11/15/04

Wheeler away Wed, Fri.

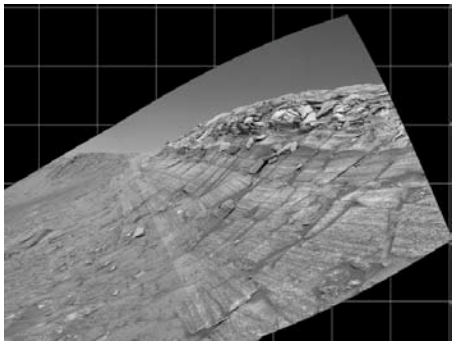
Film on Wednesday: Gamma-Ray Bursts

4th exam Friday. Review sheet, Chapters 10, 11.

Review session THURSDAY Nov 18, 5 - 6 PM RLM 15.216B

News? European space ship Smart 1, ion drive, goes into lunar orbit today. Leonid meteorite shower on Wednesday (fair game for sky watch extra credit). Swift gamma-ray burst satellite launched Wednesday?

Pic of the day: cliff on Mars



Final - Saturday, December 11, 7:00 PM

Extra credit sky-watch reports are due by 5 PM on Monday, December 6.

Gamma-ray bursts are in distant galaxies - all at huge, cosmological distances

They must be very bright to shine that far

If gamma-ray bursts shine equally in all directions, the energy released in gamma rays in the most powerful bursts would be comparable to 3000 × supernova kinetic energy or 30 × total core collapse neutrinos.

Comparable to total annihilation of entire star!

