Wednesday, February 15, 2017

Second exam, Friday, February 24.

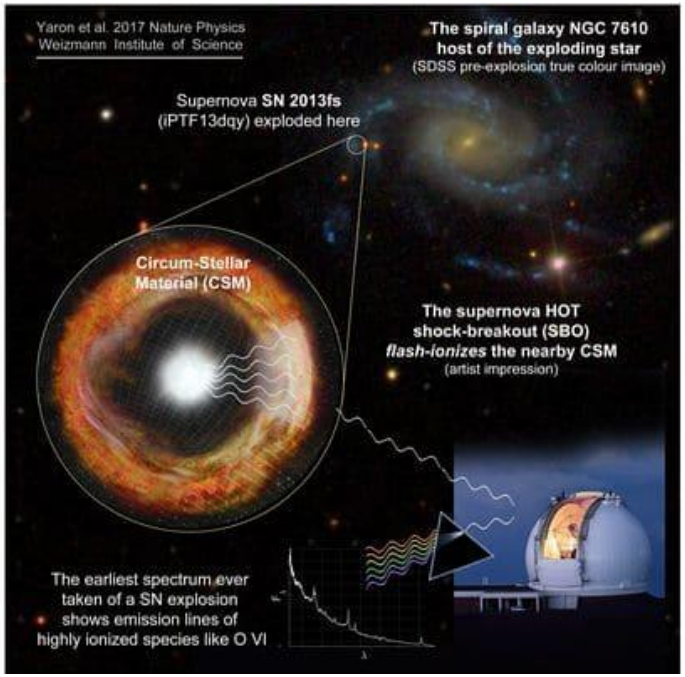
Reading for Exam 2: Sections 6.1, 6.4, 6.5, 6.6, Betelgeuse interlude.

Background: Sections 1.2.1, 2.1, 2.2, 2.4, 2.5

No Office Hours today – JCW to Texas Tech to give a colloquium on Betelgeuse.

Astronomy in the news?

New report of a Type II supernova discovered in 2013, SN 2013fs, first detected only 3 hours after the shock wave hit the surface. Evidence for a disk of material previously expelled from the star.



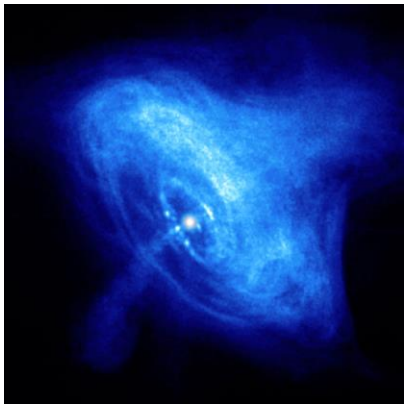
Goal

To understand how the collapse of an iron core can trigger a supernova explosion

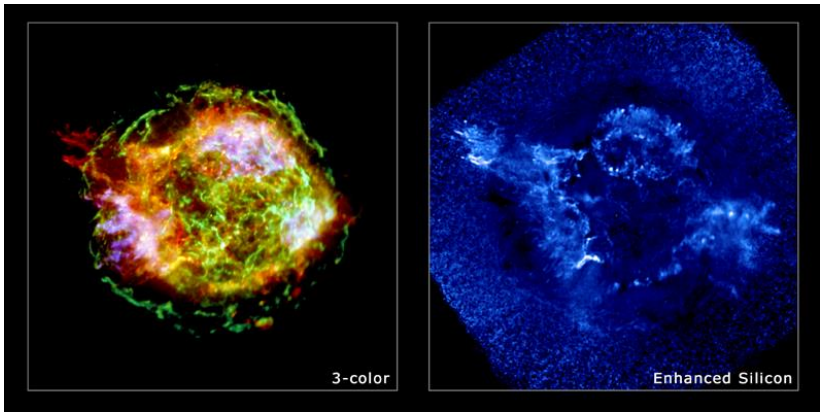
Goal

To understand how jets may trigger a core –collapse supernova explosion

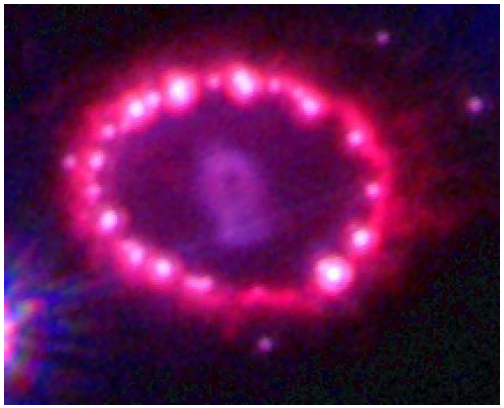
New possibility - Jet-induced supernova, Chapter 6, Section 6.5
(but not the discussion of polarization)



Crab Nebula



Cassiopeiae A



SN 1987A

Are jet-like flows typical? Are they important?

