4/19/06

Exam 4, Friday, April 28

Extra Credit reports due Friday, May 5 Midnight

For star chart that can be "tuned" to the time of night you want to observe: class web site --> links --> What's Up in the sky Tonight --> Whole Sky Chart

News:

Pic of the day; Mars near open cluster of stars

Reading:

Chapter 9, Sections 6 - 8

Chapter 10, black holes, updated material posted.

Next topic: Cosmic Gamma-Ray Bursts, part of old Chapter 11 in book, new separate Chapter 11 posted.

Then Supernovae and Cosmology, part of old Chapter 11 in book, new separate Chapter 12 posted.

The latest chapter in the story:

Intermediate mass black holes, of order 1000 - 10,000 M

First suspected from very bright X-ray sources,

Even the gravity of a neutron star would not be enough to bind the mass (see Eddington limit luminosity, Chapter 2, Section 2).

This remains controversial.

Gebhardt and co-workers have apparently found intermediate mass black holes in ***globular clusters*** using stellar velocities.

Globular clusters are old, nearly spherical clusters containing about 100,000 stars.

Remarkably, these black holes may follow exactly the same bulge mass, black hole mass as galaxies, the black hole is about one thousandth of the mass of the globular cluster!

These star clusters also "know" how big a black hole to form!

Maybe a clue to how the process works in whole galaxies.

M 15 in our Galaxy, 4000 M black hole

G1 in Andromeda galaxy, 20,000 M black hole

One Minute Exam

The X-ray flares from binary black hole systems are thought to be from the same basic physics as:

A) Dwarf Novae

B) Classical Novae

C) X-ray Bursters

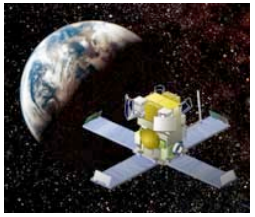
D) X-ray pulsars

Cosmic Gamma-ray Bursts

Old Chapter 11, New posted Chapter 11

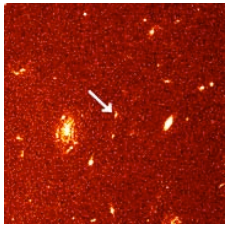
Gamma-Ray Bursts

Cosmic explosions, flashes of gamma-rays lasting about 30 seconds, detected by satellites.



High Energy Transient Explorer

Seen across the Universe.



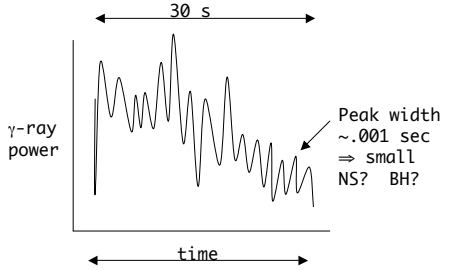
Energy is expelled in narrow jets.
Energy comparable to that of supernovae, but all in gamma-rays, with later ***afterglow*** in X-ray, radio and optical radiation.
Birth of a black hole?

Gamma-Ray Bursts unite ***stars*** and ***cosmology***

Mystery since late 60's - satellites to monitor space nuclear test ban treaty, avoid confusion between astronomical effects, and bombs

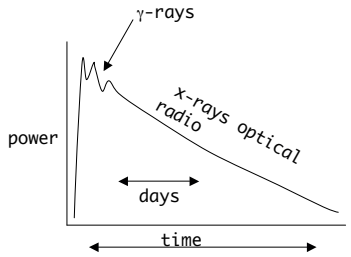
Flare of γ -rays lasts ~ 30 sec

Never Repeat - for 30 years, no optical counterpart,
Can't focus gamma-rays.
Did not know which of millions of stars to look at.



Did not know the distance: guesses ranged from within the Solar system to cosmologically distant

Revolution in 1997: 1st detection of "after glow" - optical, radio, X-ray, fading light



Position localized - could bring full armament of modern astronomy to bear on the fading radiation.

⇒Found bursts were in distant galaxies - all at huge, cosmological distances

⇒ Very bright to shine that far

January 23, 1999 optical flash associated with the gamma-ray burst itself (need to discover, swivel telescope, look in 30 seconds!)

9th magnitude - human limit 6th magnitude, could almost see with naked eye, could have seen with good binoculars, but half way across the Universe! ***Brightest optical event ever recorded.***

If gamma-ray bursts shine equally in all directions, the energy released in gamma rays would be 3000 × SN or 30 × core collapse neutrinos.

Comparable to total annihilation into pure energy of entire star!

BUT

Light bulb versus laser pointer or flash light

Bursts do not radiate in all directions!

They are strongly focused into jets!

Bursts are focused into only 1/100 to 1/1000 of total sky

Typical gamma-ray burst energy ~ 1/3 supernova kinetic energy

But send matter at 99.997% of the speed of light

Supernova energy into a mass equivalent to Jupiter, not the mass of the Sun, as for supernovae

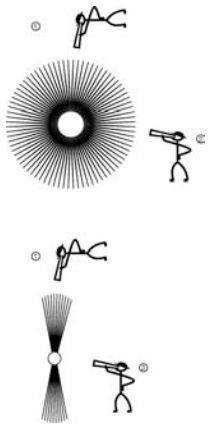


Figure 11.4

They explode ~100 times more often than observed (could observe about 2 per day if looked in all directions, all the time) because most have the jet aimed away from us.

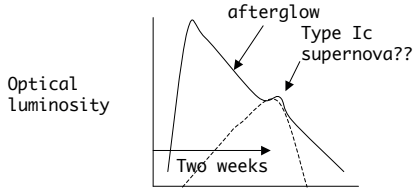
Find all gamma-ray bursts in regions of massive young stars

Something to do with death of massive stars

Explode once every 10^4-10^5 years in a given galaxy versus about once per 10^2 years for ordinary supernovae, so relatively rare.

Most popular guess is that gamma-ray bursts represent the birth of a black hole in the collapse of a massive star (might be a highly magnetized neutron star or *magnetar* - Chapter 8)

Circumstantial evidence for several bursts associated with supernovae.

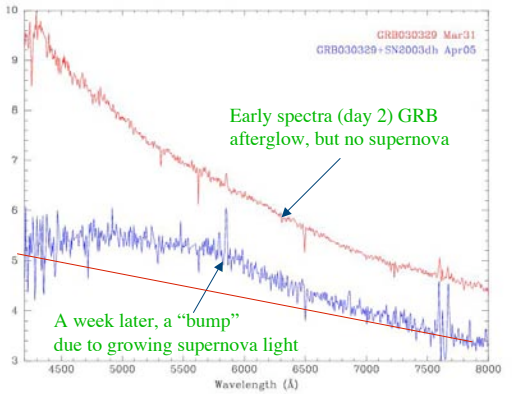


The raging issue: are gamma-ray bursts produced in some form of core collapse supernova? Circumstantial evidence...

THEN PROOF!

GRB 030329 was nearby, only 3 BILLION light years away! Relatively bright, an ideal target.

SN2003dh was discovered a week later! Spectrum of a Type Ic supernova



The current picture: Gamma-ray bursts result from the collapse of a massive star, probably to produce a black hole, that emits a tightly focused, highly relativistic jet.

Every burst, twice a day somewhere in the Universe - the birth of a black hole aiming its jet at us?

~100 aimed elsewhere for every one aimed at us.

NASA Animation: Black Hole Forming in Star, producing jet and Gamma-Ray Burst