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 speed of light

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

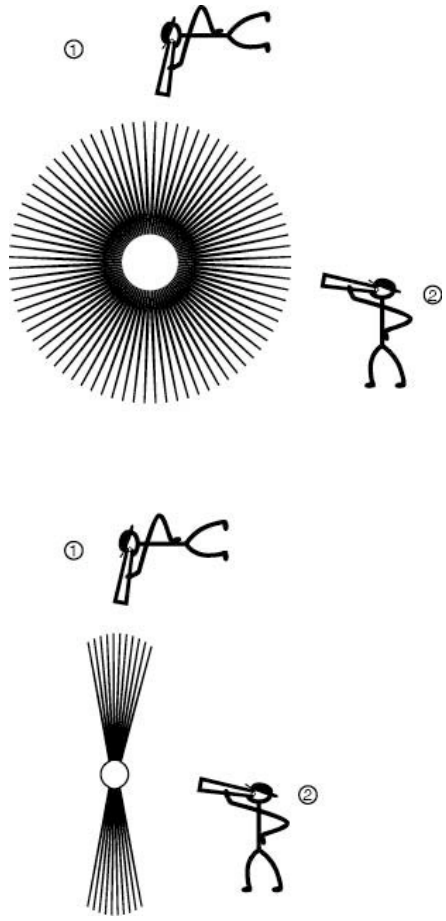
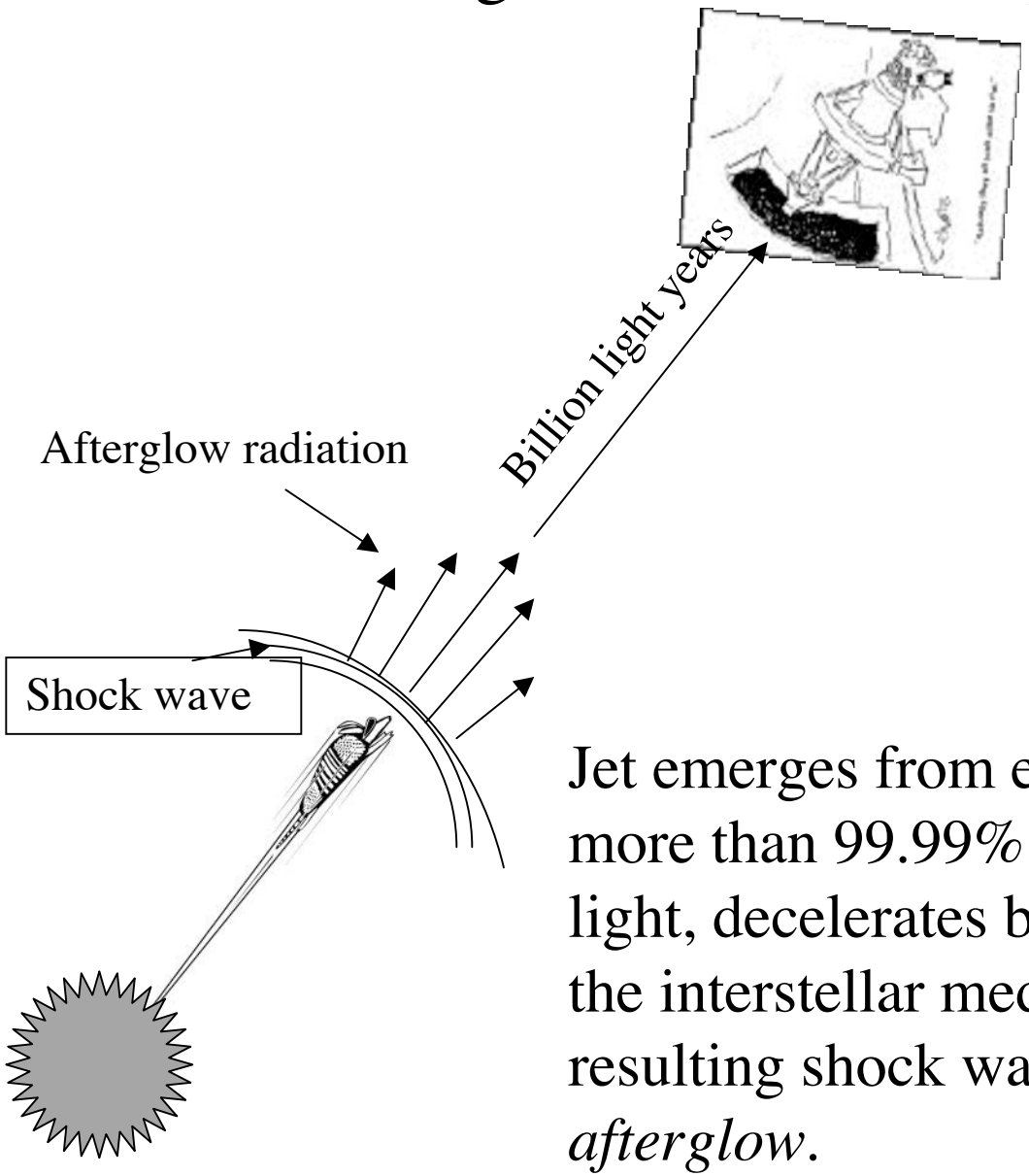


Figure 11.4

They explode ~100 times more often than observed (about 2 per day) because most have the jet aimed away from us.

Burst and Afterglow - Einstein's Special Relativity in Action



Deceleration takes months, but because shock chases its own light, we perceive a rapid speed-up of the process playing out in days through our telescopes.

Jet emerges from exploding star at more than 99.99% the speed of light, decelerates by colliding with the interstellar medium. The resulting shock wave radiates the *afterglow*.

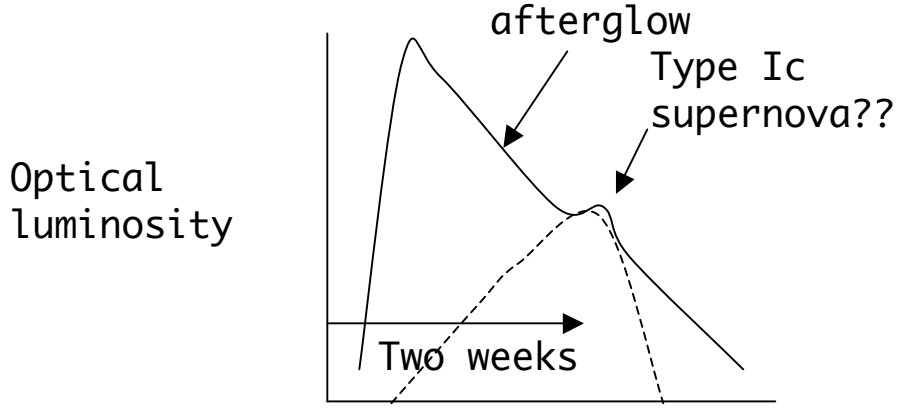
Find all gamma-ray bursts in regions of massive young stars

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 2-3 bursts associated with supernovae.



