Multidimensional Multiscale Dynamics of High-Energy Astrophysical Flows

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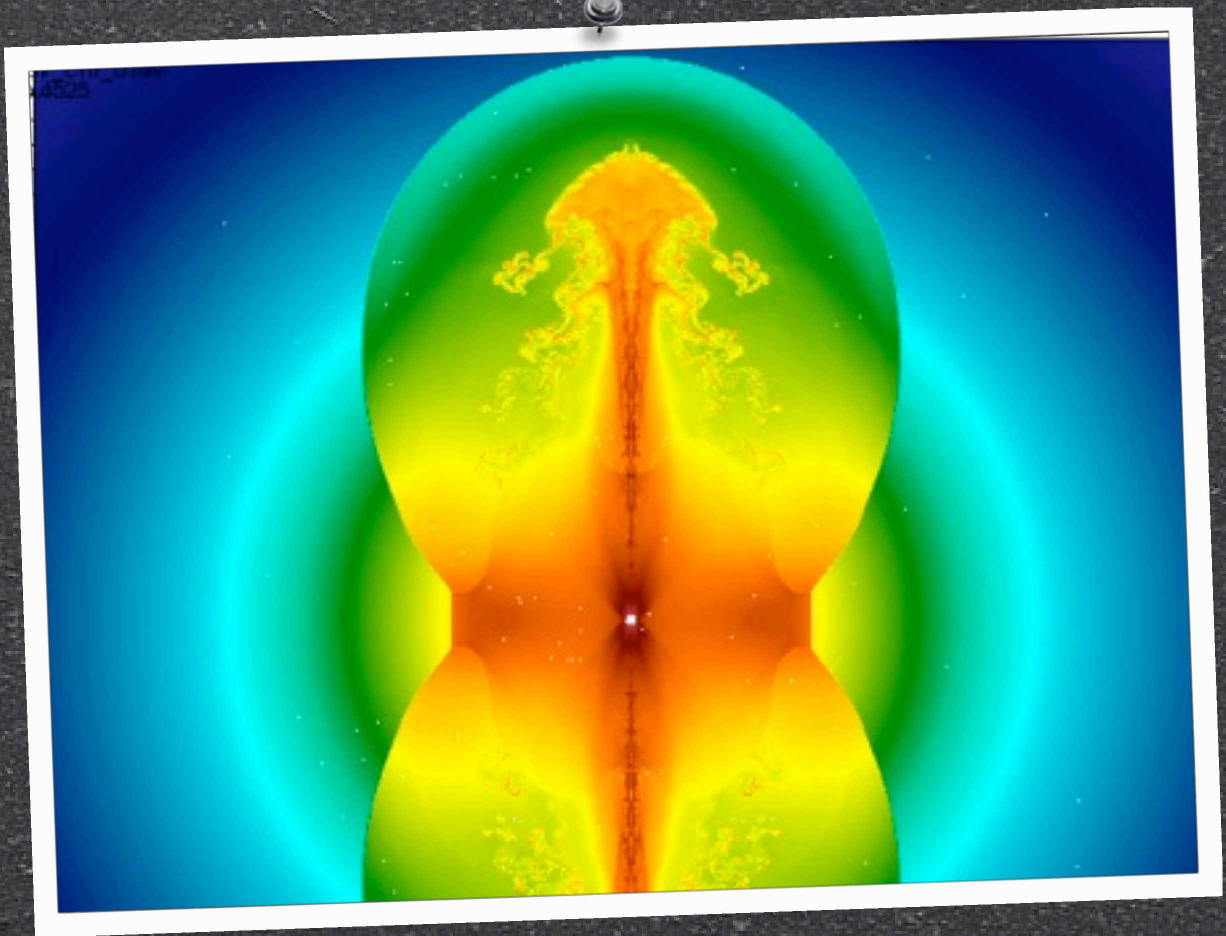
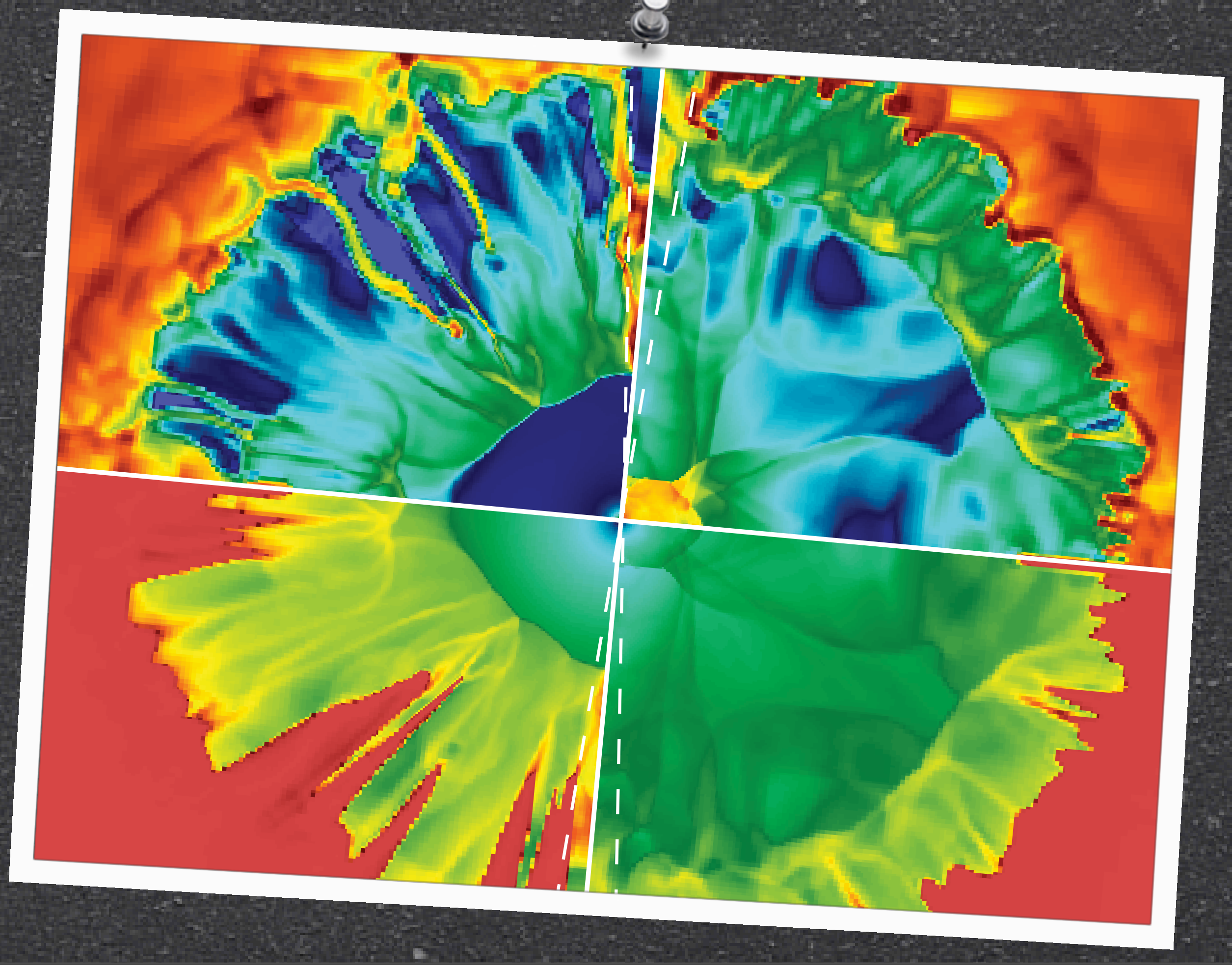
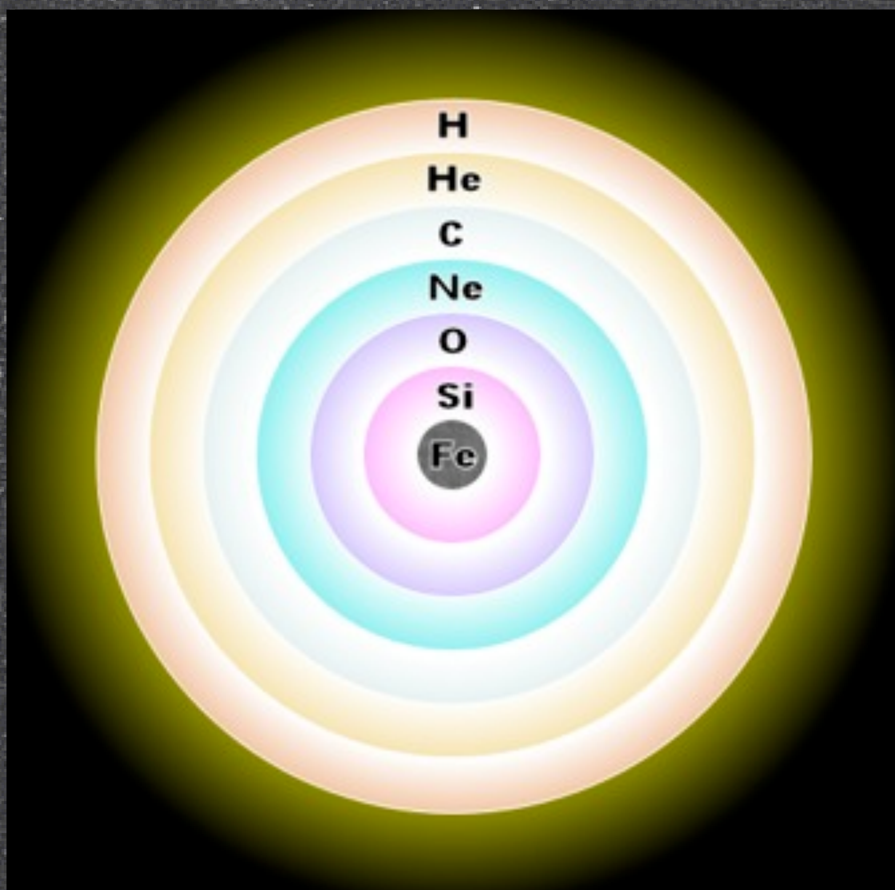
CScADS - July 26, 2010





