Monday, April 24, 2017

Fifth exam and sky watch, FRIDAY, May 5.

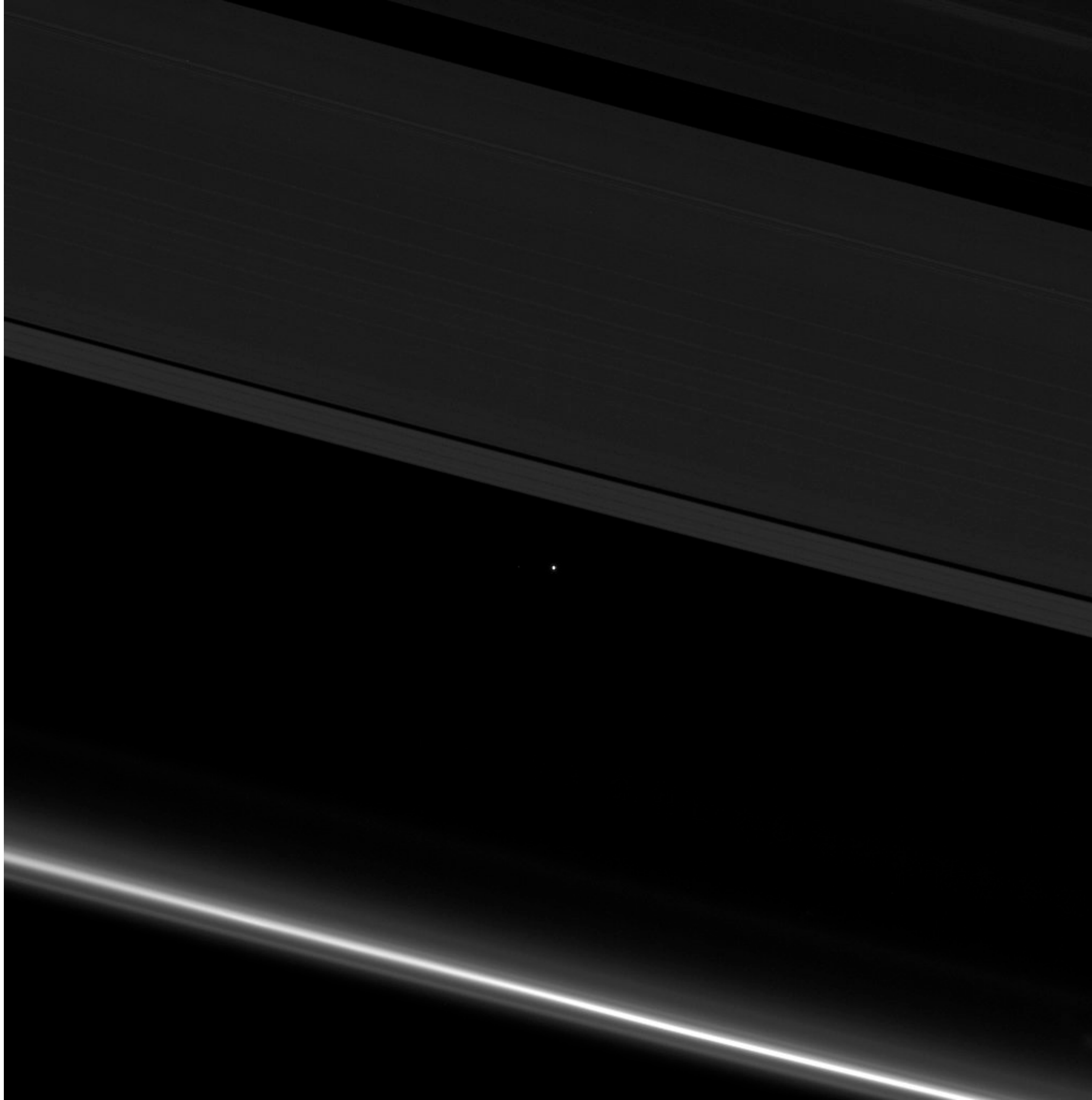
Reading for Exam 5: Chapter 9 – Sections 9.6.1, 9.6.2, 9.7; Chapter 10 - Sections 10.1-10.4, 10.9; Chapter 11 - all except Section 11.6 (abbreviated, focus on lectures); Chapter 12 - all; SKIP Chapter 13; **Chapter 14 – very abbreviated version.**

Electronic Course Survey is now available. Please respond, your feedback is very valuable.

