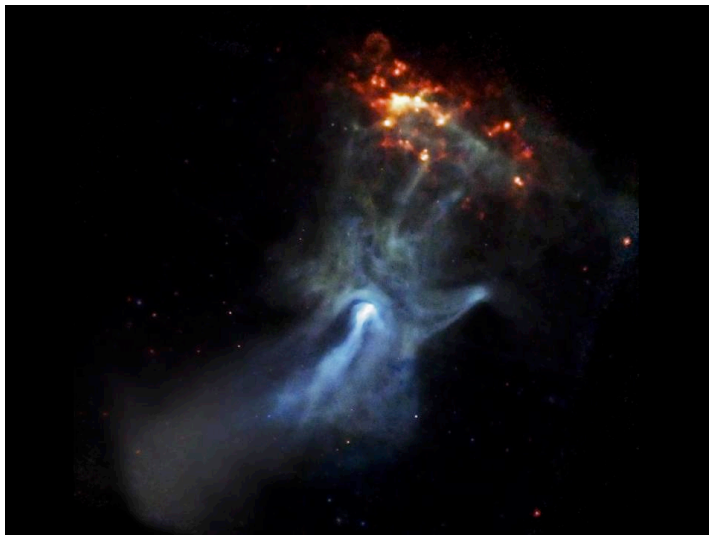
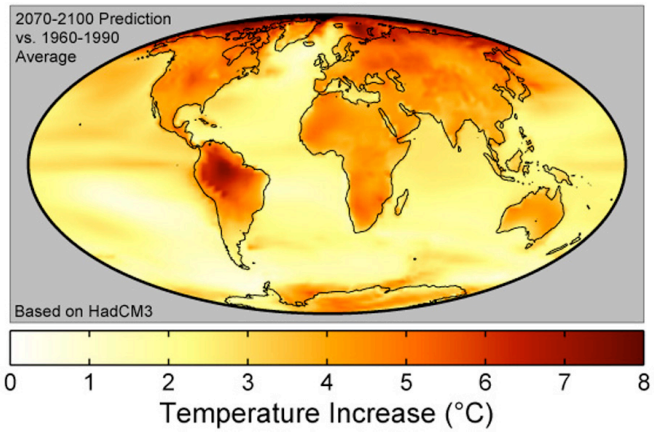
Tuesday, April 21, 2009

Fourth, and last, noncumulative exam on Thursday, May 7.
Remainder of book. No Final.



Astronomy in the News - Stephen Hawking in the hospital with a chest infection.
Hand-like image of pulsar nebula
Tomorrow, Wednesday, is Earth Day

Pic of the day - predicted global warming.



One Minute Exam

How can we discover a stellar mass black hole that has no accretion disk around it?

A) Look for X-rays

B) Look for gamma-rays

C) Look for jets

D) We can't

One Minute Exam

What is the relation between the mass of a supermassive black hole and the galaxy in which it resides?

A) There is none, the black hole can be big or small, depending on how it grew and for how long

B) The larger the mass of the galaxy, the smaller the mass of the black hole

C) The larger the mass of the galaxy, the larger the mass of the black hole

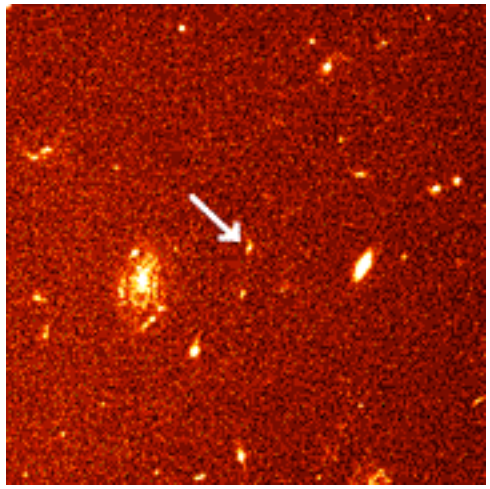
D) The larger the radius of the galaxy, the larger the mass of the black hole

Gamma-Ray Bursts (Chapter 11)

Swift satellite

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

Seen across the Universe.



