

Wednesday, November 9, 2011

Exam 4, Friday. Review sheet posted. Review session, Tomorrow, 5 – 6 PM, RLM 4.102.

Reading: Chapter 9, Sections 9.5.1, 9.5.2, 9.6.1, 9.6.2. 9.7, 9.8; Chapter 10, Sections 10.1-10.6, 10.9; Chapter 11, all except Section 11.6

Astronomy in the news? Asteroid missed. Russian sample return mission to Phobos successfully launched yesterday.

The Fabric of the Cosmos, second installment, The Illusion of Time, Wednesday, November 9, PBS (KLRU) 8 PM (re-runs <http://www.klr.org/schedule/viewProgram.php?id=246736>). Subsequent installments, next two Wednesdays, Nov 16, 23.

Pic of the day: **Asteroid 2005 YU55 Passes the Earth**



## Goal:

To understand the nature of cosmic gamma-ray bursts, how they may represent the birth of black holes or magnetars, and how they are connected with Type Ic supernovae.

Goal:

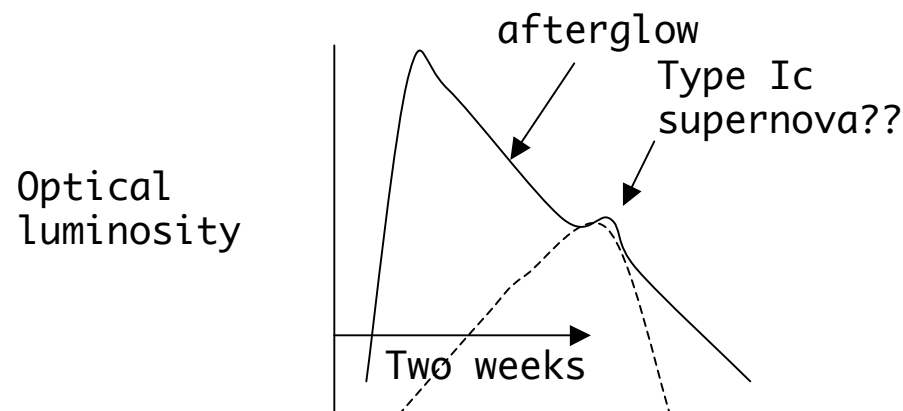
To understand how gamma-ray bursts are connected to supernovae.

***Find all gamma-ray bursts in regions of massive young stars*** (spiral arms of spiral galaxies, irregular star-forming galaxies like the LMC)  
***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. Alternative suggestion - might be a highly magnetized neutron star or *magnetar* (Chapter 8)

Early circumstantial evidence for several bursts associated with supernovae.



Are gamma-ray bursts produced in some form of core-collapse supernova?

Circumstantial evidence was 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 (but maybe a magnetar), 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.

Have not yet proven that black holes are involved. Tough problem!

# 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

 Estimates of the distance will be wrong

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

 Estimates of the energy emitted will be wrong

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



## Goal:

To understand what the “Dark Ages” of the Universe were, why they came to an end, and what gamma-ray bursts have to do with that.

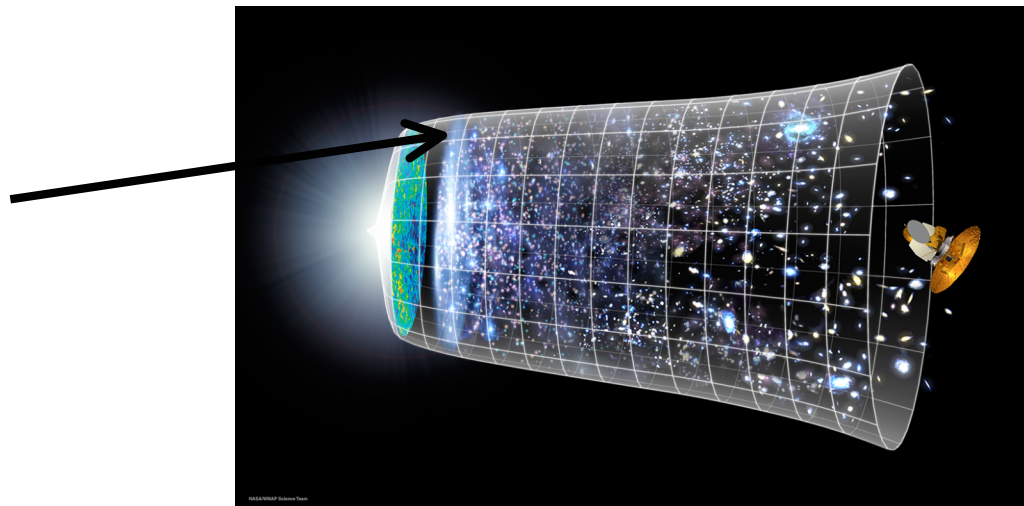
Gamma-ray bursts are intensely bright lights