Core-Collapse SNe



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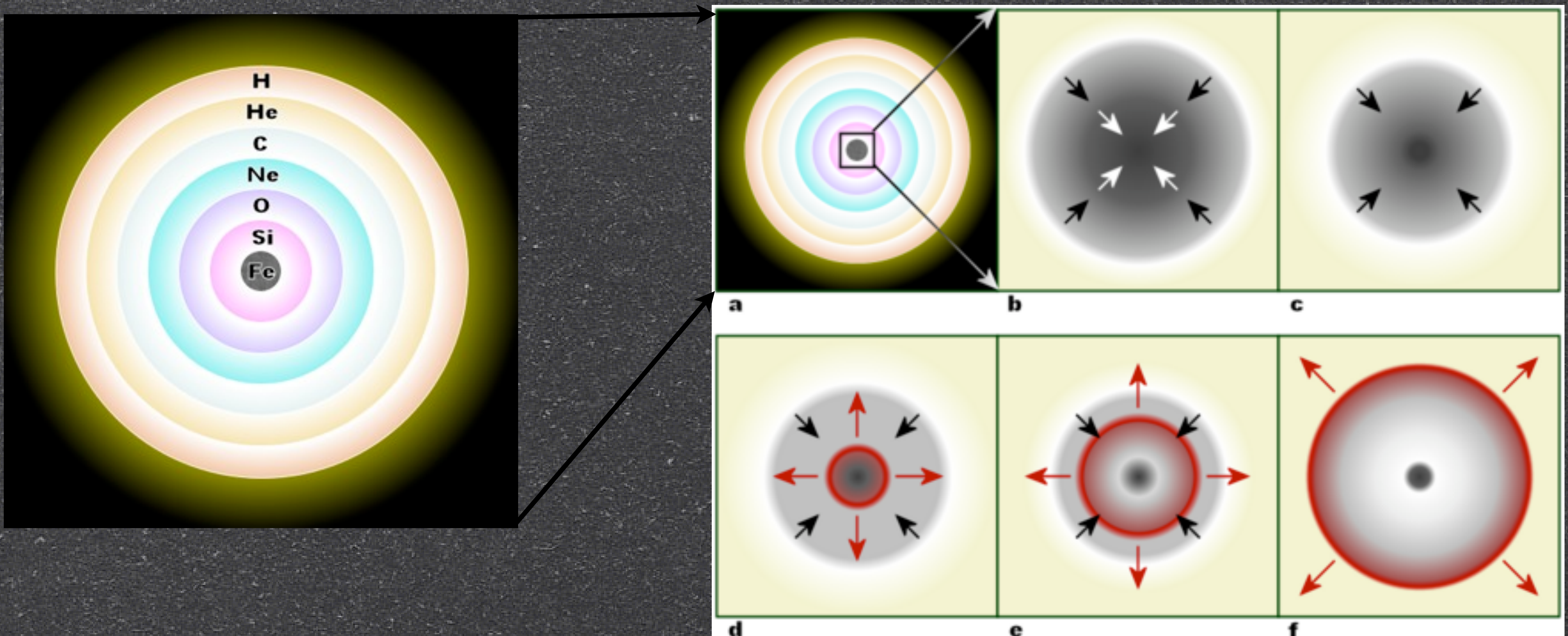
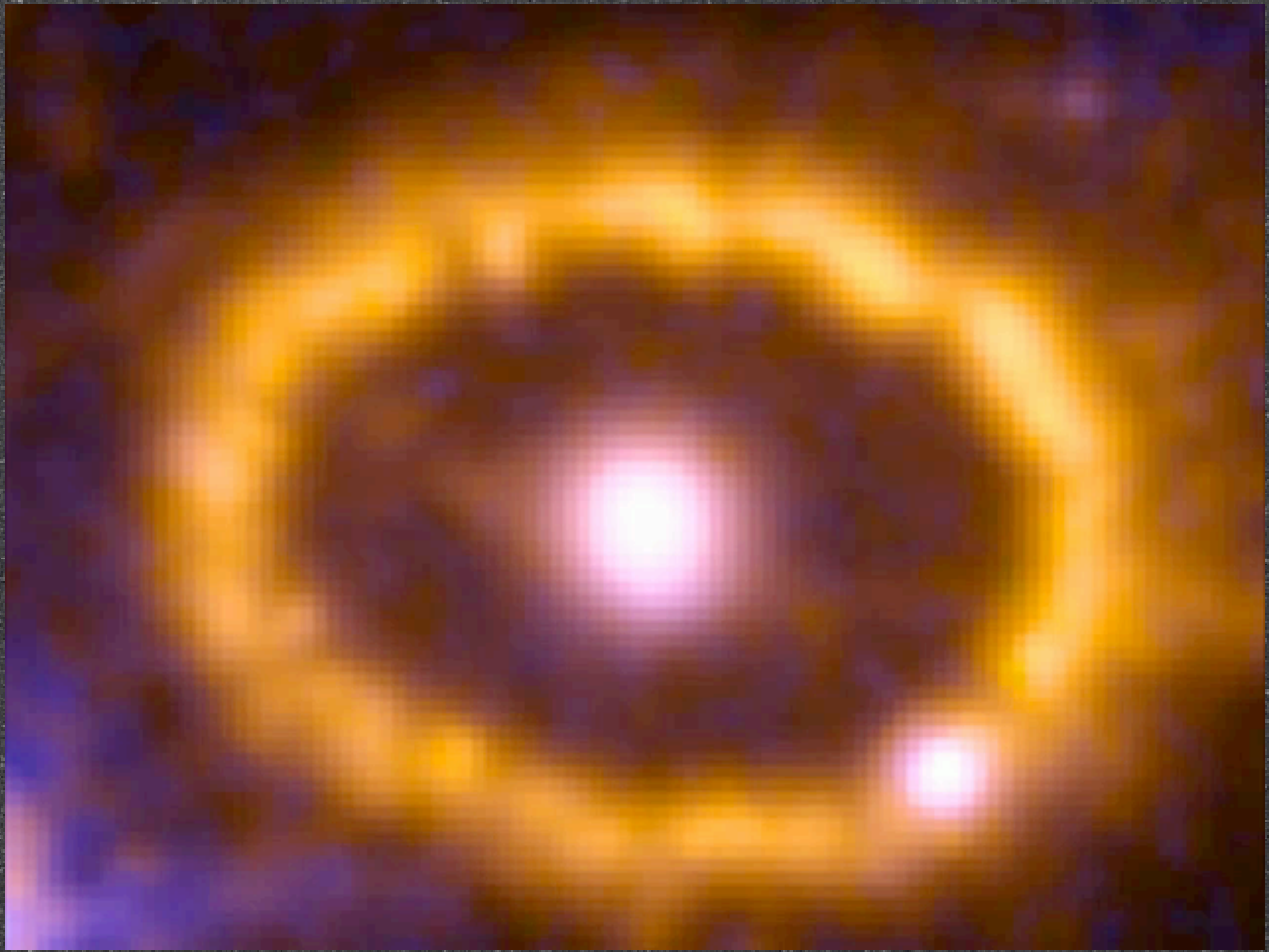
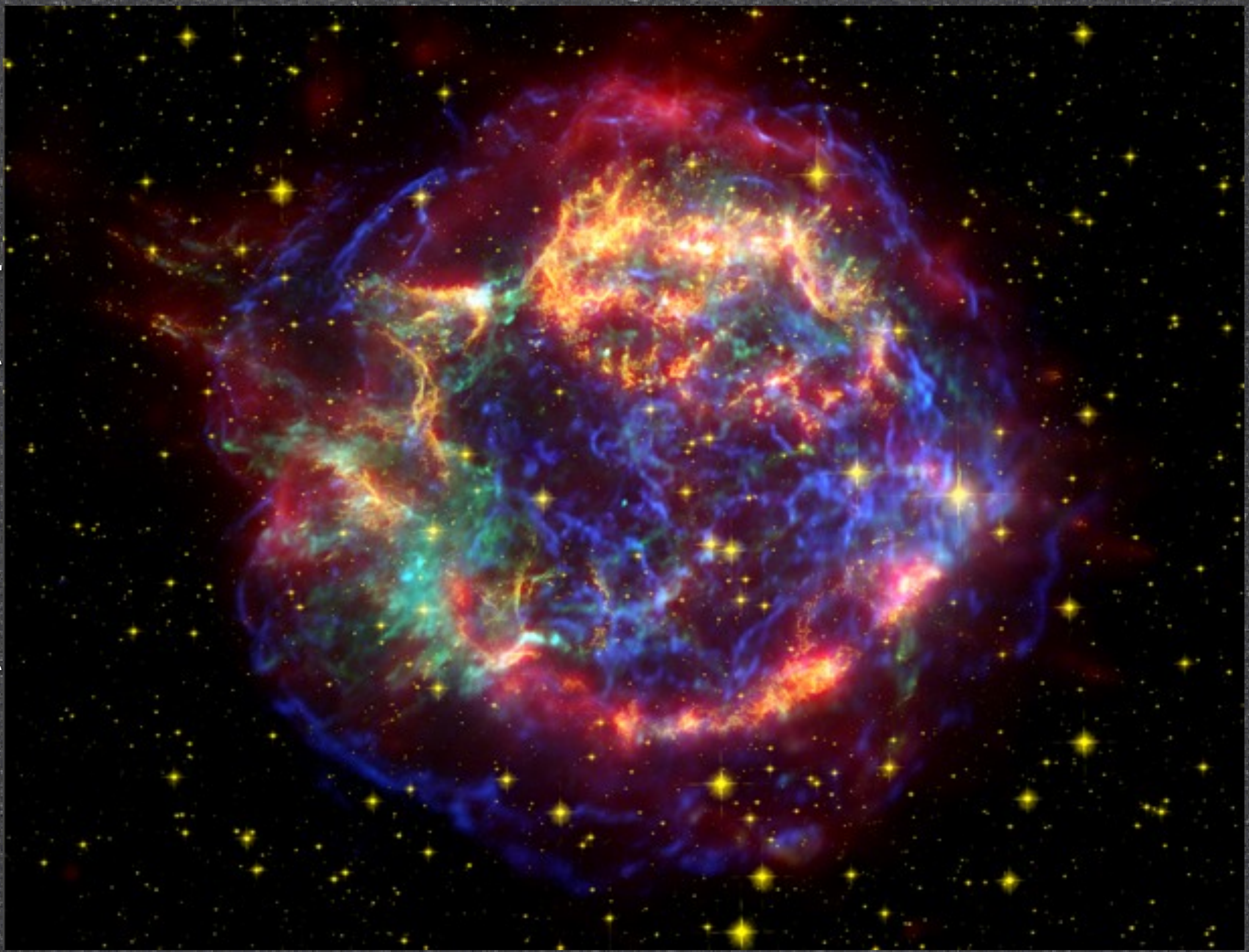