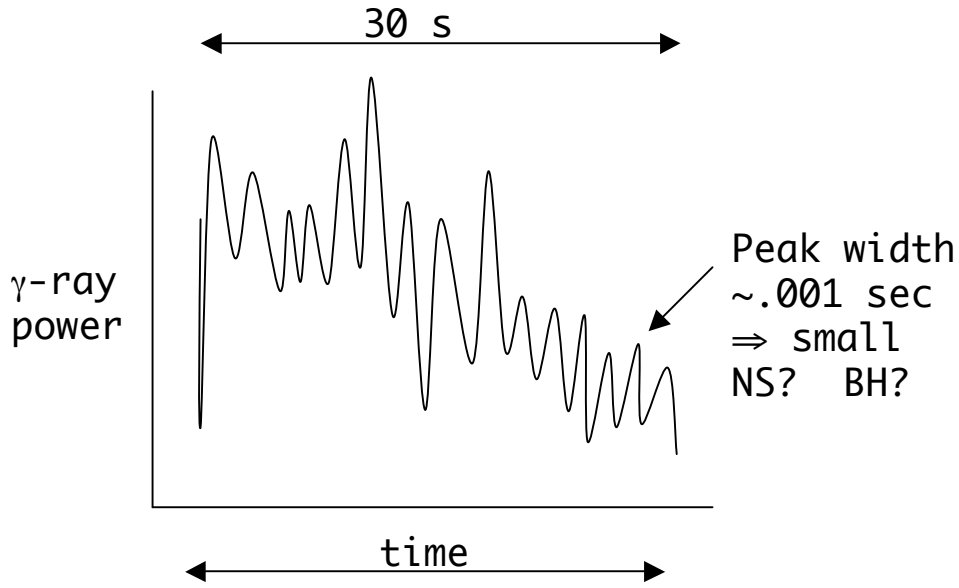
Energy is expelled in narrow jets.
Energy comparable to that of supernovae, but all in gamma-rays, with later ***afterglow*** in X-ray, radio and optical radiation.
Birth of a black hole?

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

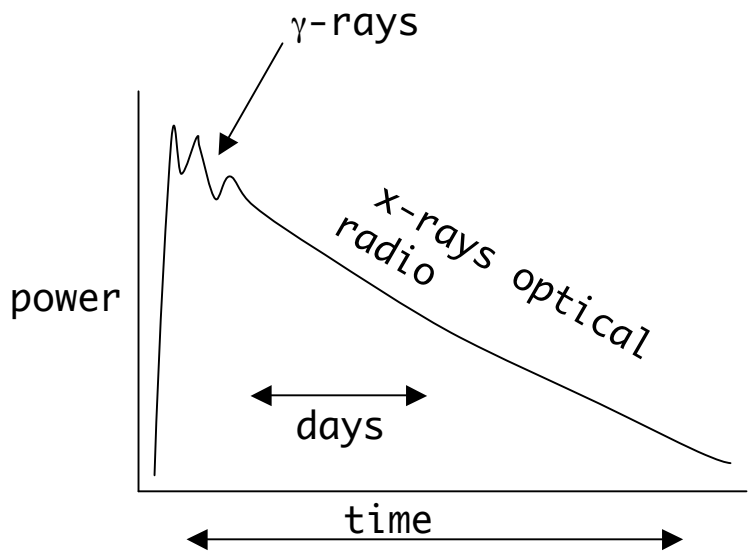
Flare of γ -rays lasts ~ 30 sec

Never Repeat - for 30 years, no optical counterpart,
C*an'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, billions of light years away.

