Wednesday, February 17, 2016

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

Exam 2, Friday, February 26

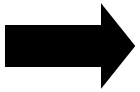
Astronomy in the news?

3 theory papers on the black hole gravity waves Tuesday, one today.
There will be a flood of thinking, assessment, and re-assessment.

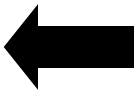
What is the phase of the Moon?

One Minute Exam

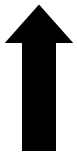
What happens to the initial ***shock wave*** produced when an iron core collapses to form a neutron star and bounces?



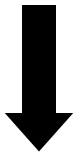
It fades away



It propagates out through the star and causes an explosion



It stalls at some distance from the neutron star

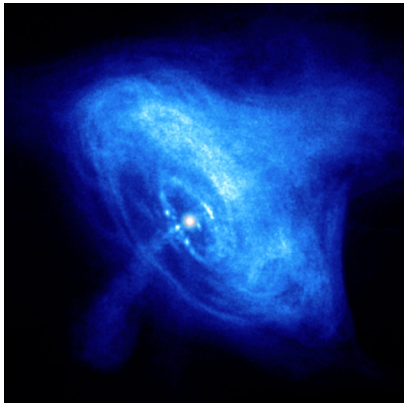


It traps neutrinos

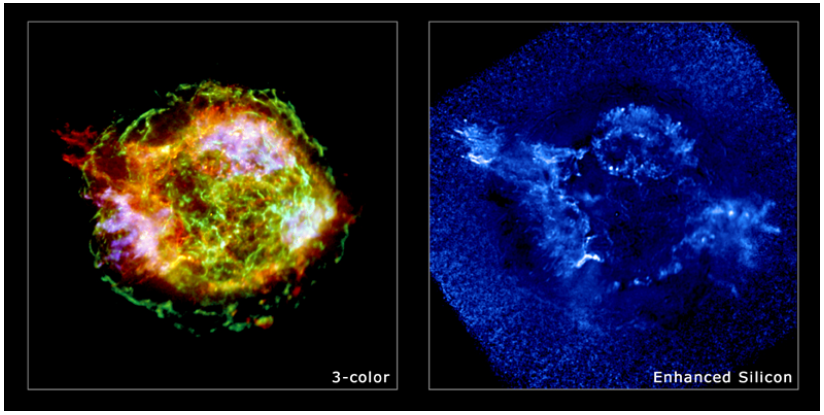
Goal

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

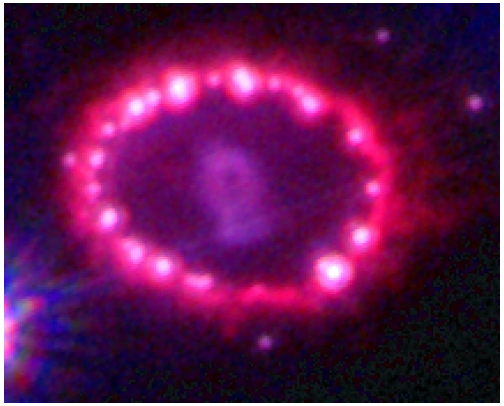
New possibility - Jet-induced supernova, Chapter 6, Section 6.5
(but not the discussion of polarization)



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.