SN 1987A



Hubble

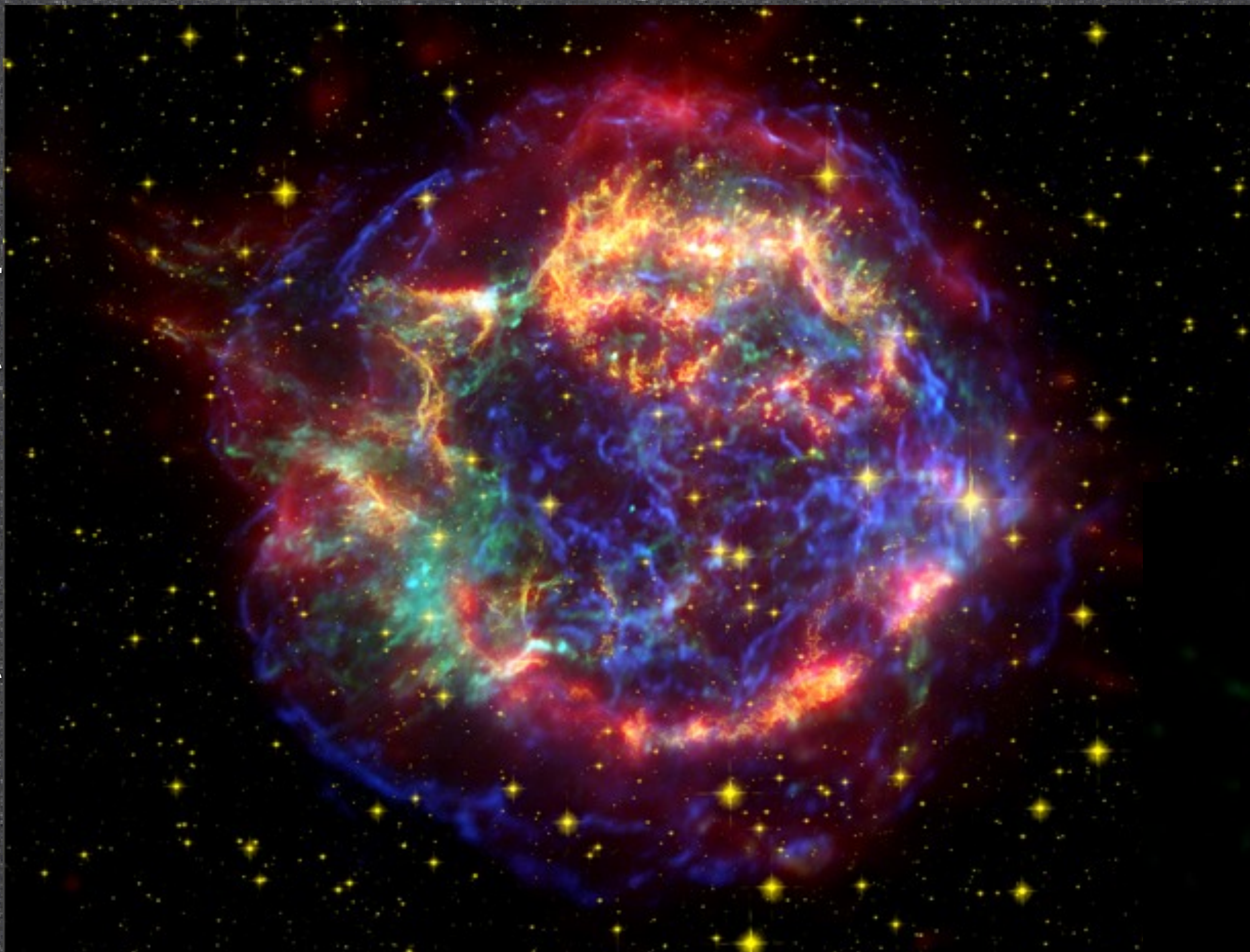
Cas A



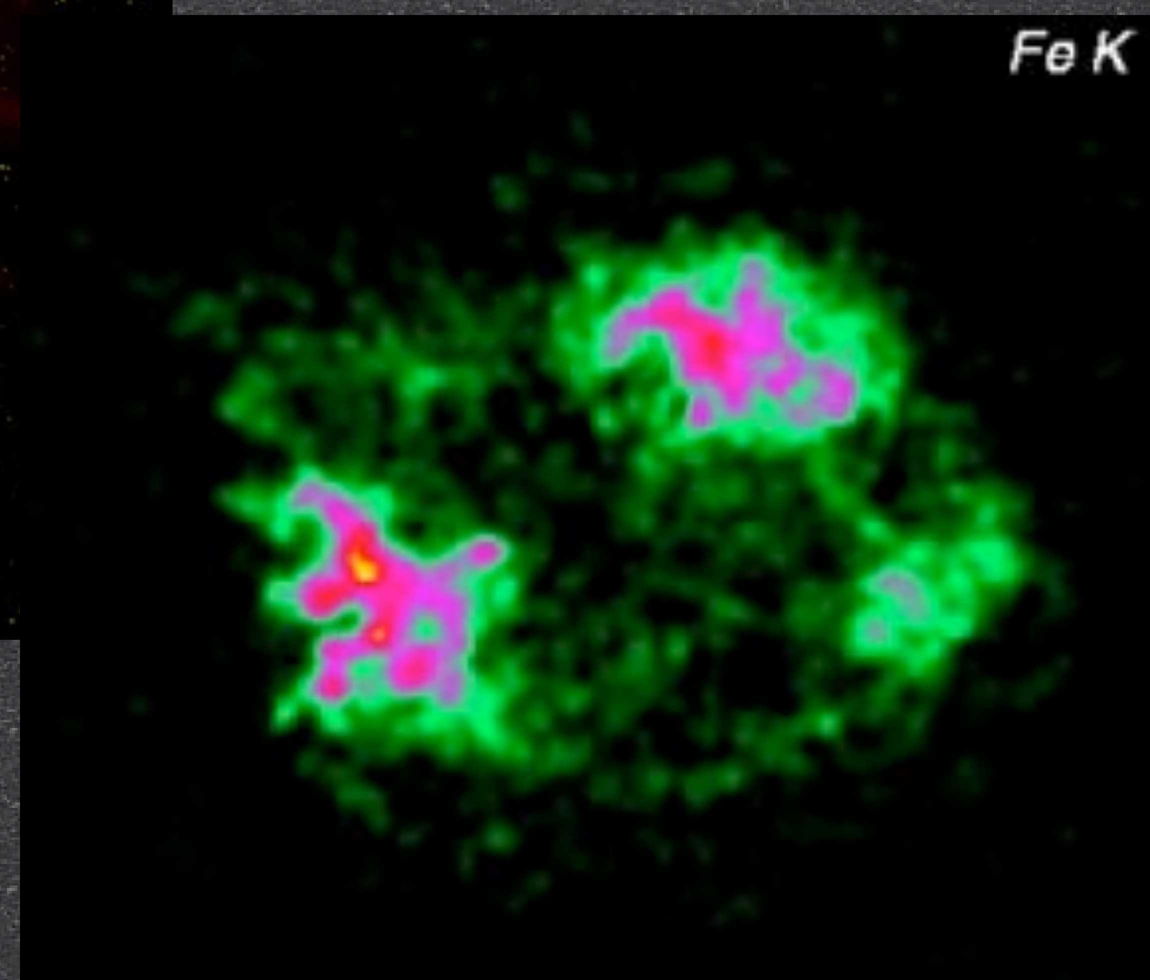
Hubble, Chandra, Spitzer

Cas A

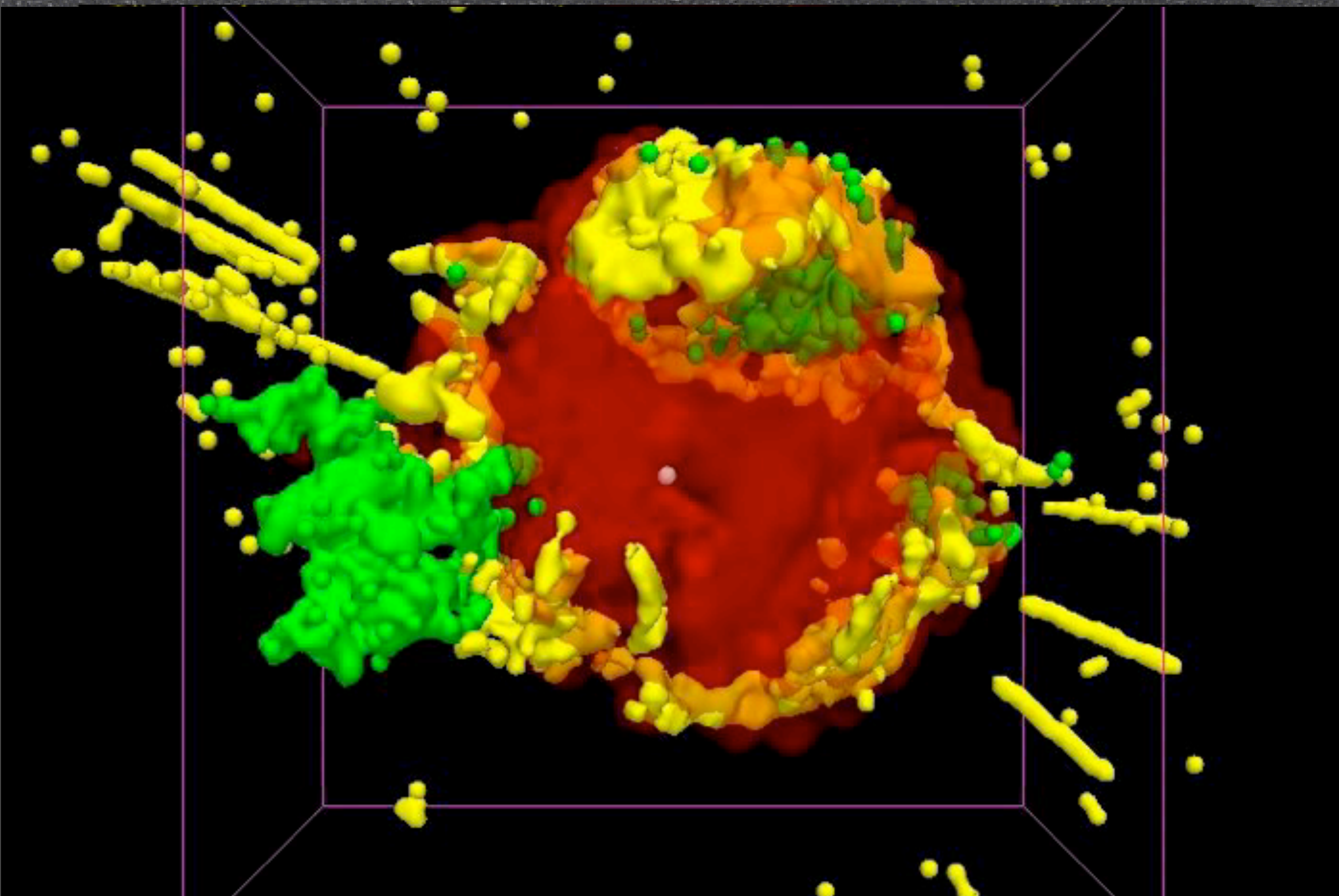
Hubble, Chandra, Spitzer



Chandra

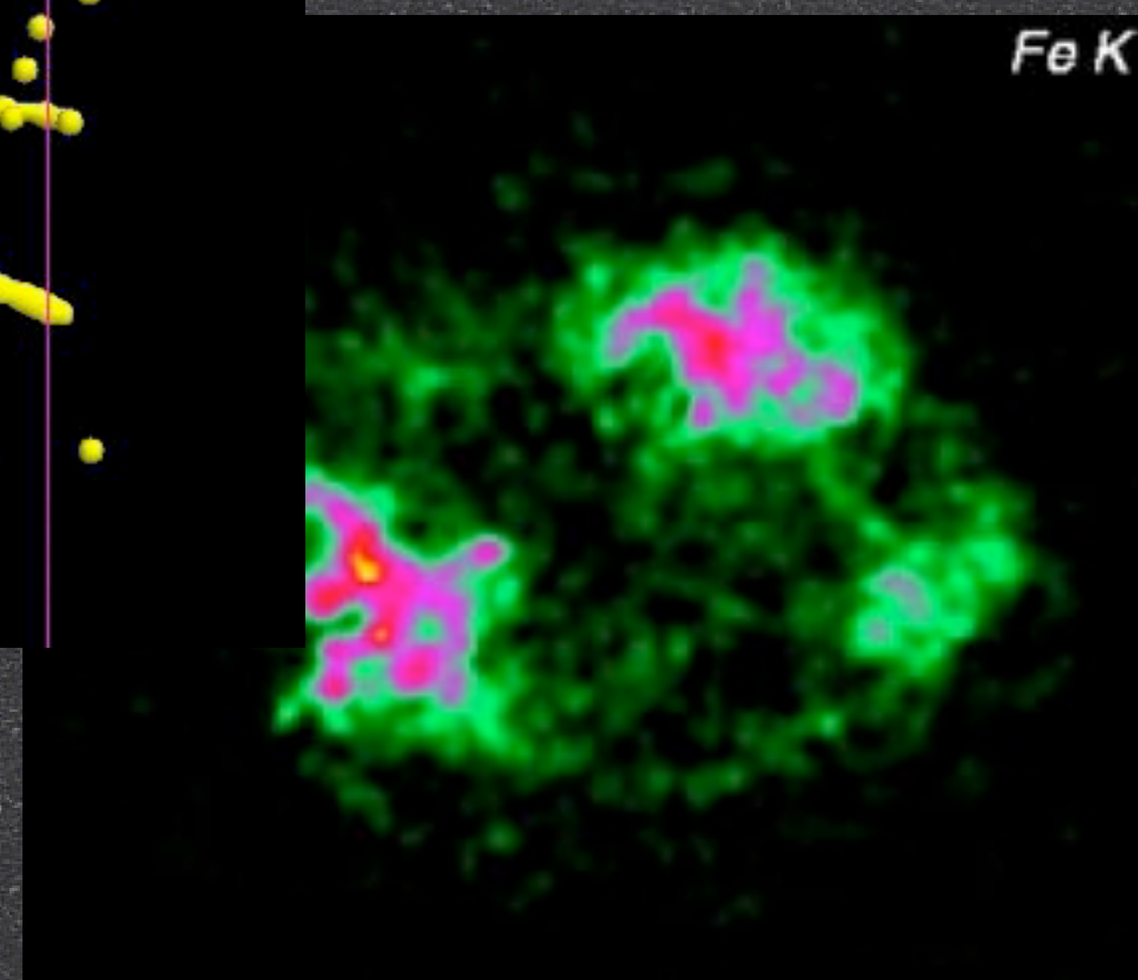


Cas A



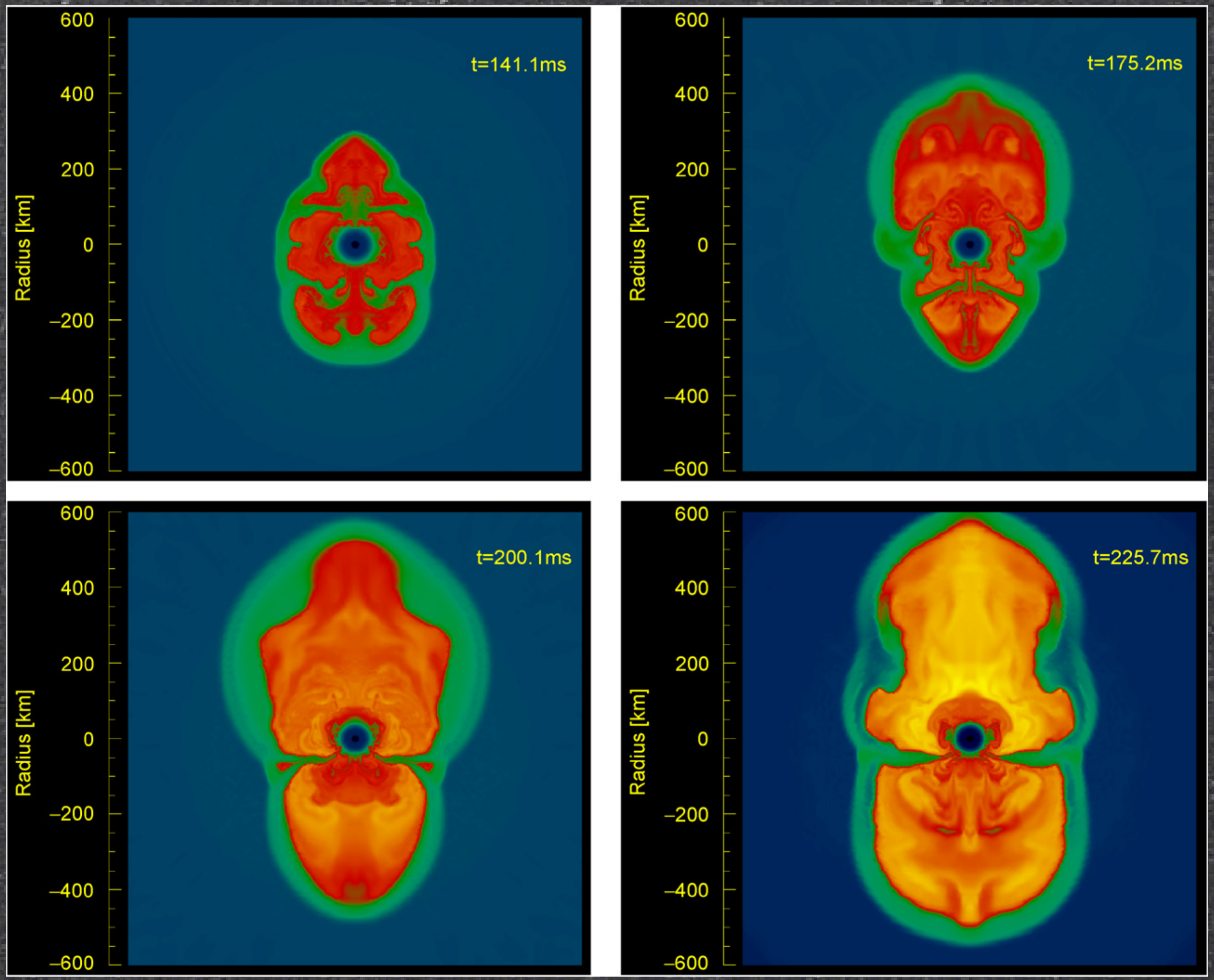