Can be seen at great distance

Probe cosmology, the early Universe

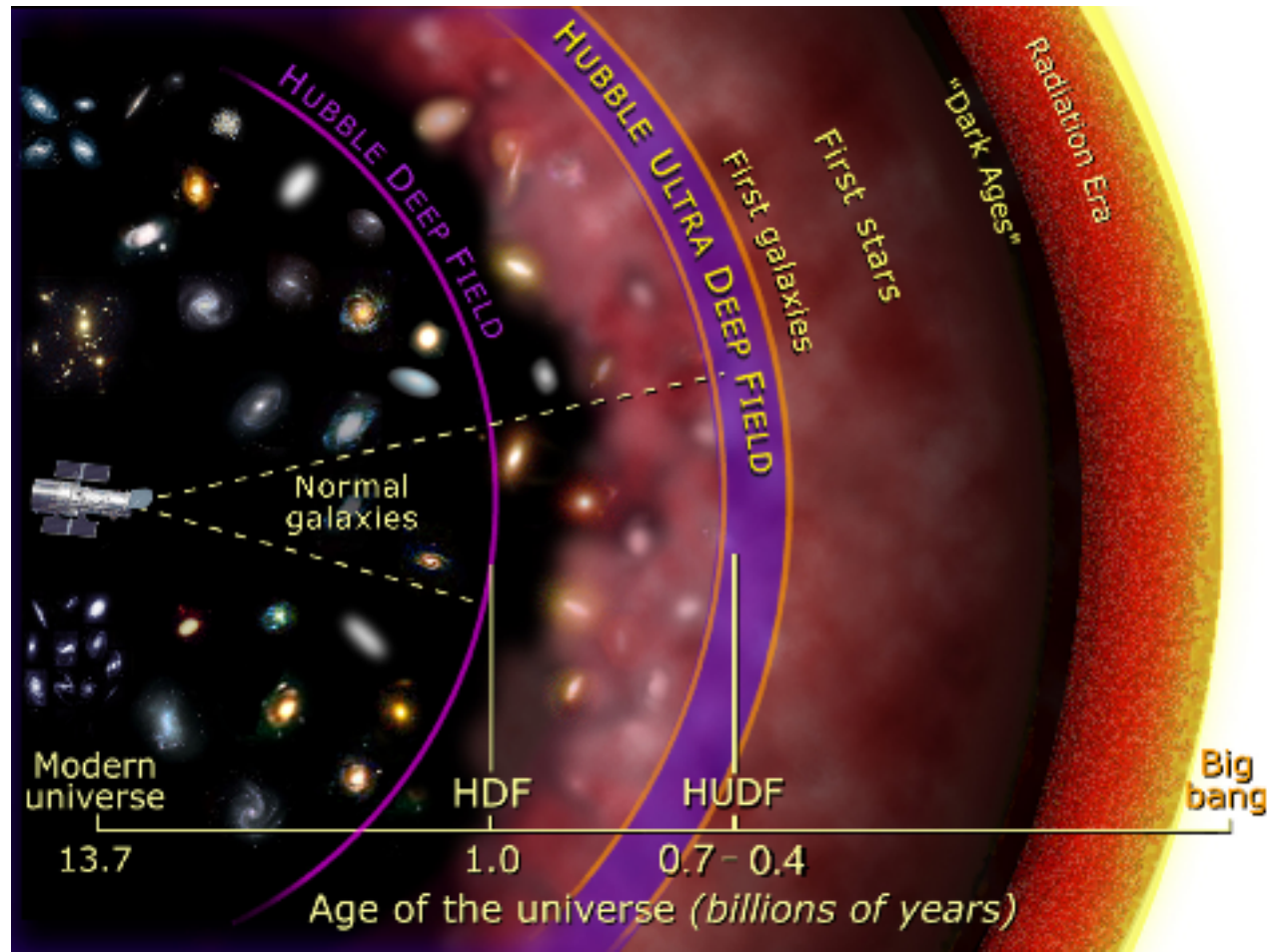
*Dark Ages*, after the Universe cooled off a million years after the Big Bang, before stars and Galaxies first formed half a billion years later