GRB 021004 (2002, Oct. 04)

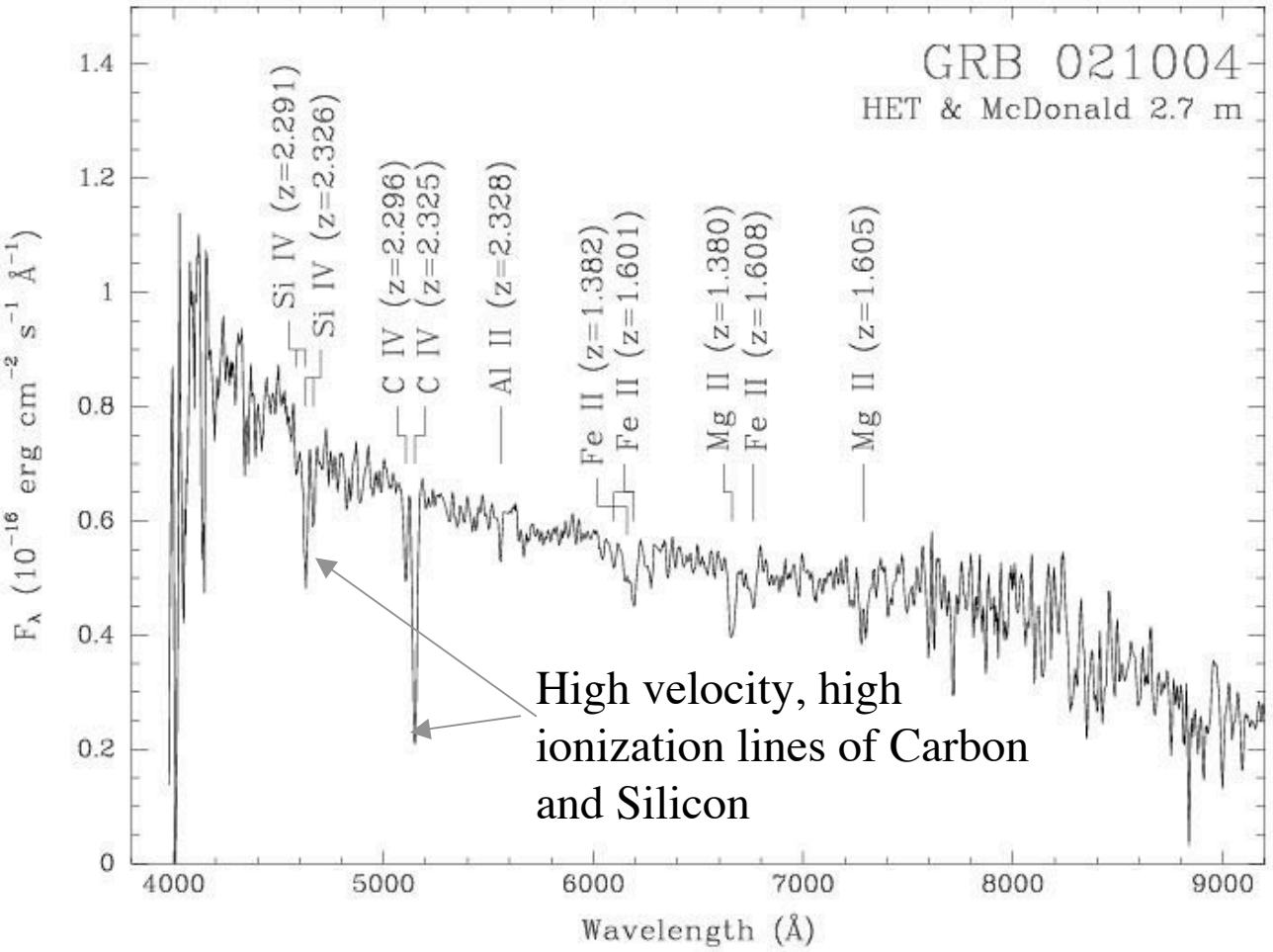
1st Gamma-ray burst observed at McDonald Observatory