Astronomy in the news?

Launched in 1997, arrived at Saturn in 2004, Cassini spacecraft will be plunged through the rings and into Saturn this Saturday to avoid possible contamination of any life forms in Saturn's moons (Enceladus). Photo next slide.

Earth from Cassini



March for Science,
4/22/17

Goal:

To understand how we have discovered supermassive black holes and how they affect galaxy formation and evolution.

Centaurus A (for Sky Watch)

One Minute Exam

The best evidence for the existence of black holes is:

➡ the orbits of stars around supermassive black holes

⬅ 10 solar mass X-ray sources with a 1/2 solar mass ordinary star companions

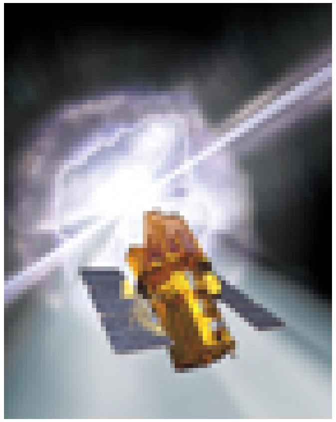
⬆ tidal disruption events

⬇ gravitational radiation from inspiralling black holes

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.

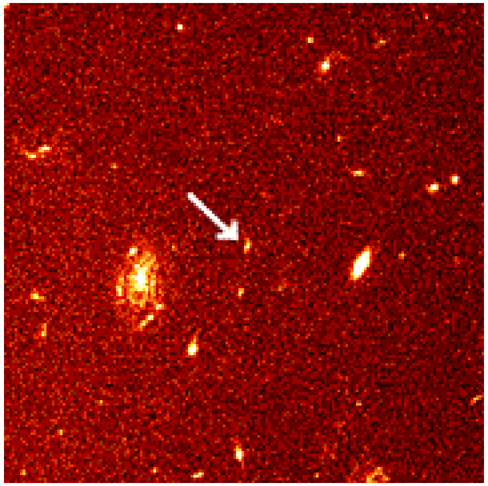
Gamma-Ray Bursts (Chapter 11)



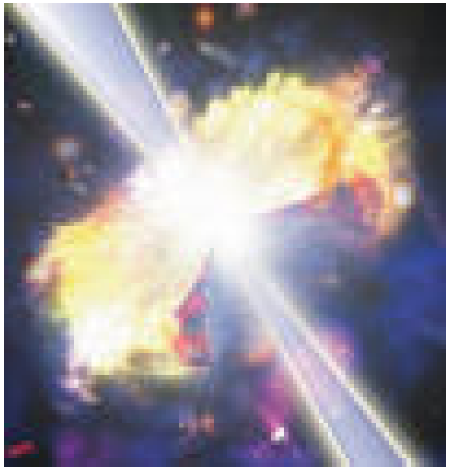
Swift satellite

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 or magnetar?