Dark Ages



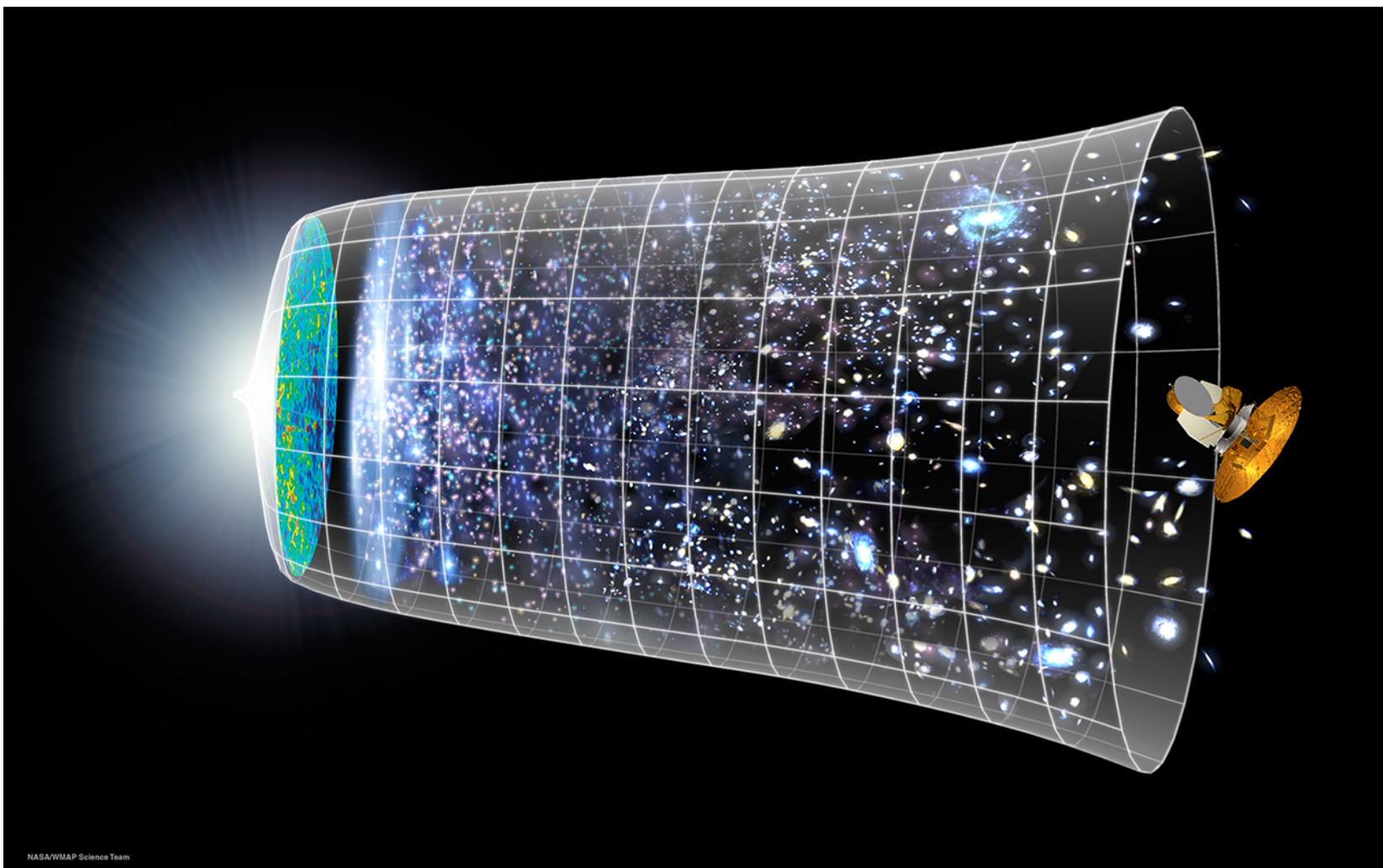
**Point toward the Big Bang.**

The past is all around us, in every direction, out in space, back in time.



Gamma-ray bursts could be among the first objects seen at the end of the Dark Ages as the first stars are born and die, over 13 billion years ago. GRB 090423 is the first example.

# From the Big Bang to Now



END OF  
MATERIAL FOR  
EXAM 4

Goal:

To understand the origin, shape, and fate of the whole Universe and how Type Ia supernovae have helped to revolutionize that understanding.

# 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*