Hobby-Eberly Telescope (HET)

Absorption lines $\Rightarrow$ maybe direct evidence of supernova material moving at 1/10 - 1/100 speed of light

Significant circumstantial evidence for connection to massive stars…

THEN PROOF!



Schaefer et al. (2003) HET GRB Collaboration:

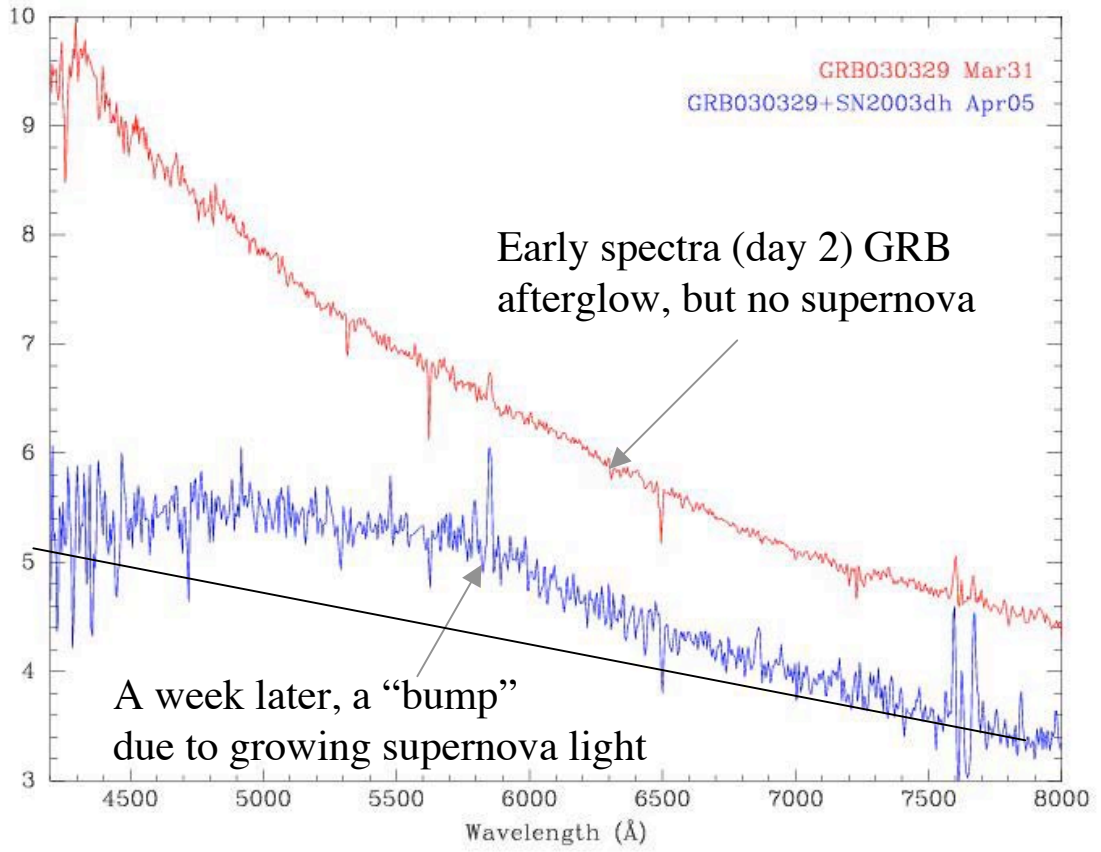
High ionization, high excitation features of Carbon and Silicon are consistent with "stellar wind" expelled by a massive star, accelerated by the gamma-ray burst.