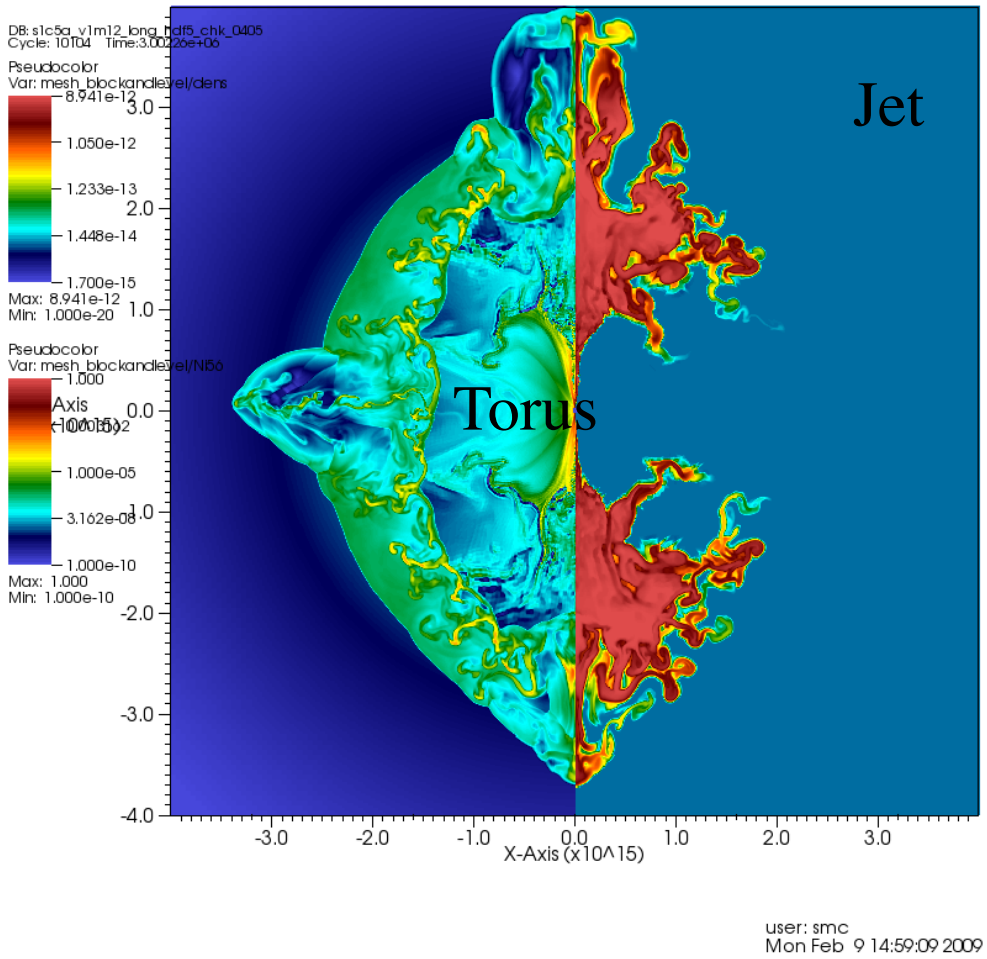
Supernovae show shapes consistent with (but not necessarily proving) jet-like flow.

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)

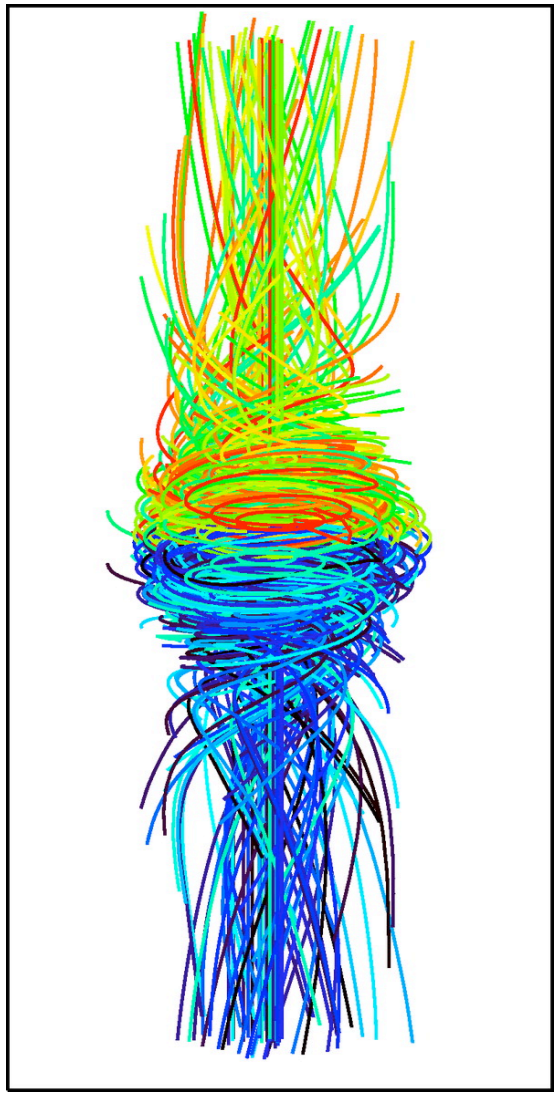
Magnetic lines of force, locus of equal field strength, act somewhat like rubber bands, they are elastic and tend to rebound if deformed and can be twisted and coiled.