Studies (last 25 years) show that all Core Collapse Supernovae (massive stars: Type II, Ib, Ic) are out-of-round.

Perhaps combination football, frisbee, or something else.

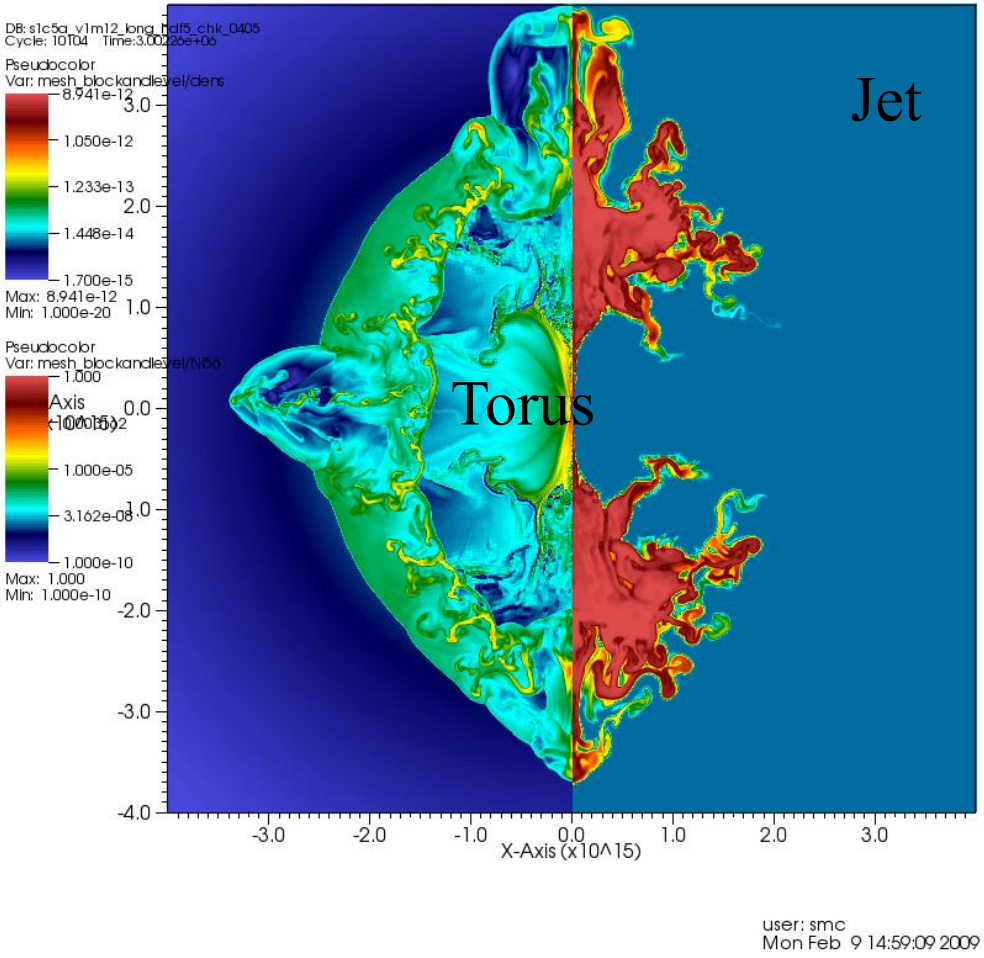
Supernovae show shapes consistent with (but not necessarily proving) jet-like flow.

Computer calculations show that jets emerging from newborn neutron star can explode the star, make it out-of-round.

Predict a jet/torus “bagel and breadstick” shape

What jets do -

Bagel and breadstick, jet/torus shape “natural.”



Explosion of two identical jets in a red giant star like Betelgeuse

Computer models predict a jet/torus, "bagel and breadstick" structure

Couch et al. 2009

This is the first new idea to understand these supernovae in thirty years.

Discussion points

How does a supernova determine a direction is space?

How does a supernova produce a jet-like flow?

How to define a particular direction in space?
Rotation - rotation axis.

