

11/19/07

Informal discussion, Wednesday, November 21

Astronomy in the News -

Pic of the day - Aurora - particles from solar wind channelled to the north magnetic pole of the Earth



⇒ Found *Gamma Ray 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.*

If gamma-ray bursts shine equally in all directions, the energy released in gamma rays would be  $3000 \times$  SN or  $30 \times$  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  $\sim$  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

They explode  $\sim$ 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.

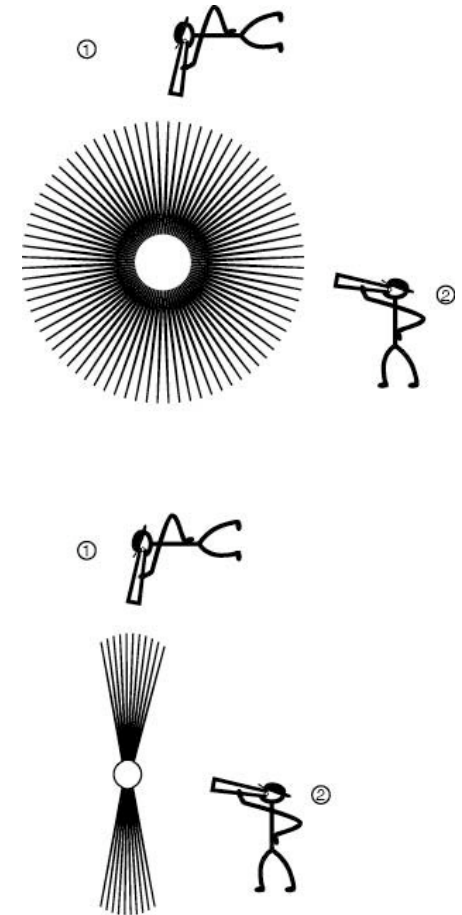


Figure 11.4

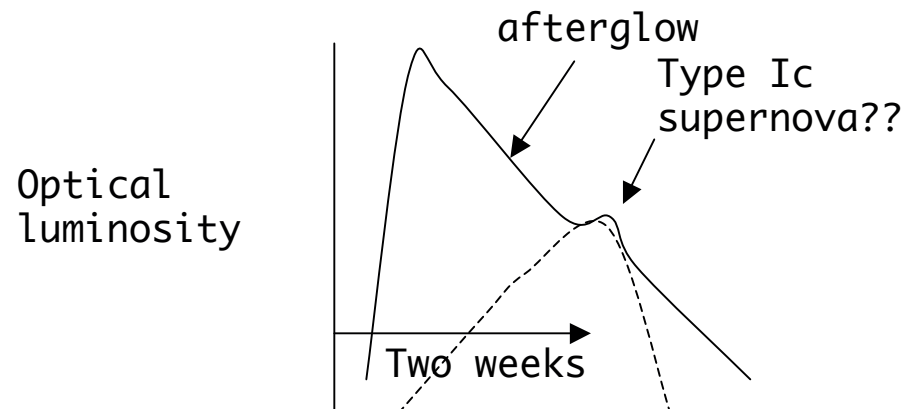
## *Find all gamma-ray bursts in regions of massive young stars*