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

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 and 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.

Open Issues

Are gamma-ray bursts the birth of black holes?

How are the relativistic jets produced?

Is every burst associated with a supernova?

What kind of supernova?

What do gamma-ray bursts do when they hit something?

When do the first gamma-ray bursts light up in the Universe?

Can gamma-ray bursts tell us about the end of the Dark Ages?

What's Next?

The Swift satellite may be launched this week!
Wednesday, November 17, if conditions permit

Swift should discover a gamma-ray burst
every few days!

Detailed follow up will tax all the
world's great observatories.

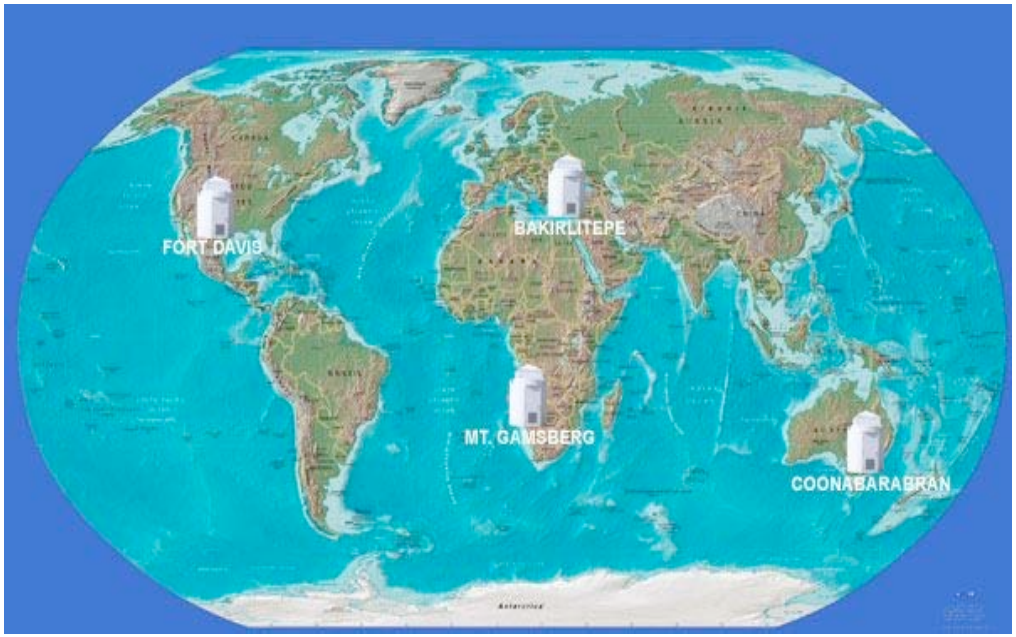
With on-going improvements, the rapid-
response, queue-scheduled HET should be
well-situated to compete.

Swift can do optical observations,
but needs a minute to swivel - too long!

We have joined the U. of Michigan RObotic Transient Source Experiment (ROTSE) collaboration.

Four ROTSE telescopes around the world. Texas, Australia, Namibia andTurkey.

18 inch mirrors, 1.85 degree squared field of view.



ROTSE can point and shoot within 6 secs of electronic satellite notification,take automatic snapshots every 1, 5, 20, 60 secs.

ROTSE will:
Discover the optical transient ***during*** the burst;
Follow the light in unprecedented detail;
Relay the discovery and coordinates to the HET for spectroscopic follow up.

Things to look for in Wednesday's movie

Nova Program ***Death Star*** 2002

Interplay of observations and theory to solve the 30 year old mystery

Role of Vela satellites (Vela = watchman en español)

The importance of the positions of the bursts in the sky, random, not in the disk of the Milky Way.

Does not quite make clear that bursts are focused, collimated, so bright, but not overwhelmingly energetic. Most "powerful" means brightest (if you are looking down the jet), not necessarily the most energetic explosions since the Big Bang.

There is still a small probability that the bursts could be some form of neutron star birth.

Bursts are a threat to life, but rare…