Wednesday, October 16, 2013

Reading: Chapter 8 - Sections 8.1, 8.2, 8.5, 8.6, 8.10

Astronomy in the news?

NASA still shut down.

Senate reached bipartisan deal 5 minutes ago

Goal – to understand the nature of a new class of superluminous supernovae

Shell-Shock Model

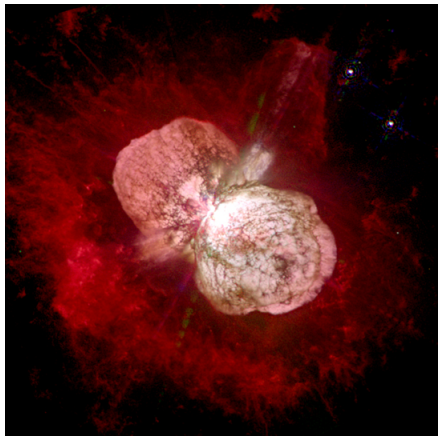
Need a massive shell of circumstellar matter expelled by the progenitor star months to years prior to its explosion.

Shell sitting at a radius of about 100 times the size of the Earth's orbit, so does not need to expand at all to radiate.

Supernova then collides with that shell, efficiently radiates kinetic energy as radiant energy, no loss to expansion and cooling.

Candidate progenitor stars - Luminous Blue Variables such as Eta Carinae, known to eject shells of matter in a burst, mechanism unknown

The shell-shock model works for SN 2006gy and related hydrogen-rich events, SN 2008es, SN 2008am



JCW proposed a different kind of explosion for SN 2006gy, first worked out theoretically 40 years ago, more recently hypothesized to occur among the first stars ever formed in the Universe, but never seen.

A Pair-Formation Supernova

Goal:

To understand the nature of Pair-Formation Supernovae

The energy of high-energy photons can be converted to mass ($E = mc^2$) in the form of particles and their anti-particles, same mass, opposite electrical charge, ***matter and anti-matter***. When matter and anti-matter combine they produce pure energy.

From Wikipedia: **Warp core** A primary component of the warp drive method of propulsion in the Star Trek universe is the "gravimetric field displacement manifold," more commonly referred to as a *warp core*. It is a fictional reactor which taps the energy released in a matter-antimatter annihilation to provide the energy necessary to power a starship's warp drive, allowing faster-than-light travel. In the *Star Trek* universe, fictional "dilithium crystals" are used to regulate this reaction. Usually, the reactants are deuterium, an isotope of hydrogen, and antideuterium (its antimatter counterpart).

Also *Angels and Demons* – vial of anti-matter threatens to explode the Vatican.

Other examples of anti-matter in books, film?

A very massive star, > 100 solar masses, gets so hot in the post-helium burning, oxygen-core phase, that its radiation, gamma-rays, converts some energy to matter and anti-matter, pairs of ***electrons*** and ***positrons***.

According to theory, this process reduces the energy available to exert pressure, the oxygen core contracts, heats, undergoes a thermonuclear explosion, totally disrupting the star: a ***pair-formation supernova.***

Computer models of the explosion produce a large amount, 10's of solar masses, of radioactive ^{56}Ni, the decay of which to ^{56}Co and then to ^{56}Fe is predicted to produce a very bright, slow light curve.

The Pair-Formation Supernova Model was wrong for the first superluminous supernovae that defined the class.

SN 2005ap - very bright requiring a large amount of nickel if that were the power source,

But

Rather narrow light curve, meaning the ejected mass was modest.

Would require more ^{56}Ni to power the peak light than the total mass constrained by the width of the light curve.

Physically impossible, so power by radioactive decay ruled out.

Need another mechanism for many of these very bright events.

An example of pair formation?

SN 2007bi had no Hydrogen, no sign of circumstellar interaction, must be massive and is bright, radioactive decay might be consistent, could be a pair-formation supernova. Recent work says “no,” wrong spectrum.

Hydrogen-rich shell shock works for SN 2006 and related events.

What about SN 2005ap and similar events?

No Hydrogen, no sign of circumstellar interaction, must be massive, but cannot be radioactive decay.

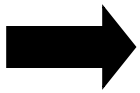
Shell shock in shell of carbon and oxygen? Some very massive stars might eject their hydrogen and helium in strong winds, then eject shells of carbon and oxygen, explode and collide with that.

SN 2007bi might be something like this, not pair-formation.

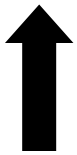
Or something else??? Birth of especially strong neutron star?

One Minute Exam

What can we say about all the superluminous supernova with some confidence?

 They have hydrogen

 They do not have hydrogen

 They are bright because of the shell-shock mechanism

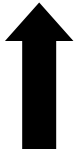
 They arise in very massive stars

One Minute Exam

What aspect is **not** a property of the Pair-Formation model?

 Creation of matter and anti-matter

 Thermonuclear explosion of oxygen core

 Production of many solar masses worth of radioactive nickel-56

 Collapse of the core to form a neutron star

Current Status of Superluminous Supernovae

Superluminous supernovae involve very massive stars.

They tend to occur in regions of active star formation in low mass, irregular galaxies.

Some show hydrogen, some do not.

Some show evidence for the shell-shock picture, some do not.

Not clear than any are fully consistent with the pair-formation model.

Some are definitely not consistent with the pair-formation model.

Current Status of Superluminous Supernovae

Some show no hydrogen and no evidence for circumstellar shocks, but also are not consistent with the pair-formation model.

Shell shock in shell of carbon and oxygen? Some very massive stars might eject their hydrogen and helium in strong winds, then eject shells of carbon and oxygen.

Some evidence for a shell rich in oxygen in one case.

If there is a single mechanism, then it is probably shell-shock, but perhaps there is more than one mechanism at work.