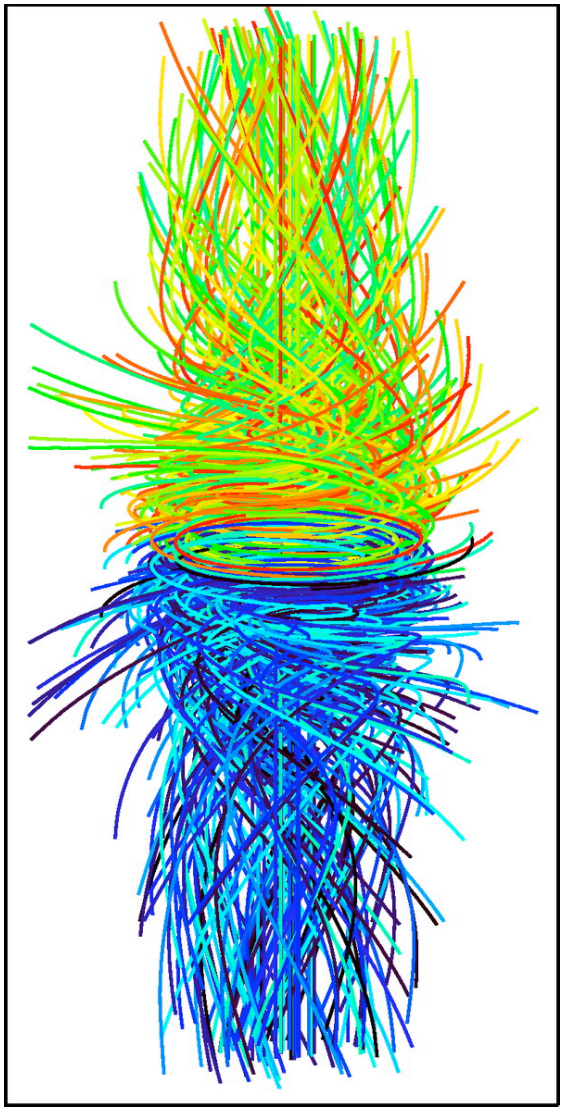
Twisted magnetic fields have tension along them and exert pressure sideways and along the lines of force.

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 -

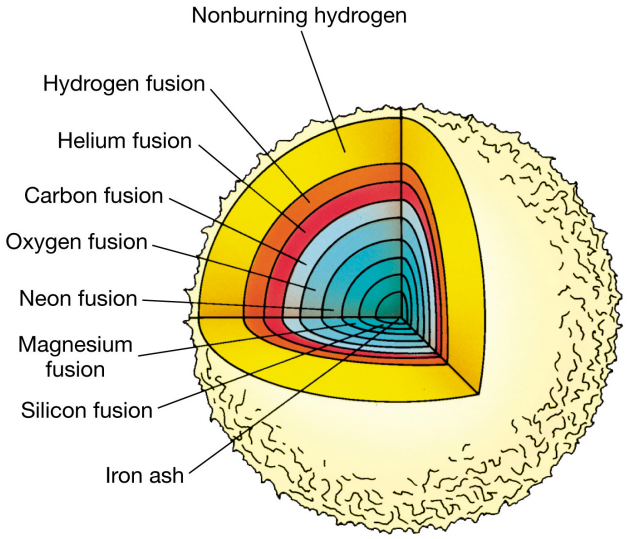
Bagel and breadstick, jet/torus shape "natural."

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

Account qualitatively for out-of-round shapes.

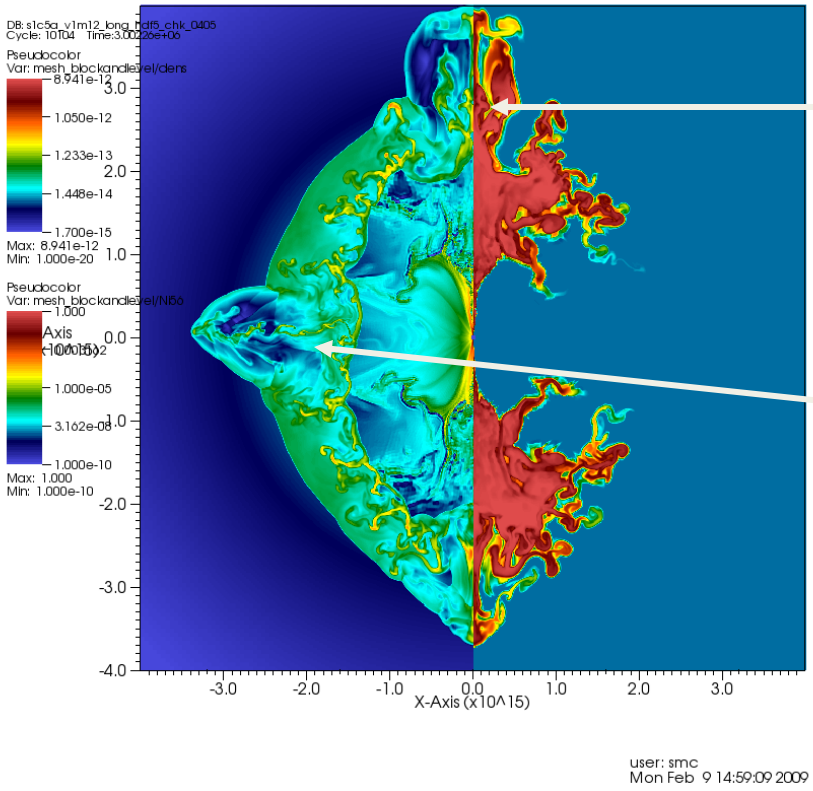
Test for shape (jet/torus), prediction of different elements exploded in different directions.