Delaney et al.

Chandra



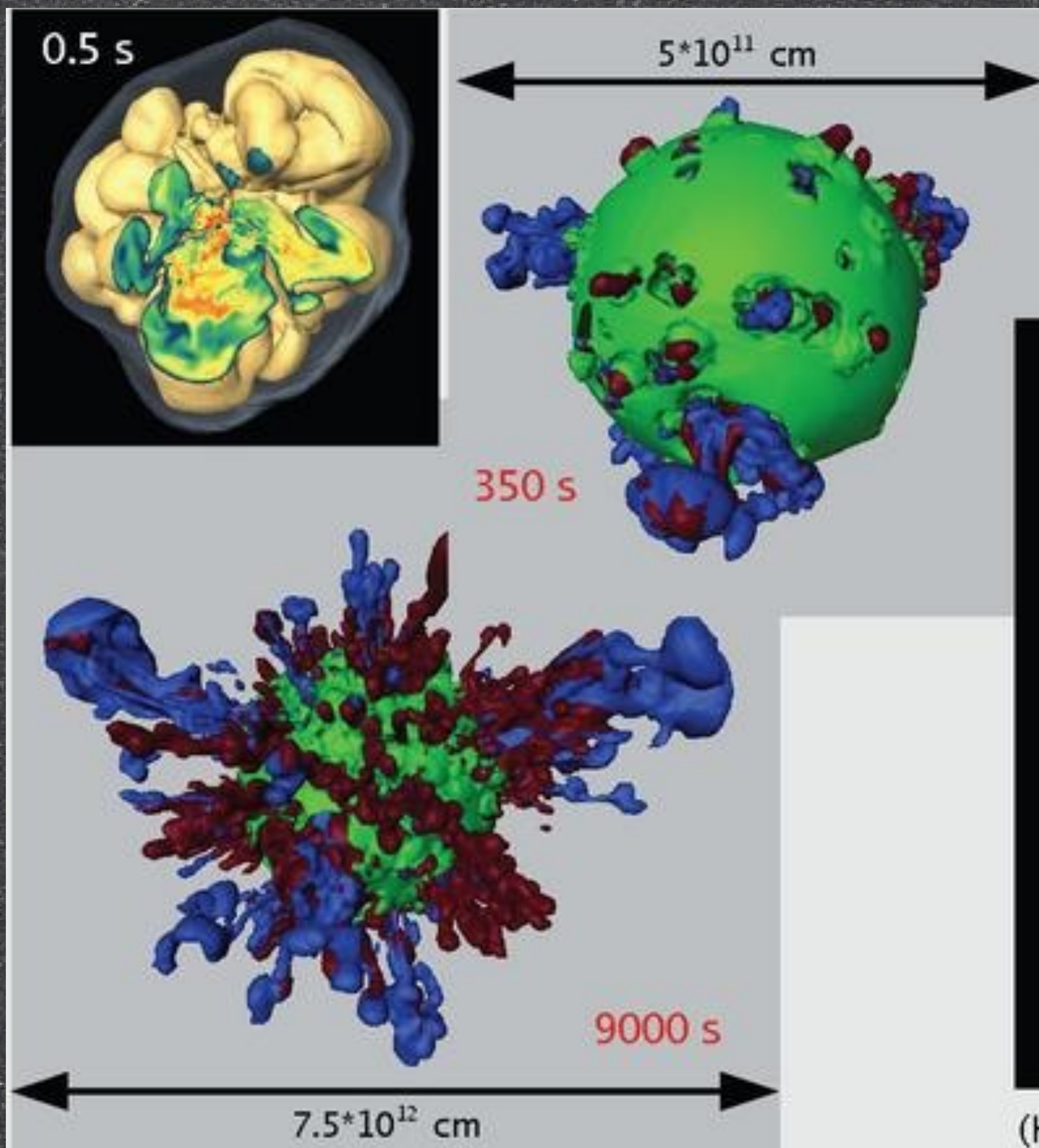
Core-Collapse SNe

- 2D effects such as neutrino convection, SASI, and perhaps advective-acoustic effects, make explosions marginally successful
- Results from different groups don't always agree
- Explosions may be robust in 3D, but too early to tell