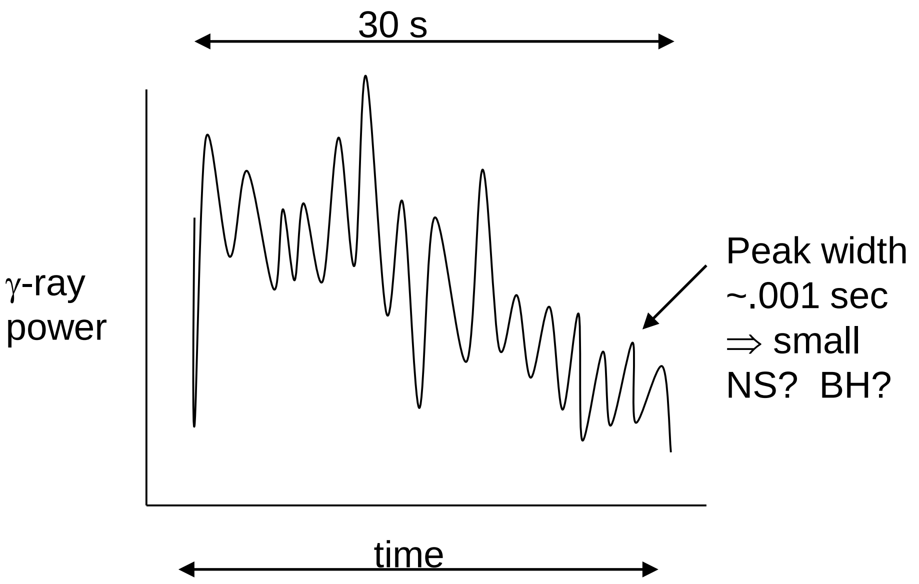


Gamma-Ray Bursts unite ***stars*** and ***cosmology***

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.

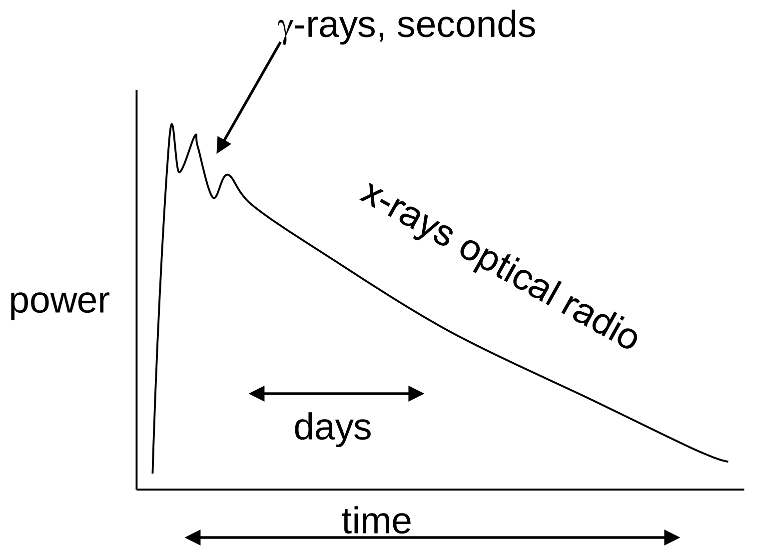


Did not know the distance: guesses ranged from within the Solar system to cosmologically distant

Goal:

To understand what a gamma-ray burst “afterglow” is and why it is so important.

Revolution in 1997: 1st detection of "afterglow" - 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

If gamma-ray bursts shine equally in all directions, the energy released in gamma rays would be 1000-10,000 × SN or 10-100 × core collapse neutrinos.

Comparable to total annihilation of entire star into pure energy!

Goal:

To understand the energy in gamma-ray bursts and why it is important that the energy is “beamed.”

BUT

Light bulb versus laser pointer or flash light

Bursts do not radiate in all directions!

They are strongly focused into jets!