Initially spherical model,



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

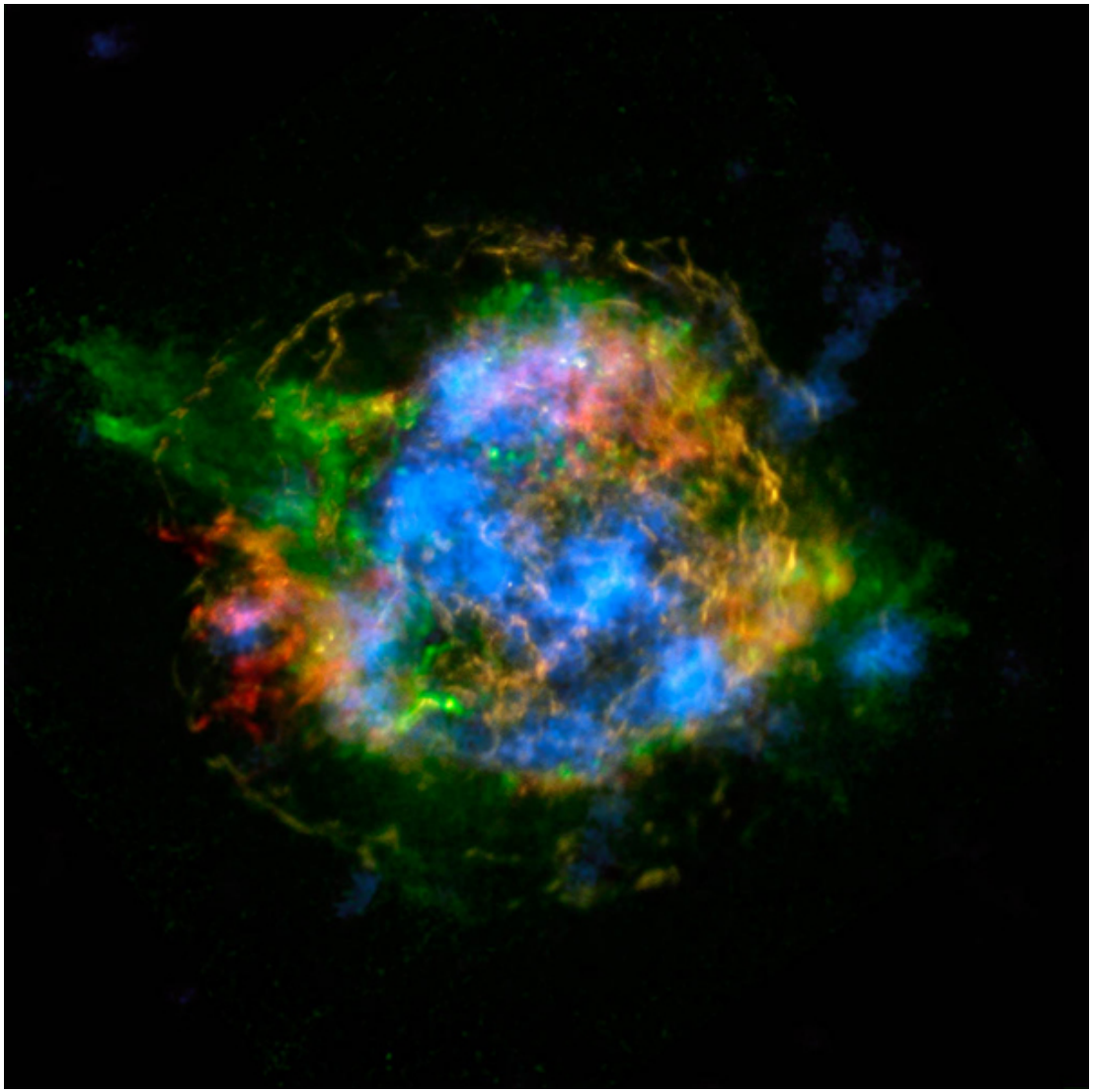
Jet-induced Explosion axis/torus structure



Jet
iron, O bread stick

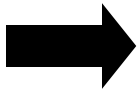
Torus
He bagel

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



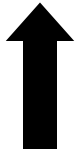
One Minute Exam

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

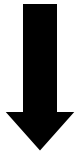


Iron makes jets

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

Understanding how magnetic fields form and behave in core collapse is on the cutting edge of research.

There is yet no general agreement as to how *implosion* of the iron core is turned into the *explosion* of the supernova.

Rebounding, boiling neutron star, standing shock, neutrinos, rotation, and magnetic fields are all important ingredients.

Still a huge challenge to simulate properly on supercomputers.

Nature does not care what astrophysicists do not understand.

Type II and Type Ib/c supernovae continue to explode!