⇒ 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, until recent Feb 19, 2009 burst discovered with new Fermi Satellite.***

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

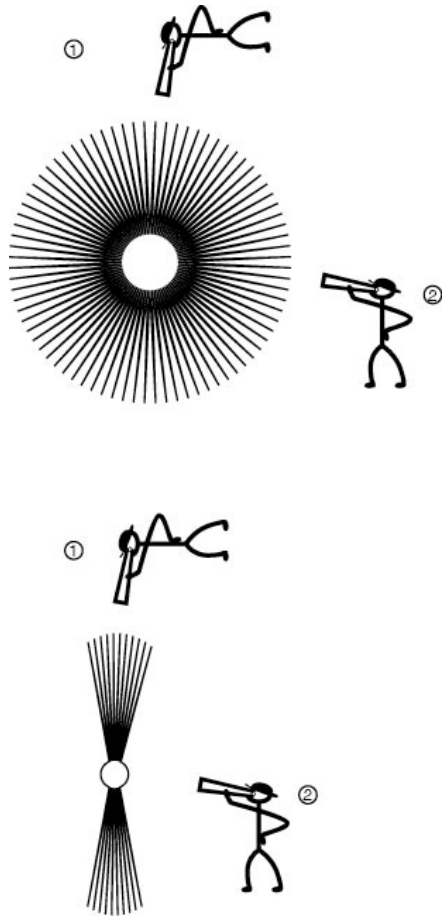


Figure 11.4

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.

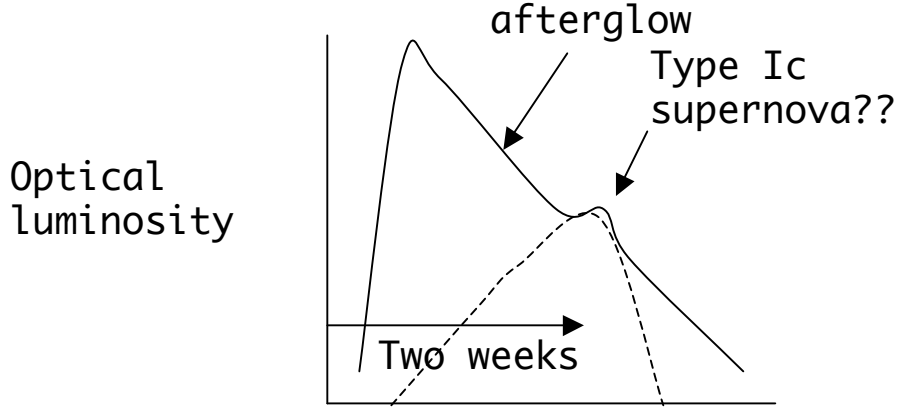
Find all gamma-ray bursts in regions of massive young stars

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 followed by 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

By now many associated supernovae have been found: all are Type Ic supernovae

But all Type Ic supernovae are not gamma-ray bursts

The current picture: Gamma-ray bursts result from the collapse of a massive star from which the hydrogen and most of the helium have been stripped, 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

One Minute Exam

It is important to understand that gamma-ray bursts emit their energy in tightly collimated beams because otherwise