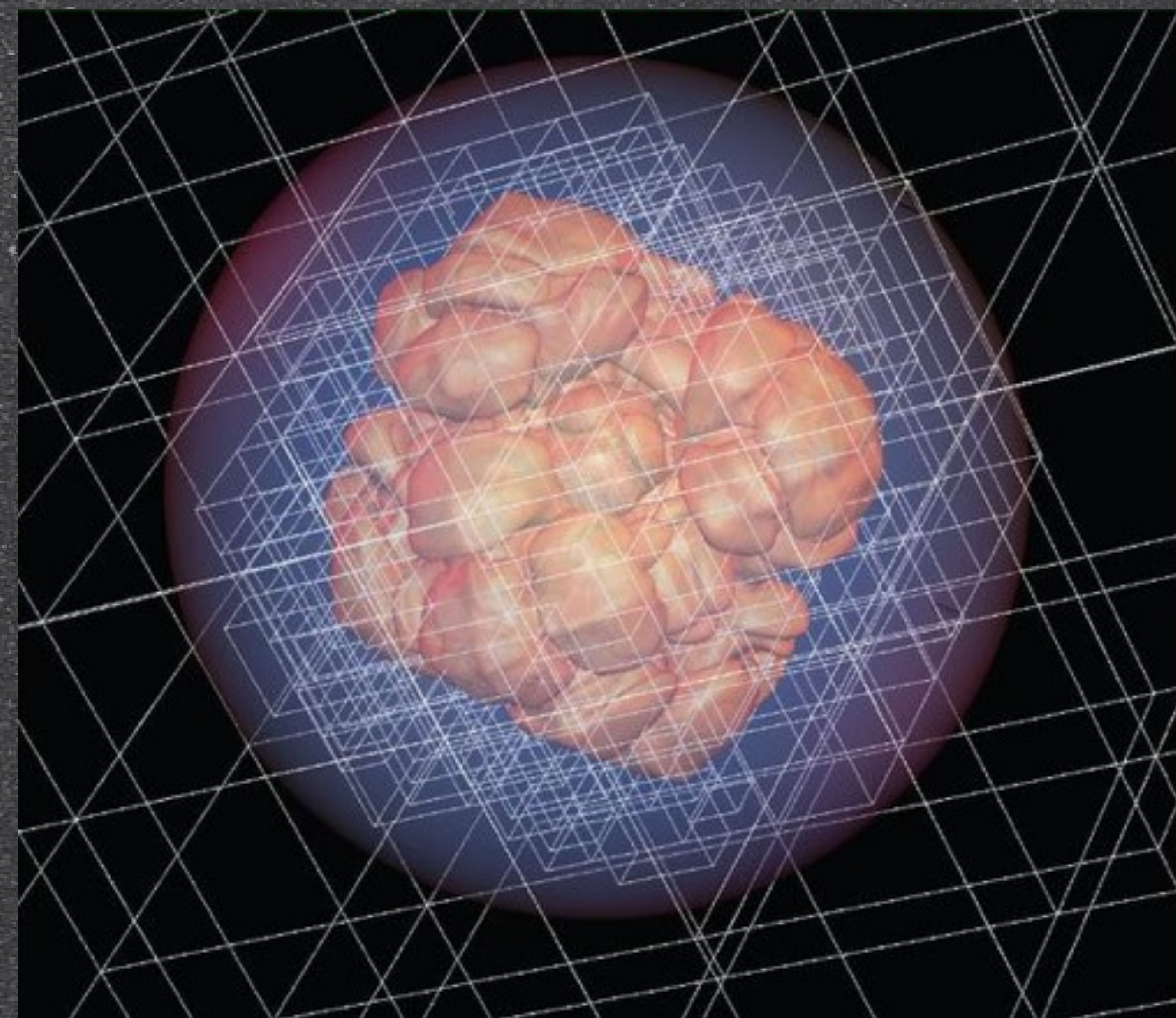


Buras et al. 2006

Core-Collapse SNe

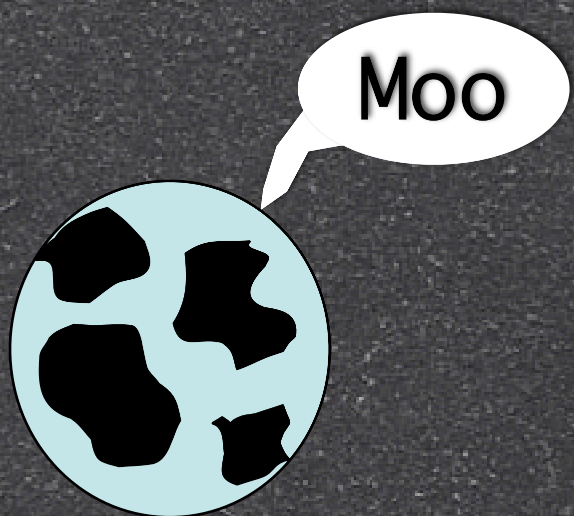


Hammer et al. 2009

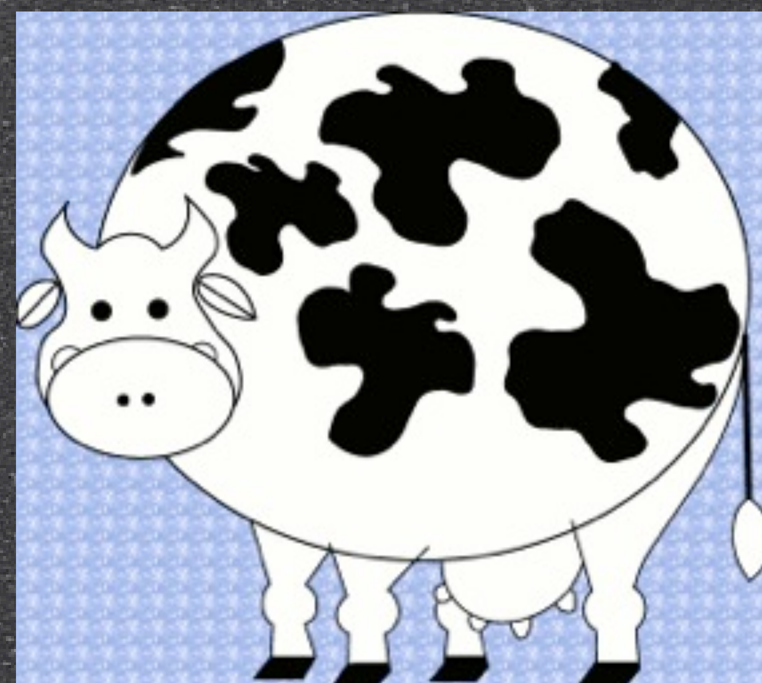


Burrows & Nordhaus 2010

Core-Collapse SNe



Core-Collapse SNe



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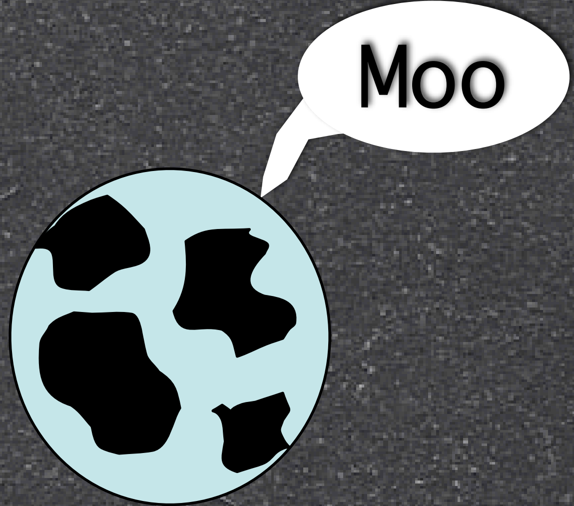
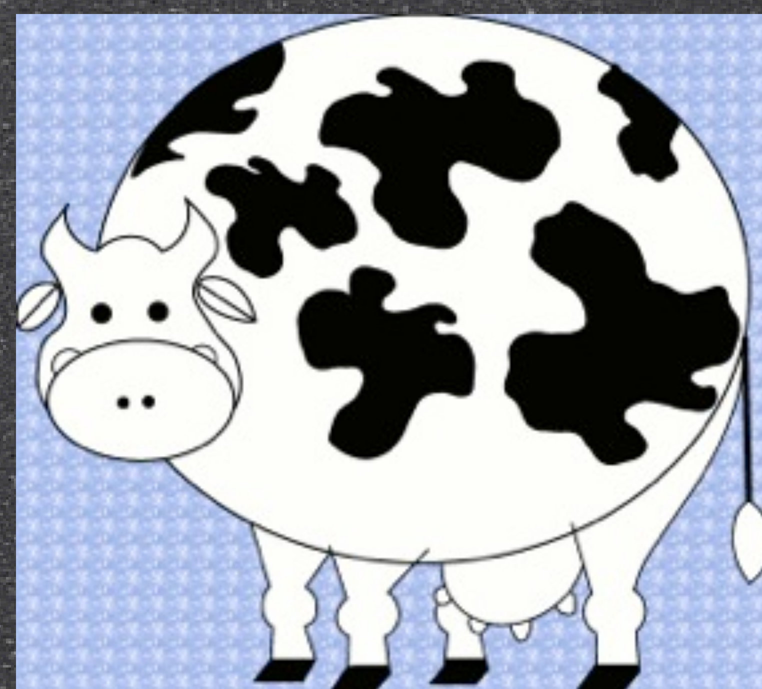
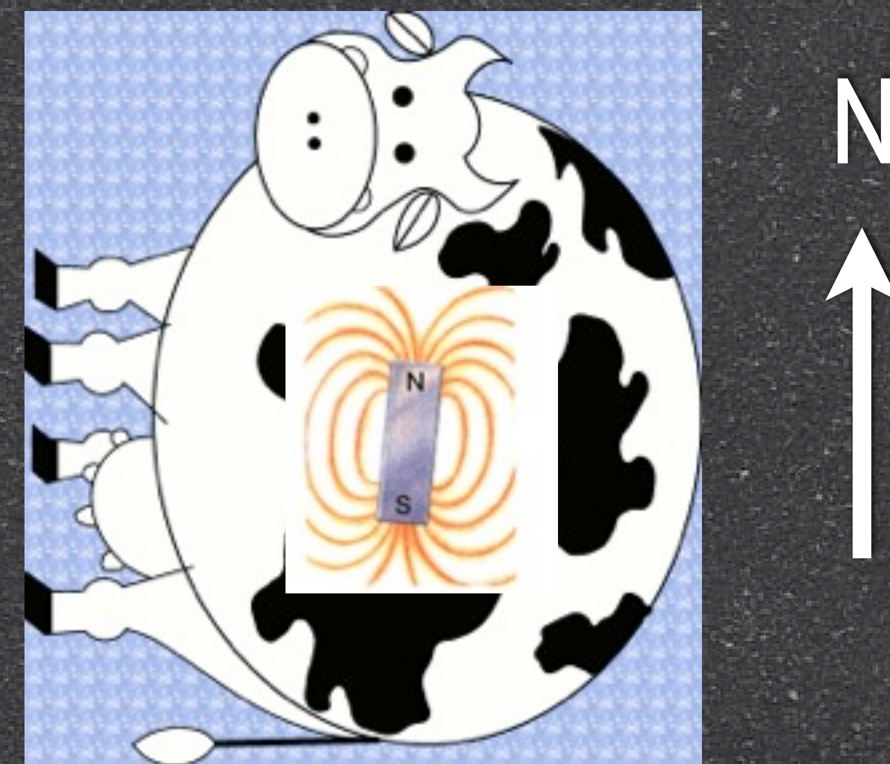
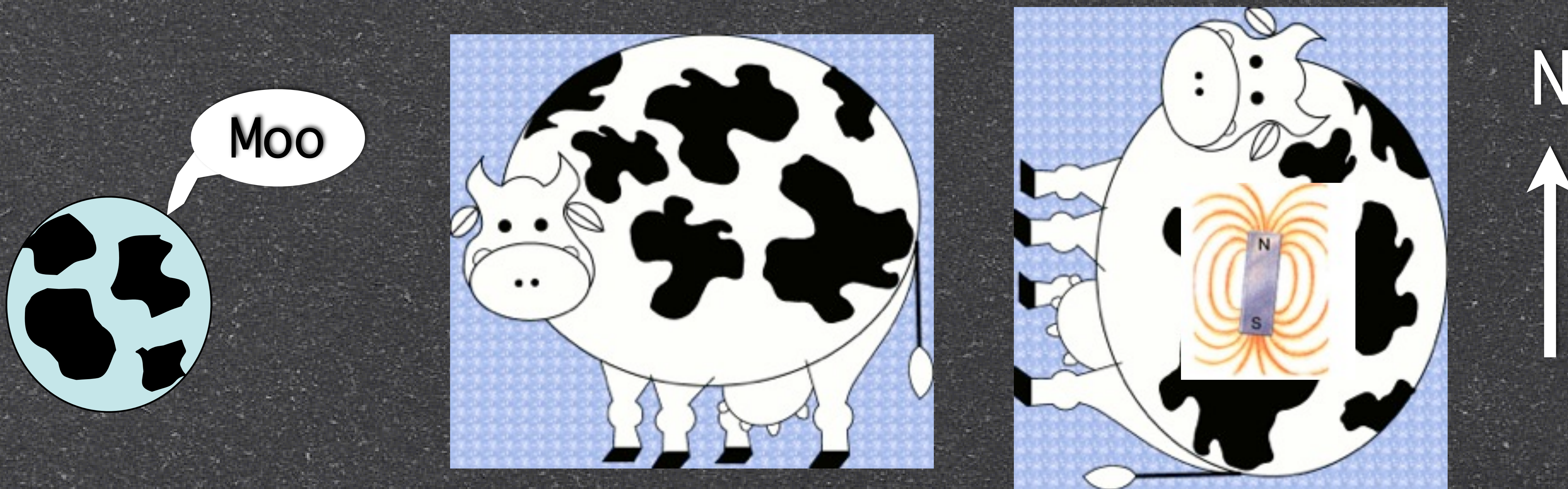