### *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.

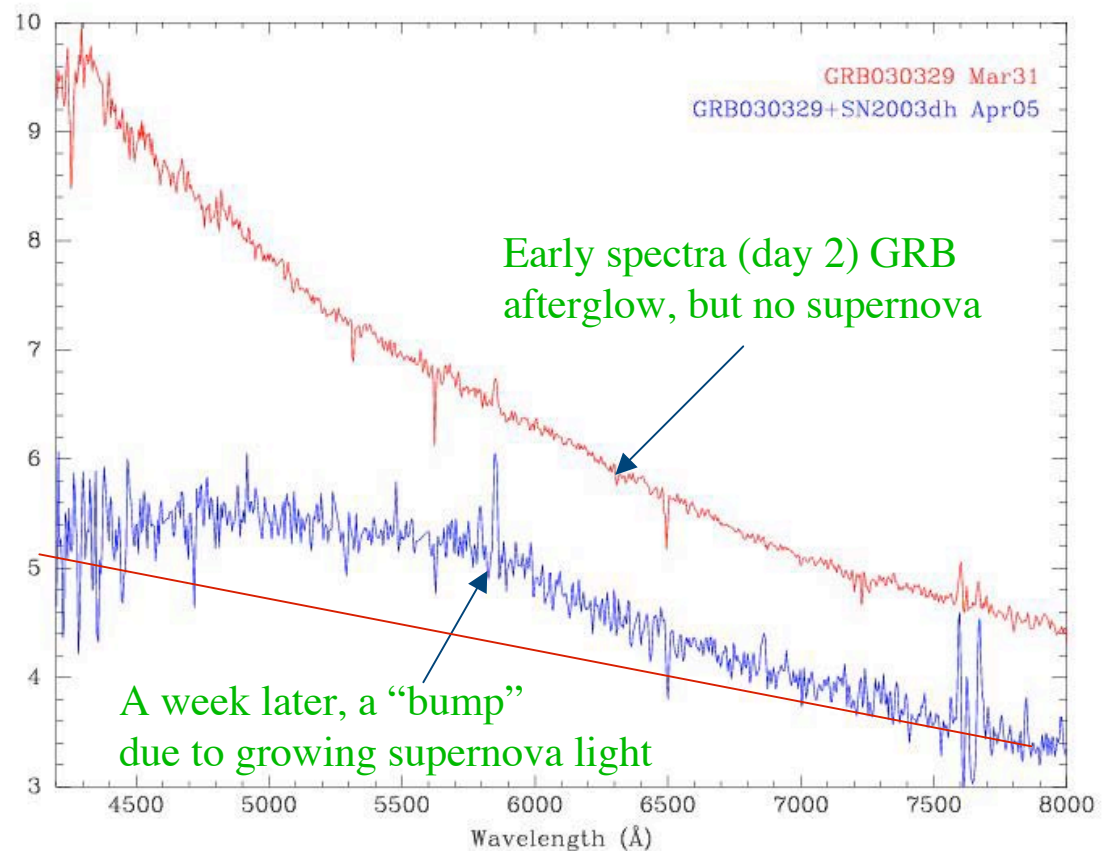


The raging issue: are gamma-ray bursts produced in some form of core collapse supernova? Circumstantial evidence...

## 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





## One Minute Exam

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

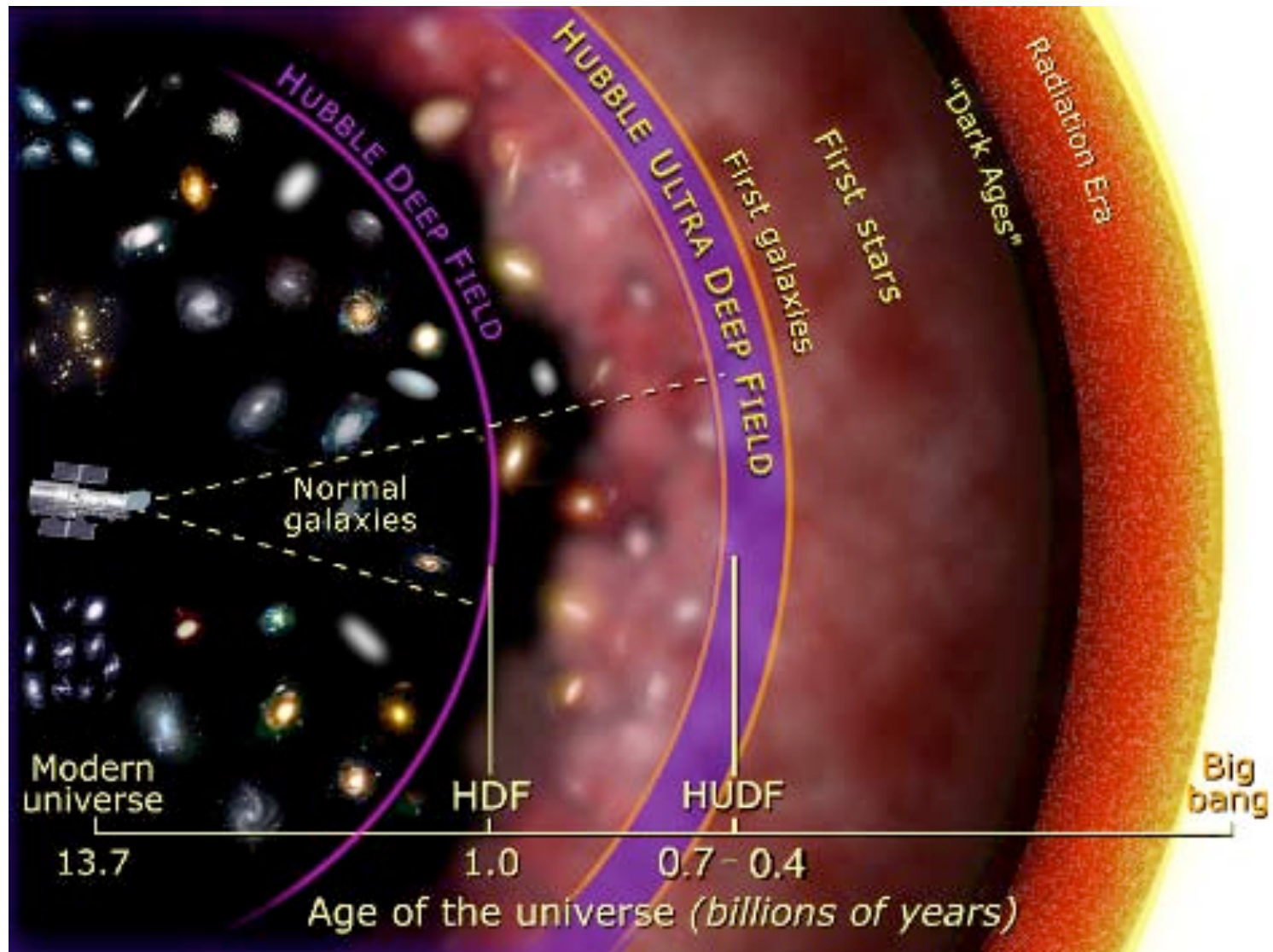
- A) Estimates of the distance will be wrong
- B) Estimates of the mass of the black hole formed will be wrong
- C) Estimates of the energy emitted will be wrong
- D) Estimates of the type of supernova in which they explode will be wrong.

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.