How to make a jet? Some variation on squeeze and squirt (toothpaste mechanism)

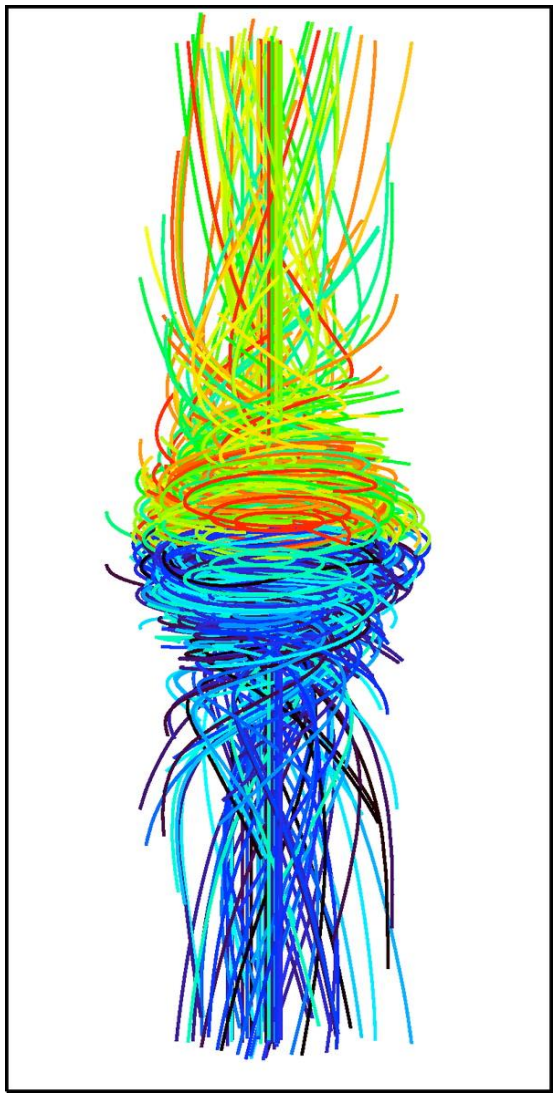
Magnetic lines of force, locus of equal field strength, act somewhat like rubber bands, they are elastic and tend to rebound if deformed and can be twisted and coiled.

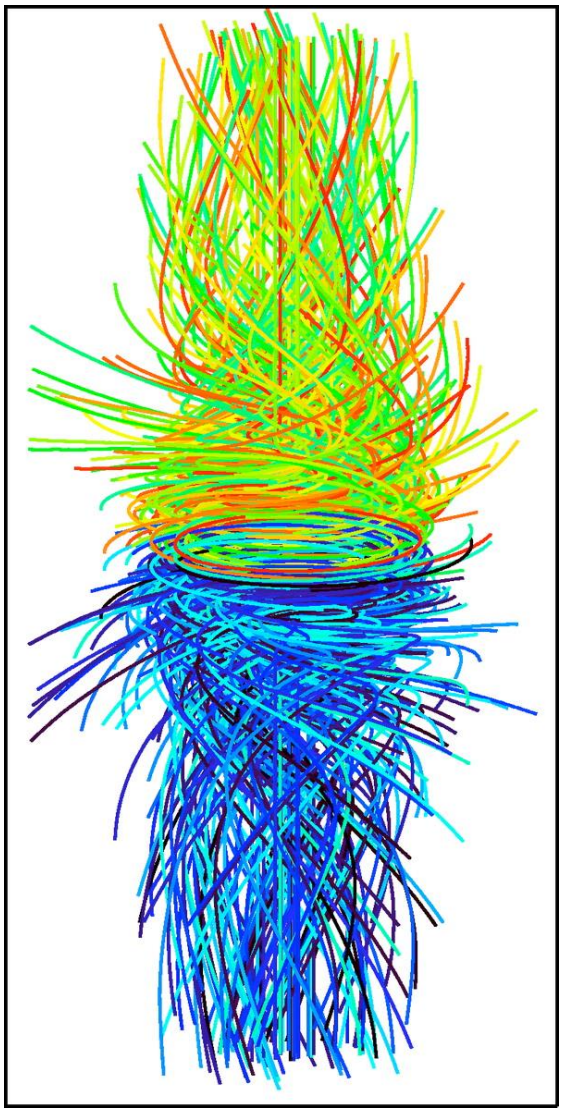
Twisted magnetic fields have tension along them and exert pressure sideways and along the lines of force.

Rubber band - twist moves along the rubber band.

Rotate magnetic neutron star, amplify the magnetic field, confine matter, eject mass along rotation axis if field is strong enough.