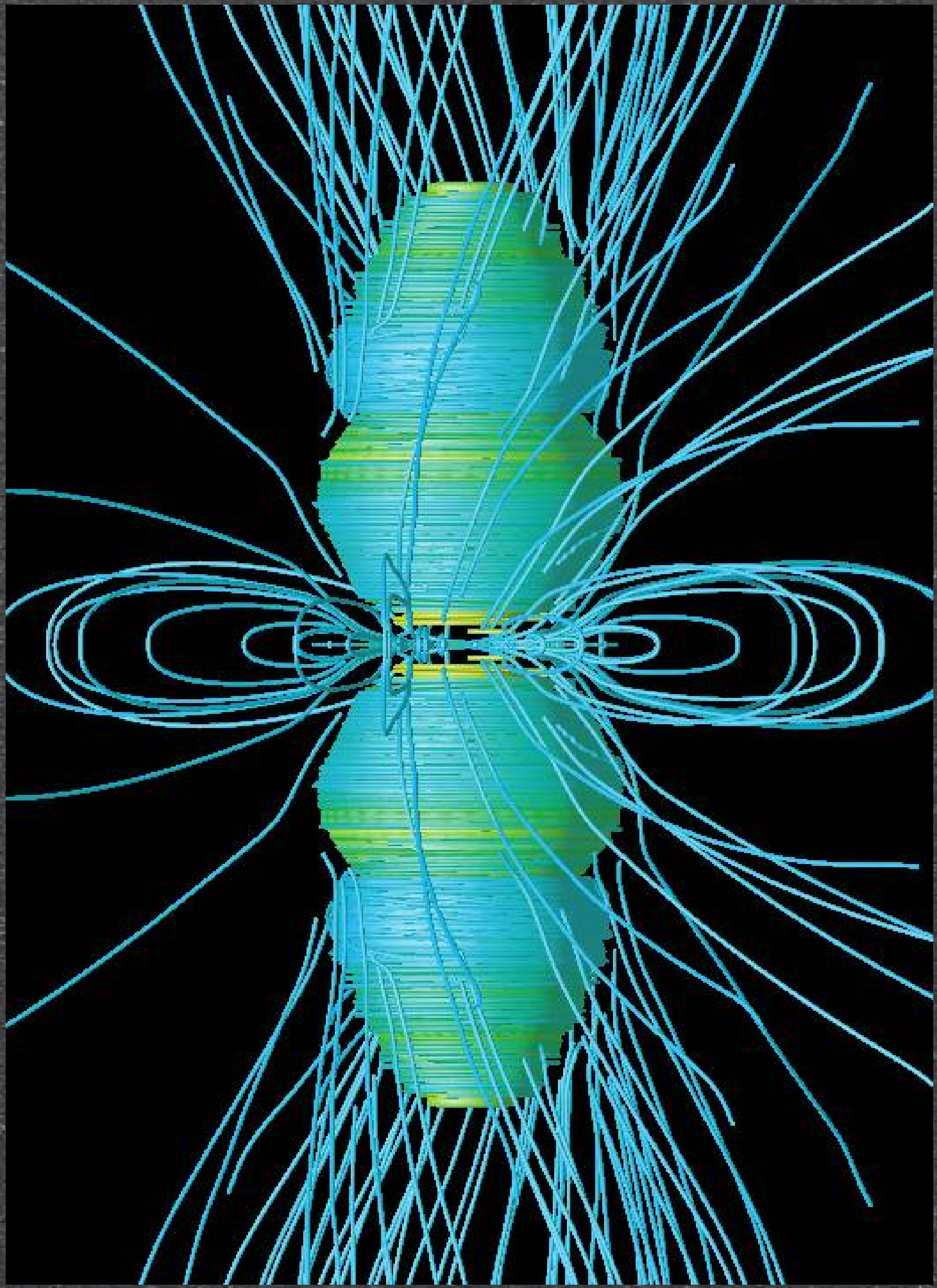
Core-Collapse SNe

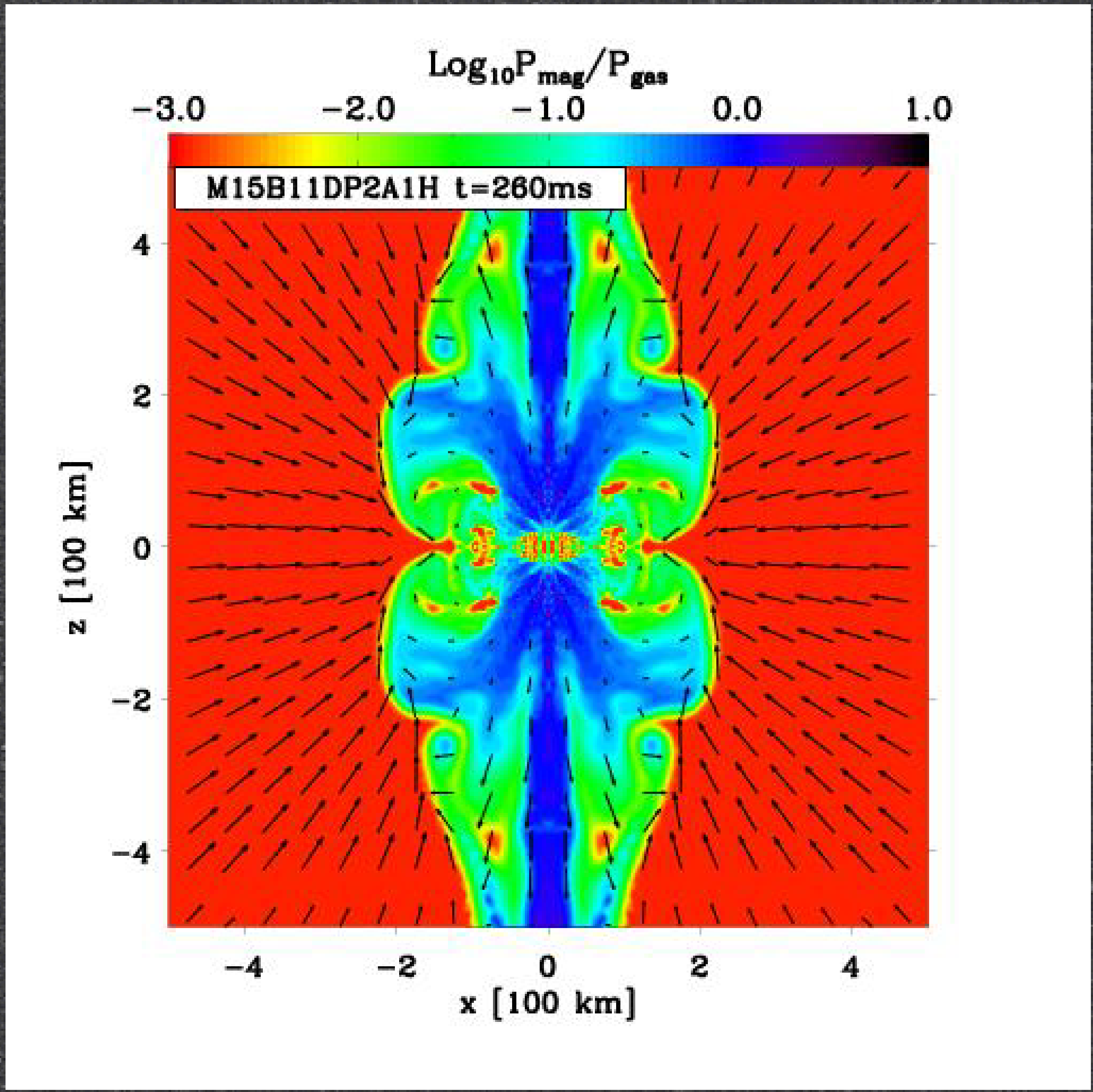


Cows are aspherical and magnetic, and so are supernovae!

Begall, S. *et al. Proc. Natl. Acad. Sci. USA* advanced online publication, doi: 10.1073/pnas.0803650105 (25 August 2008)

Magnetorotational SNe

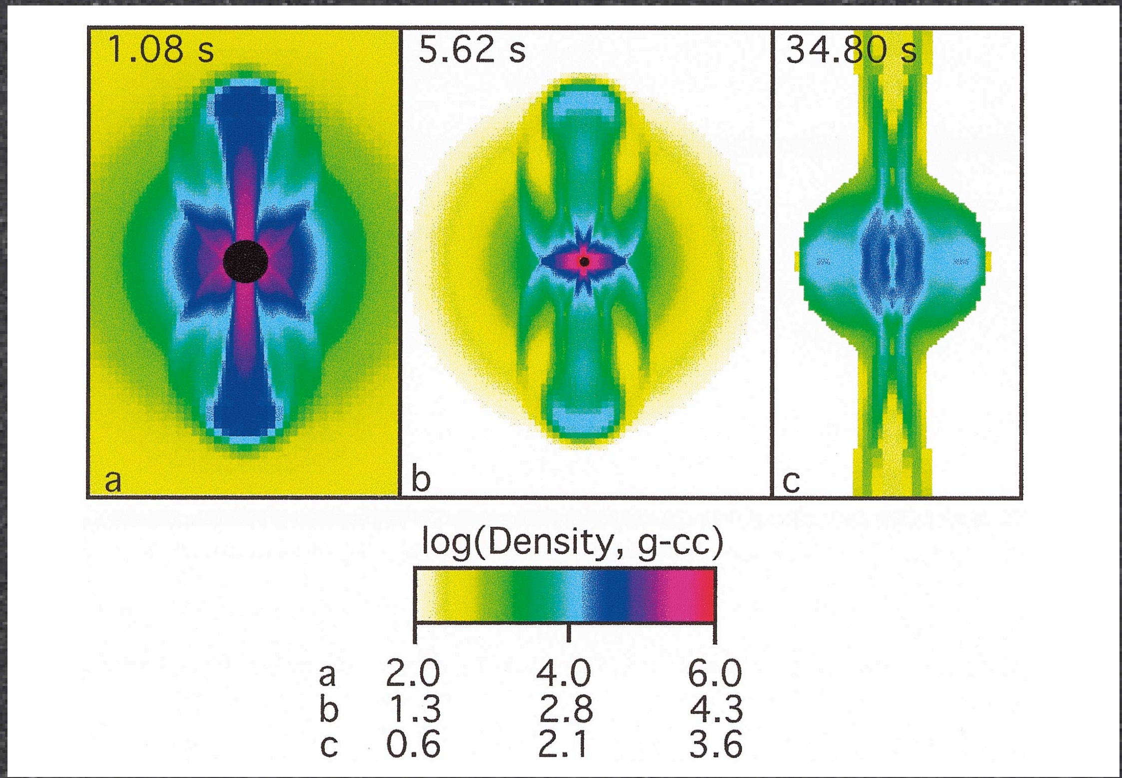




Burrows et al. 2007

What do Jet-driven SNe Look Like?

