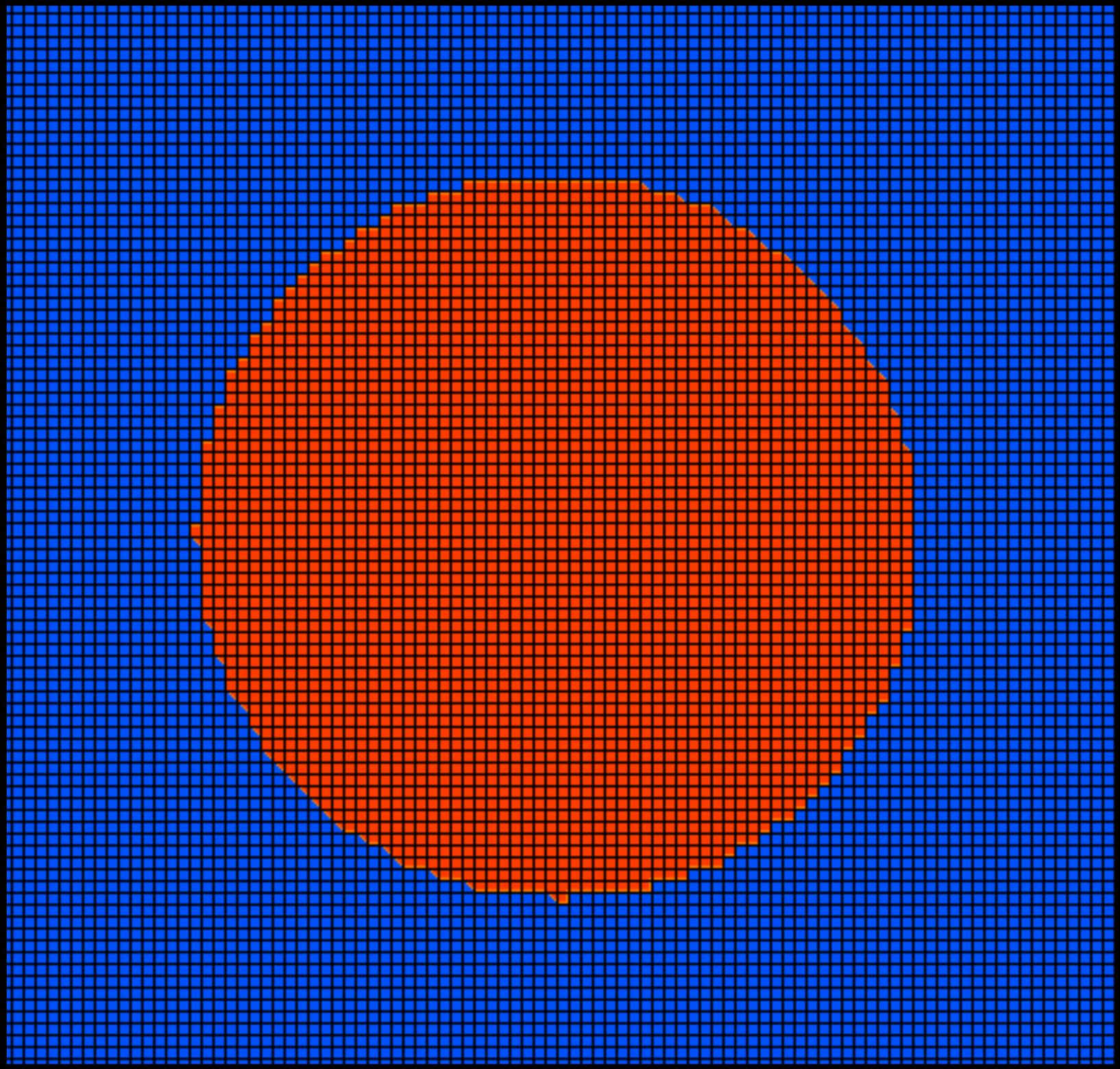


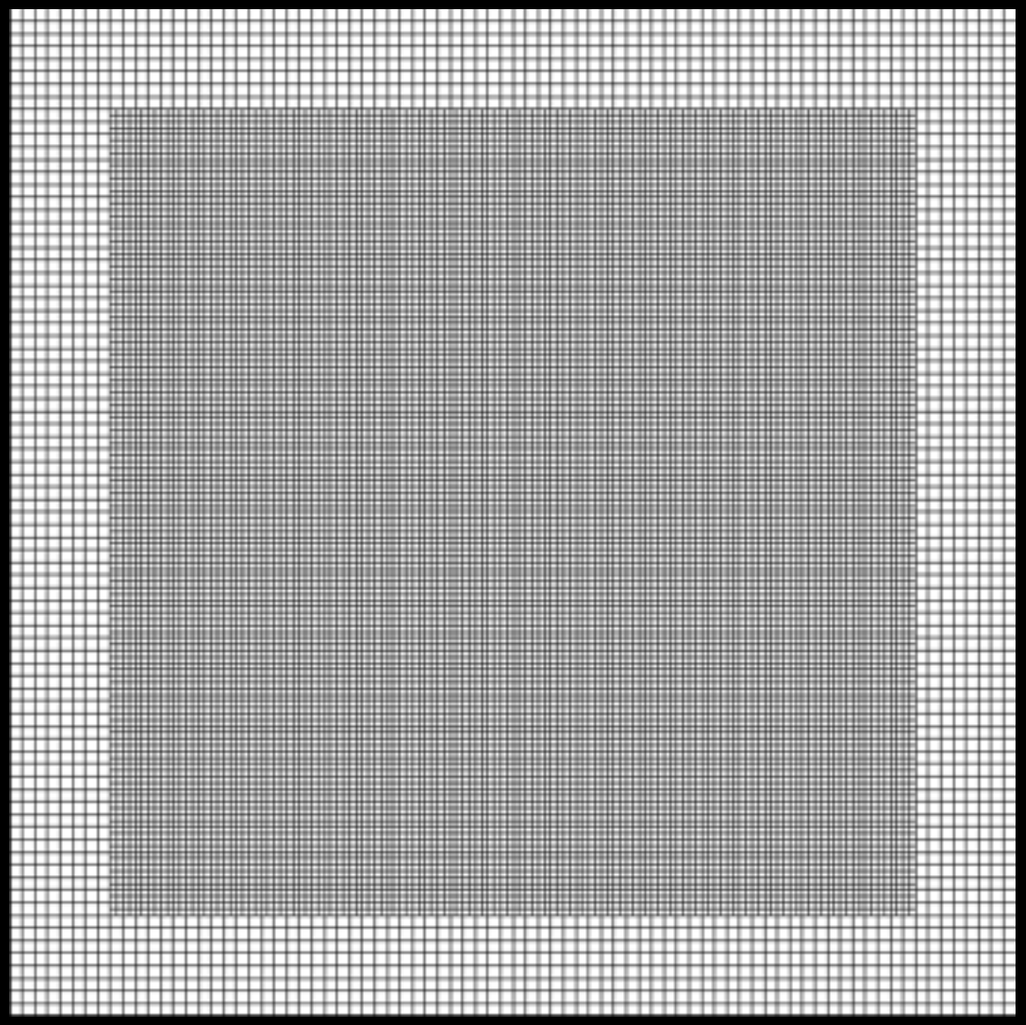
Refined Box



Adaptive Mesh Refinement





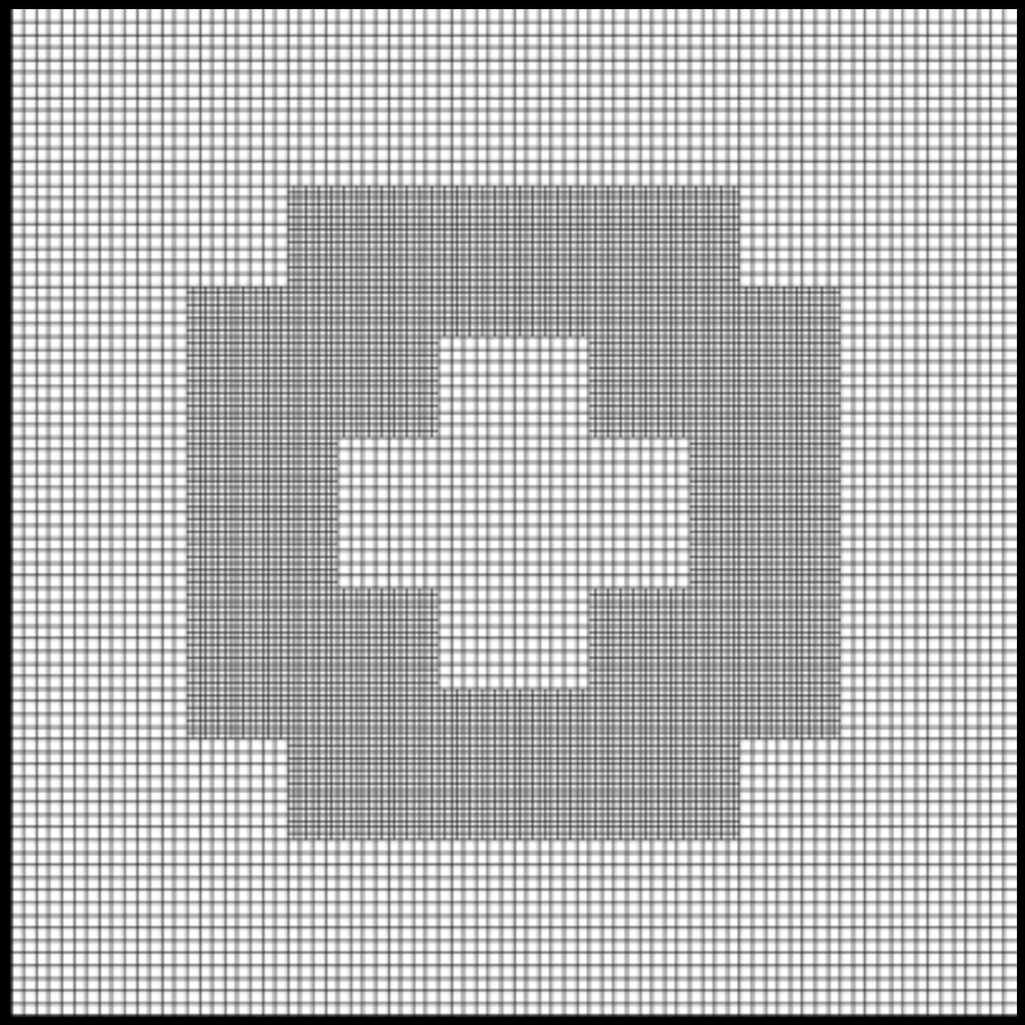


Refined Box

More Points to Store