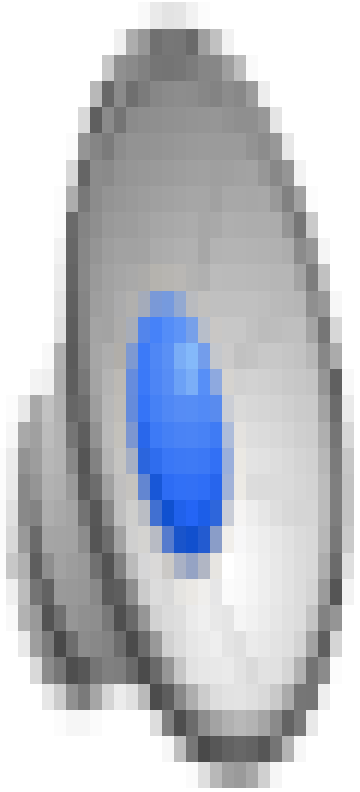
Twisted magnetic field lines of force making a magnetic jet during core collapse – A. Burrows et al.





More recent 3-D magnetic jet simulation – S. Couch

Latest supercomputer simulation, Philipp Moesta



What jets do -

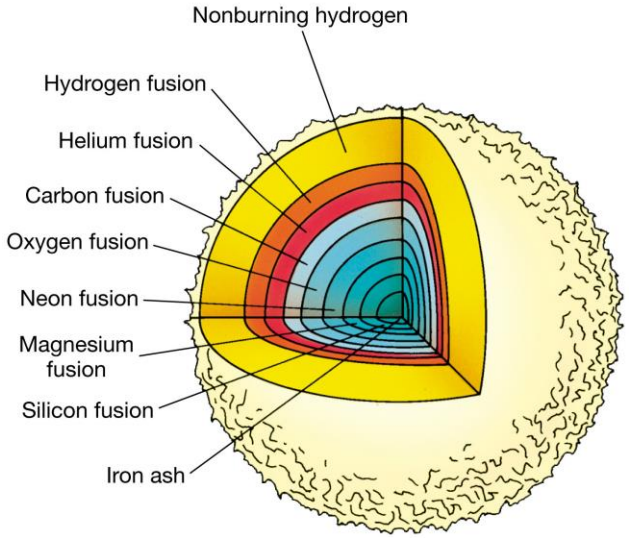
Bagel and breadstick, jet/torus shape "natural."

Strong enough jet can explode the star, but neutrinos also play a role - complicated problem!

Account qualitatively for out-of-round shapes.

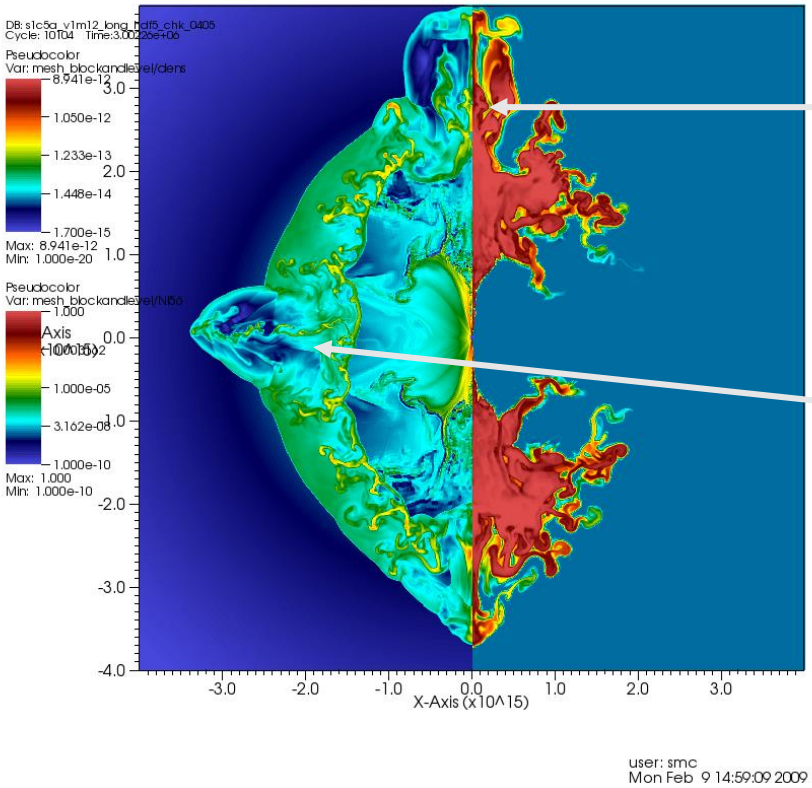
Test for shape (jet/torus), prediction of different elements exploded in different directions.