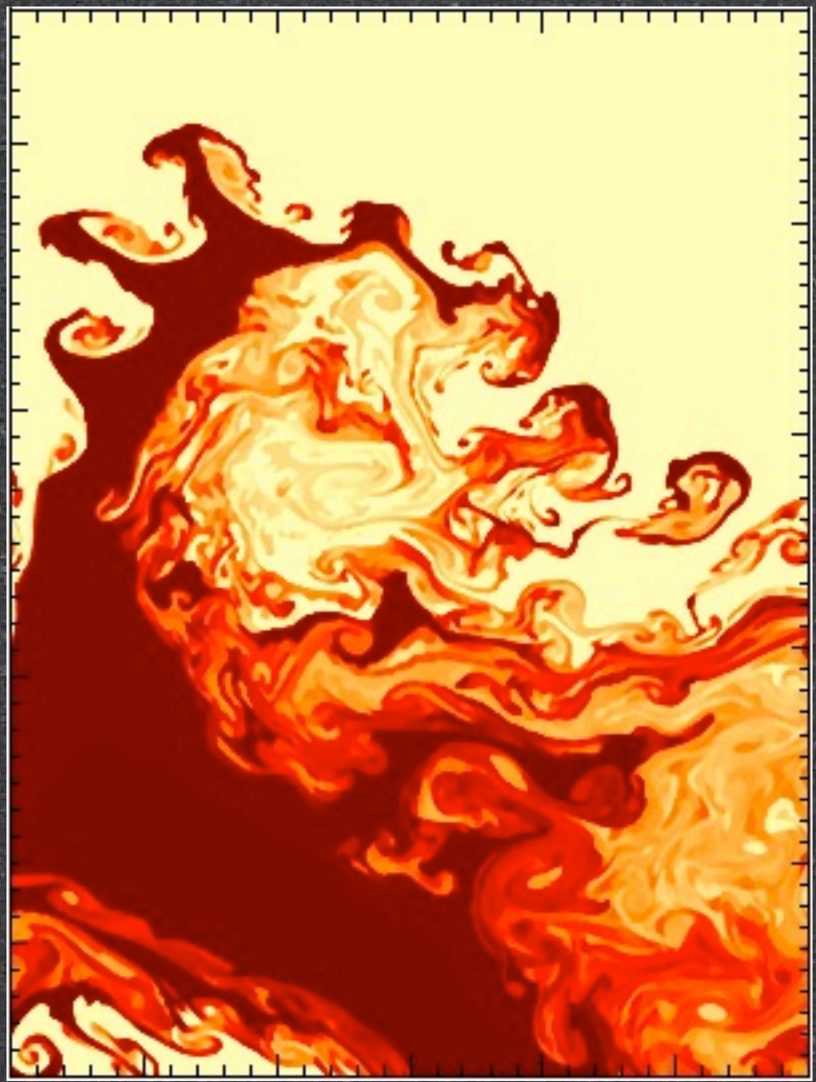
- Need simulations of the late-time dynamics
- Need resolution to study instabilities
- Need means of directly comparing to observations



Khokhlov et al. 1999

The FLASH Code

- Block-structured Adaptive-Mesh Refinement
- Piecewise-Parabolic Method, explicit Eulerian hydro
- Tabular EoS
- Poisson self-gravity
- HDF5 output



Kevin Olson

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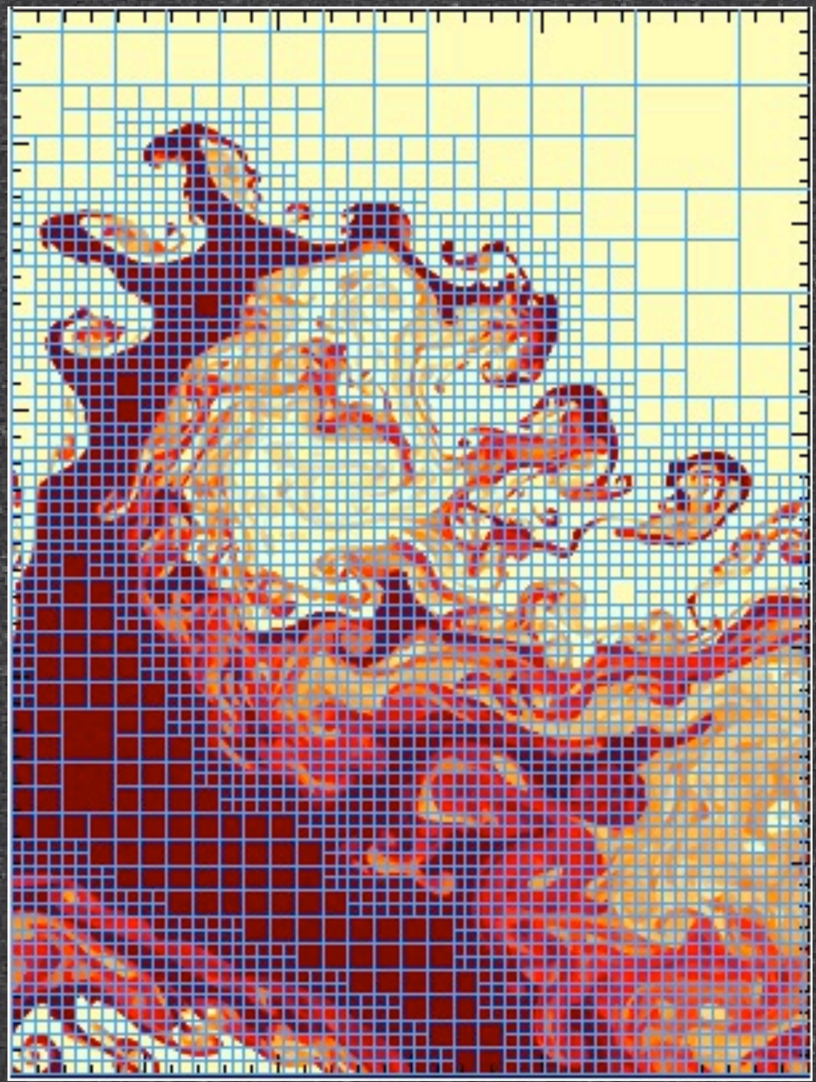


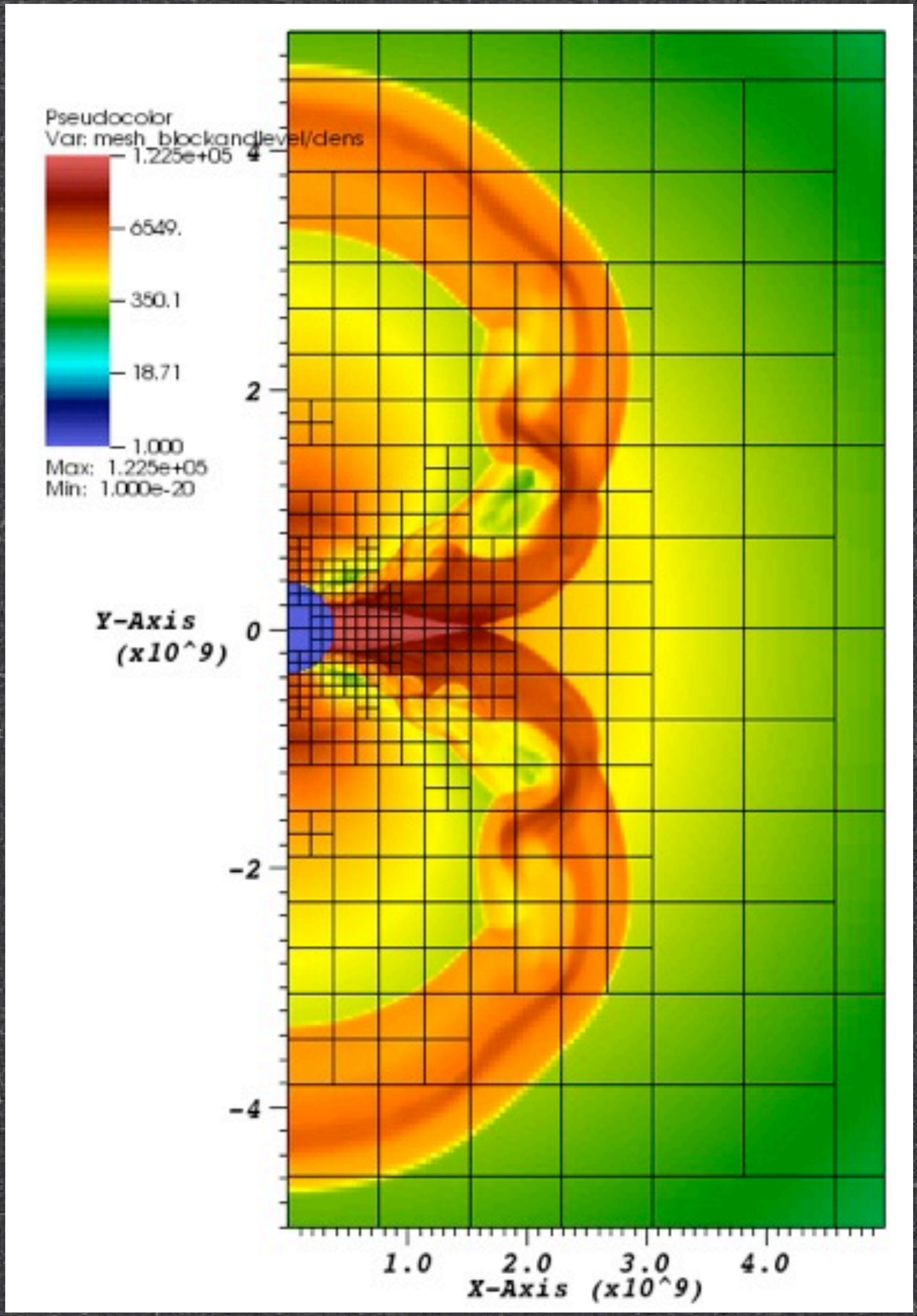
Kevin Olson

Viz & Analysis Tools

- Primarily VisIt through Python interface
- Parallel viz hardware (primarily at TACC)
- Also, some IDL...