to Evolve

Less Grid Restructuring



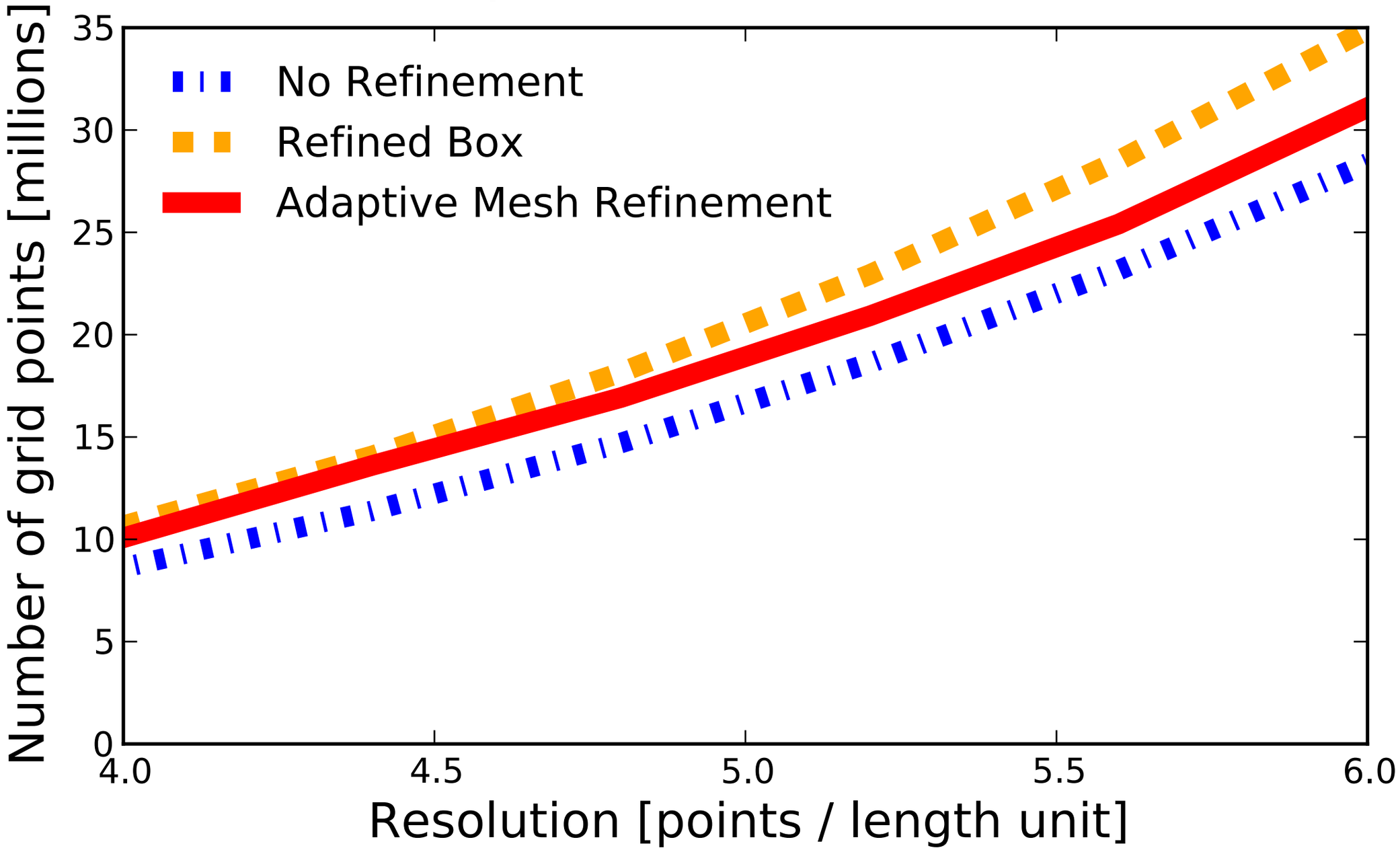
Adaptive Mesh

Fewer Points to Store

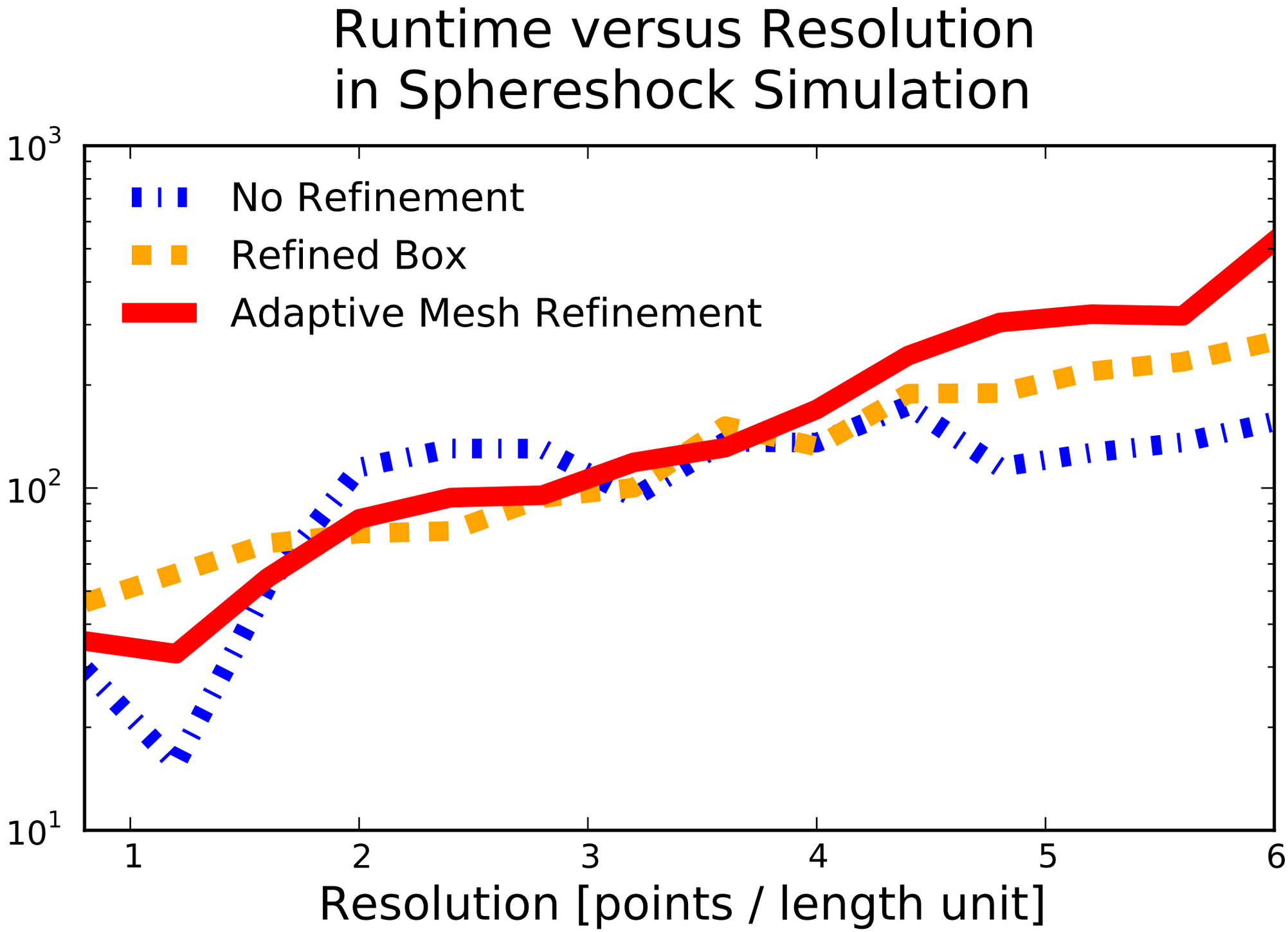
to Evolve

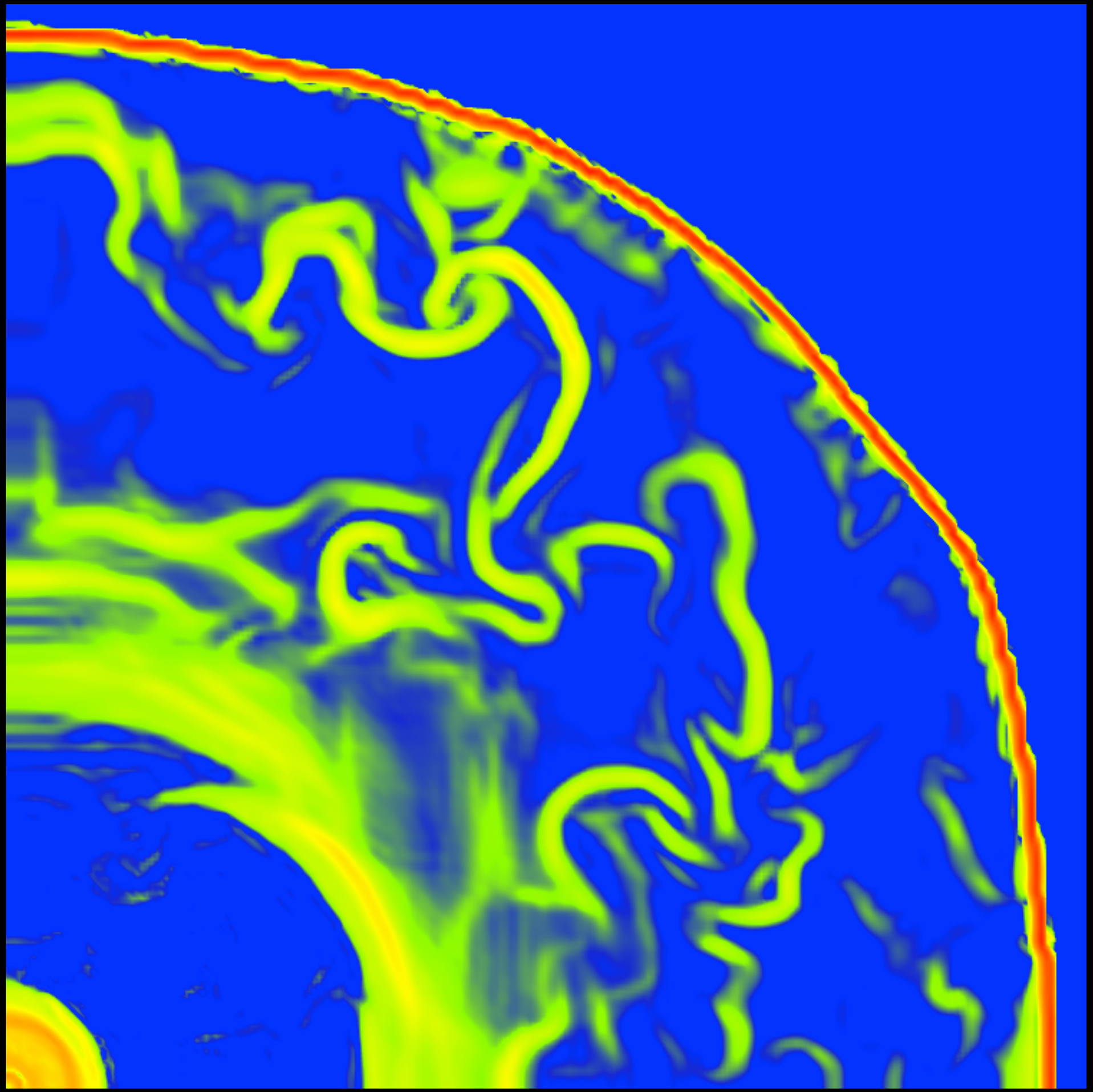
More Grid Restructuring

Results


Number of Grid Points versus Resolution
in Sphereshock Simulation
No Refinement
Refined Box
Adaptive Mesh Refinement
Number of grid points [millions]
0
5
10
15
20
25
30
35
4.0
4.5
5.0
5.5
6.0
Resolution [points / length unit]

Results


Runtime versus Resolution
in Sphereshock Simulation
No Refinement
Refined Box
Adaptive Mesh Refinement
Runtime [s]
10^3
10^2
10^1
1
2
3
4
5
6
Resolution [points / length unit]



Conclusions

Adaptive mesh refinement has potential.

It is still yet to be seen whether it can decrease runtimes.

It can certainly decrease memory usage, though only **slightly**.

Future Work

Can we make adaptive mesh refinement work with a more **complicated physics**?

Can we integrate it into a **real** supernova simulation?

Acknowledgments

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