Initially spherical model,



Spherical Explosion hydrogen, helium, oxygen, silicon, calcium, and iron would be exploded in all directions

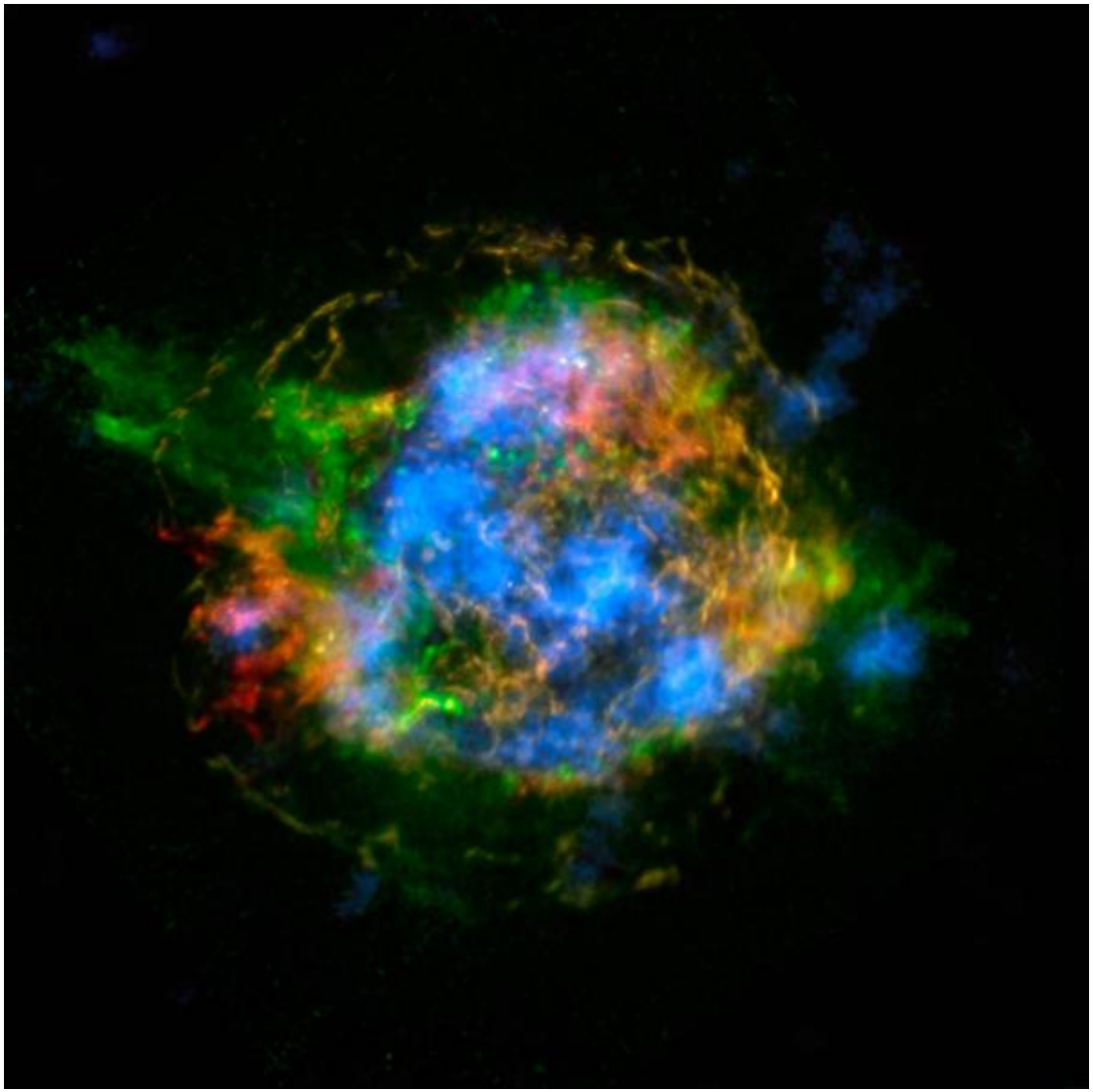
Jet-induced Explosion axis/torus structure



Jet iron, O bread stick

Torus He bagel

Cas A: some radioactive material (blue) in the "counterjet," some in the "bagel?"

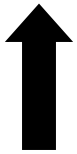


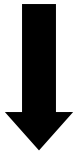
One Minute Exam

Why do astronomers think that jets may be involved in the core collapse explosion of massive stars?:

 Iron makes jets

 Jets make iron and oxygen

 Cassiopeia A has a collapsed object in the center of the explosion

 All core collapse supernovae are out of round