Dynamic range

- 2D cylindrical geom.
- Radius, time-dependent max. refinement level
- Modified FLASH to excise central hole
- Hole radius expands with time
- Start with 25 refinement levels

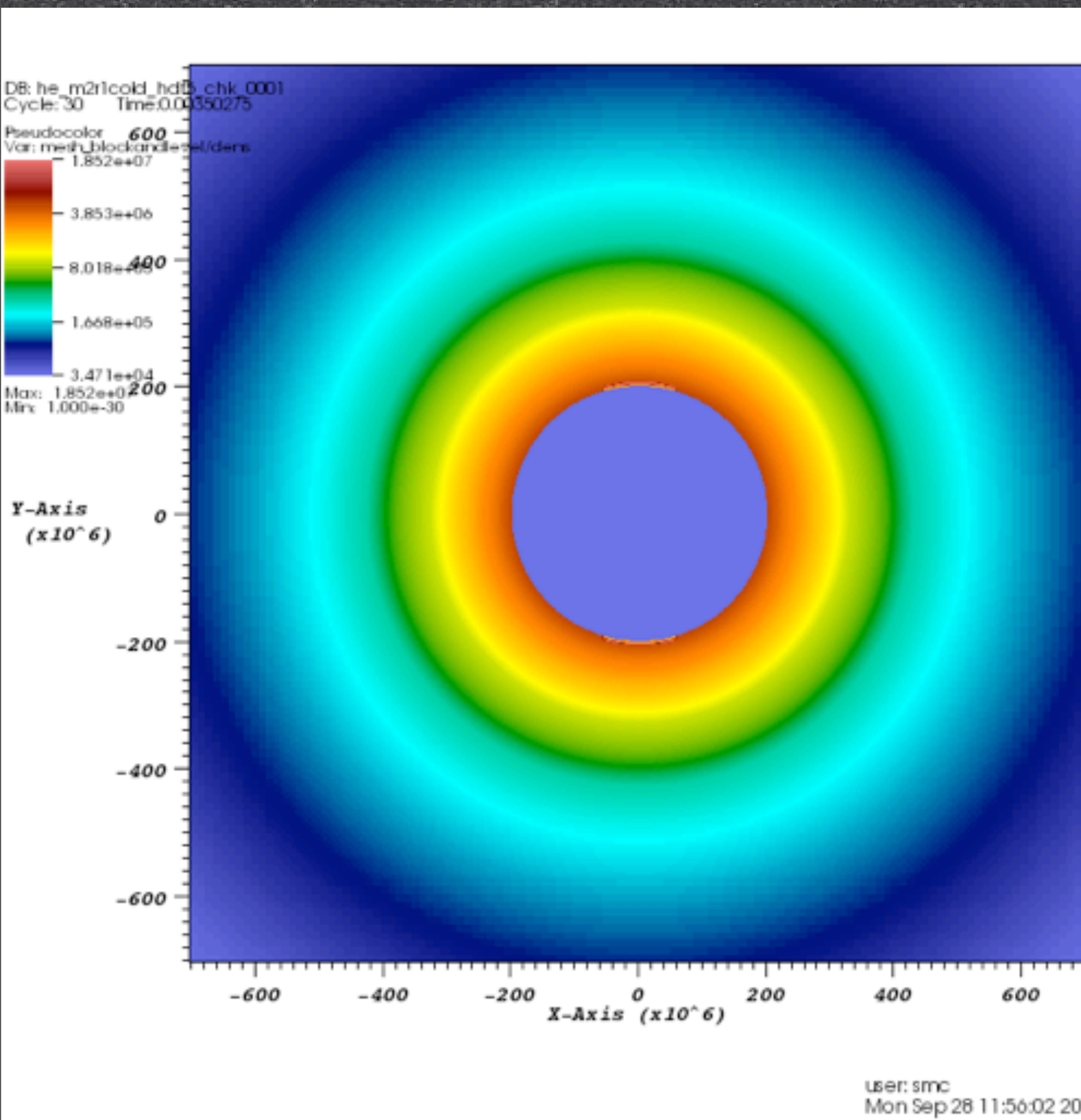


Density

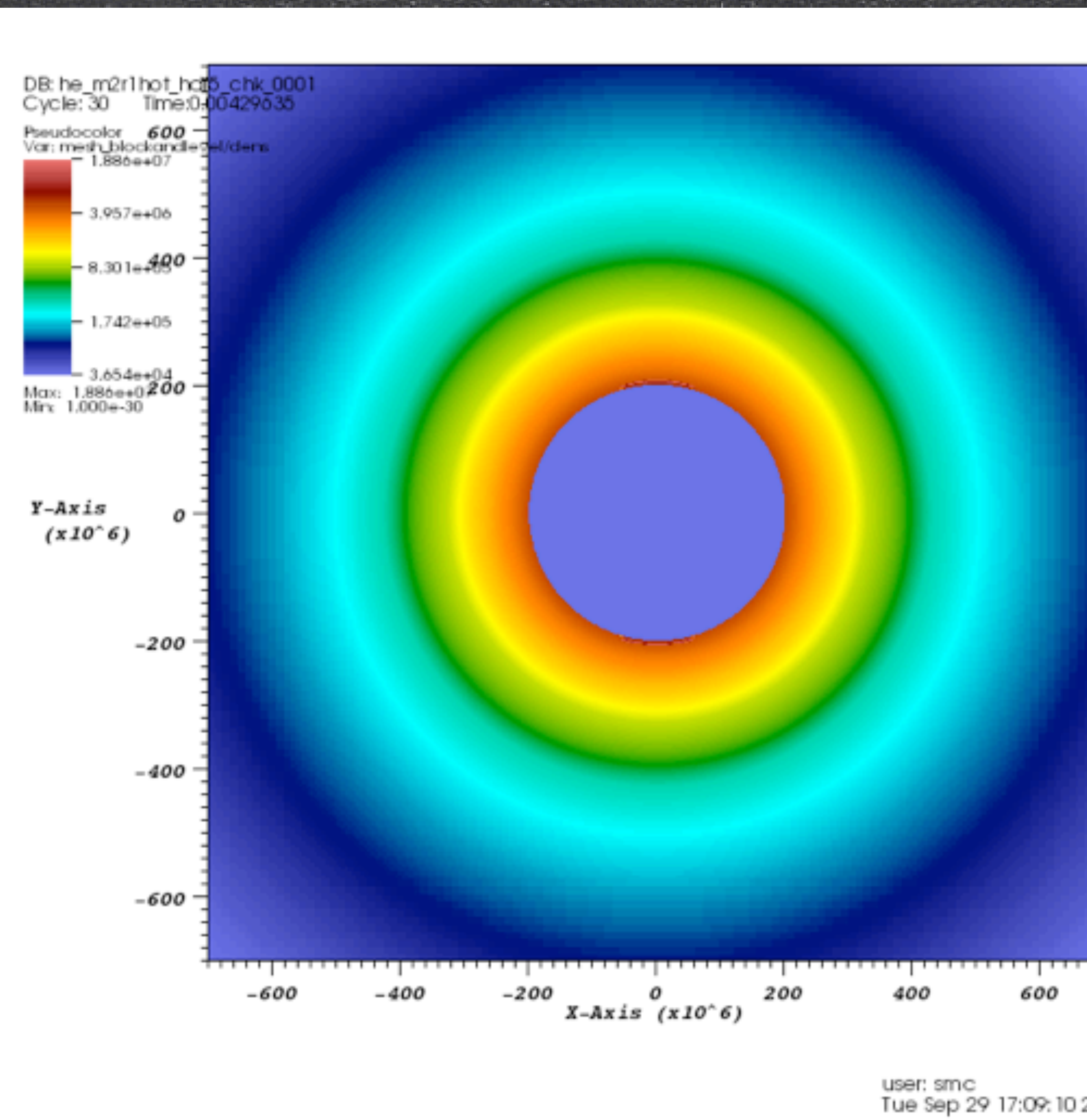
Kinetic

Thermal

Density

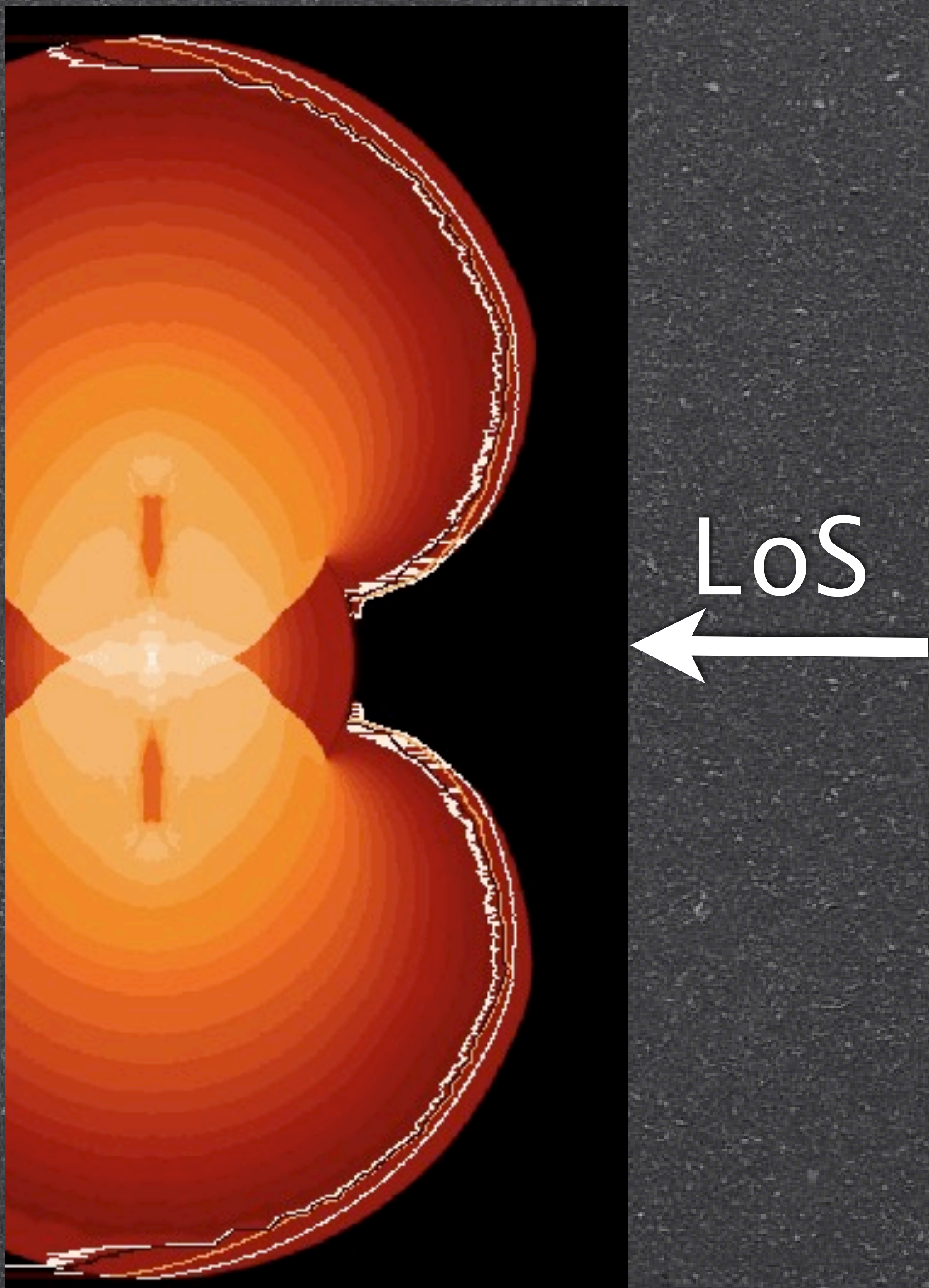


Kinetic



Thermal

X-ray emission modeling



Temperature

- Optical depths integrated along lines of sight
- Accurate opacities from LANL
- Multiple photon energy groups
- Composition: helium with 0.5 solar metallicity
- Black body emission with color temperature = gas temperature at therm. depth

$$\tau_{\mathrm{tot}} = \tau_{\mathrm{scat}} + \tau_{\mathrm{abs}} \approx 2/3$$
$$\tau_{\mathrm{eff}} = \sqrt{3\tau_{\mathrm{abs}}\tau_{\mathrm{tot}}} \approx 2/3$$

- Would like to get away from IDL...
- Need parallel resources capable of handling 3D AMR data
- Lagrangian particle analysis
- Vector field viz
- Minimize data movement
- Fast viz important, flexible data manipulation also needed