A) Estimates of the distance will be wrong

B) Estimates of the mass of the black hole formed will be wrong

C) Estimates of the energy emitted will be wrong

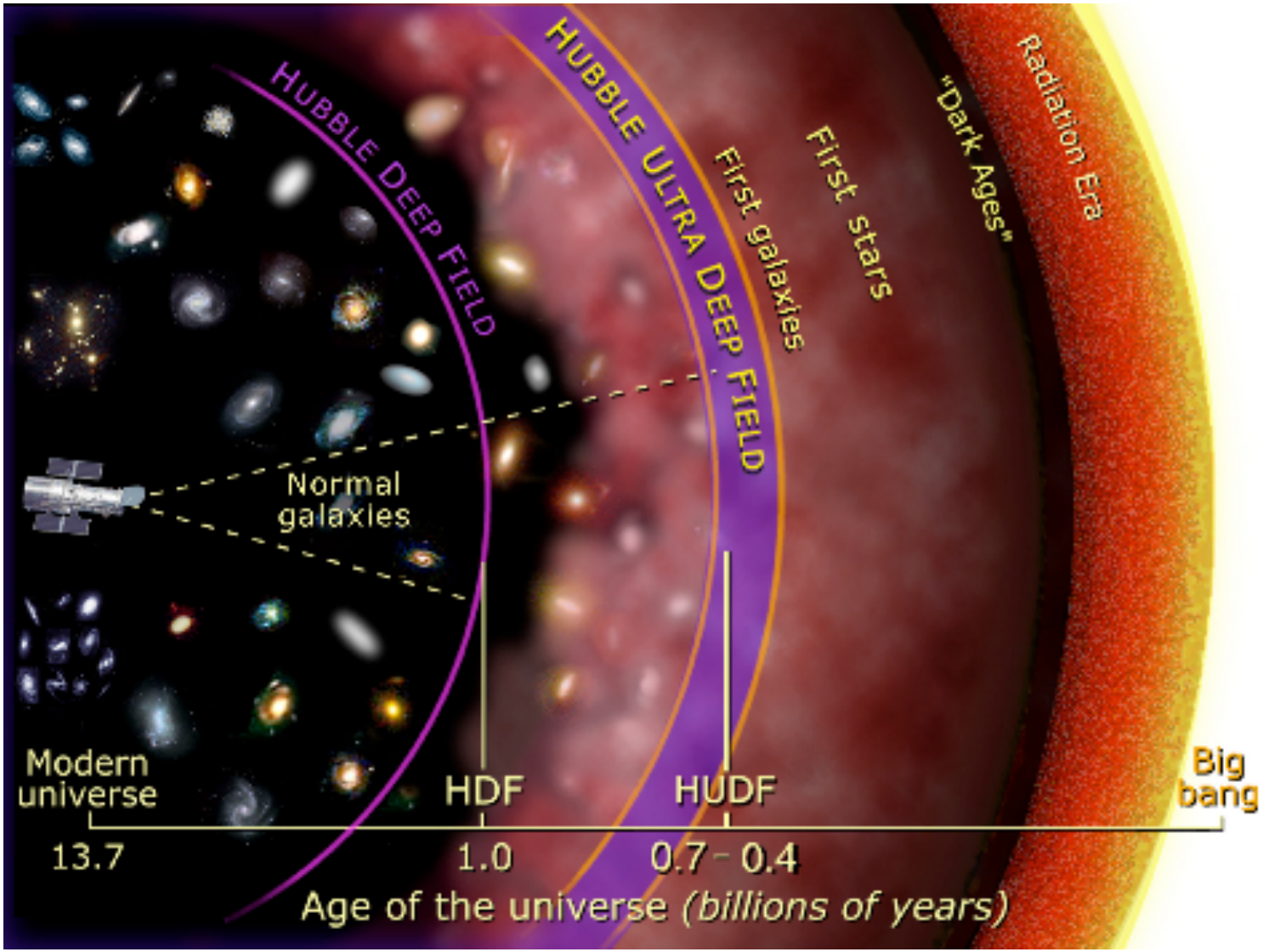
D) Estimates of the type of supernova in which they explode will be wrong.

Gamma-ray bursts are intensely bright lights

Can be seen at great distance

Probe cosmology, the early Universe

Dark Ages, after the Universe cooled off a million years after the Big Bang, before stars and Galaxies first formed half a billion years later



Gamma-ray bursts could be the first objects seen at the end of the Dark Ages as the first stars are born and die, over 13 billion years ago.

Chapter 12 Supernovae and the Universe

Expanding Universe - we observe all distant galaxies (so far away we cannot sense their individual gravity) moving away from us with speed proportional to distance: as if we were in the center of an explosion.

Our Universe is not a bomb in pre-existing empty 3-D space!

Lesson from Einstein - ***space itself can expand carrying the*** (almost motionless***) galaxies***

All distant galaxies move away from all other distant galaxies.
No galaxy, certainly not us, is in the center.

The result: speed proportional to distance

Our Expanding Universe

Expanding ***surface*** of a balloon as an example

2D embedding diagram of 3D expanding Universe

No 2D center, no 2D edge, no 2D outside

There is a 3D center, a 3D edge, a 3D outside, in 3D hyperspace

Our Expanding Universe

All 3D space expands - carrying essentially motionless matter (galaxies)

No 3D center, no 3D edge, no 3D outside

As 3D astronomers, we don't have to ask what the Universe is expanding into, but if anything it is a 4 (or more) D hyperspace, just as a 2D balloon expands into 3D hyperspace.

Infinite flat rubber sheet could expand without expanding into any hyperspace (2D embedding diagram example).