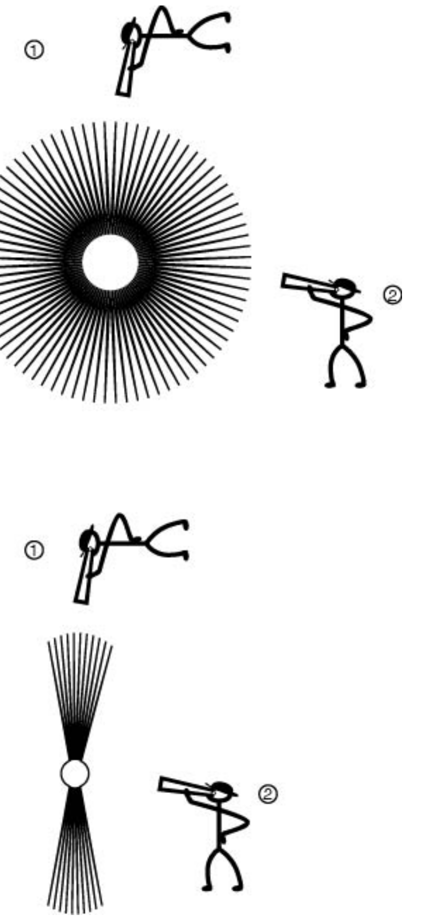


Figure 11.4

Bursts are focused into only about 1/100 of the total area of the 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

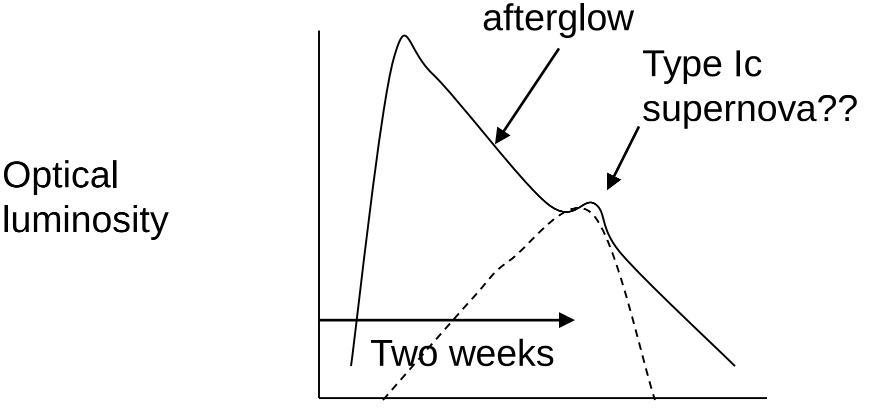
They explode ~100 times more often than observed (could observe about 2 per day if looked in all directions, all the time) because most have the jet aimed away from us.

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

Perhaps only in Type Ic, missing envelope, so that jet can escape from the star.

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 and superluminous supernovae have to do with that.

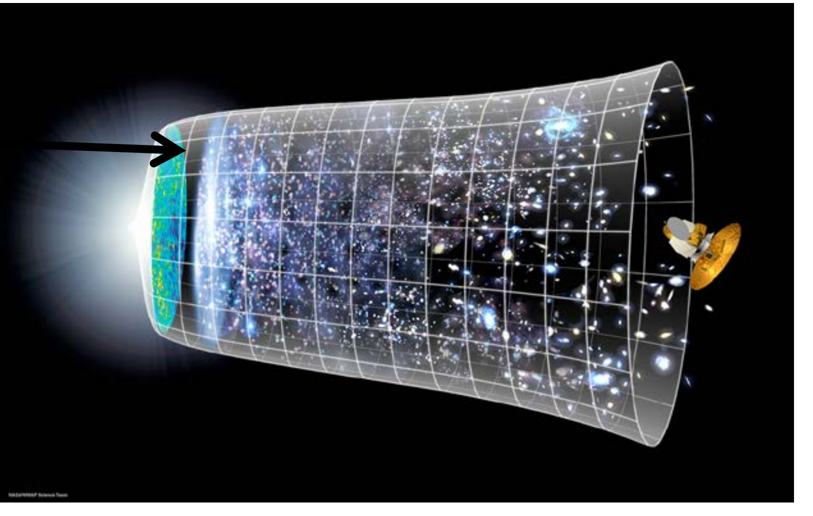
Gamma-ray bursts and superluminous supernovae are intensely bright lights

Can be seen at great distance

Probe cosmology, the early Universe

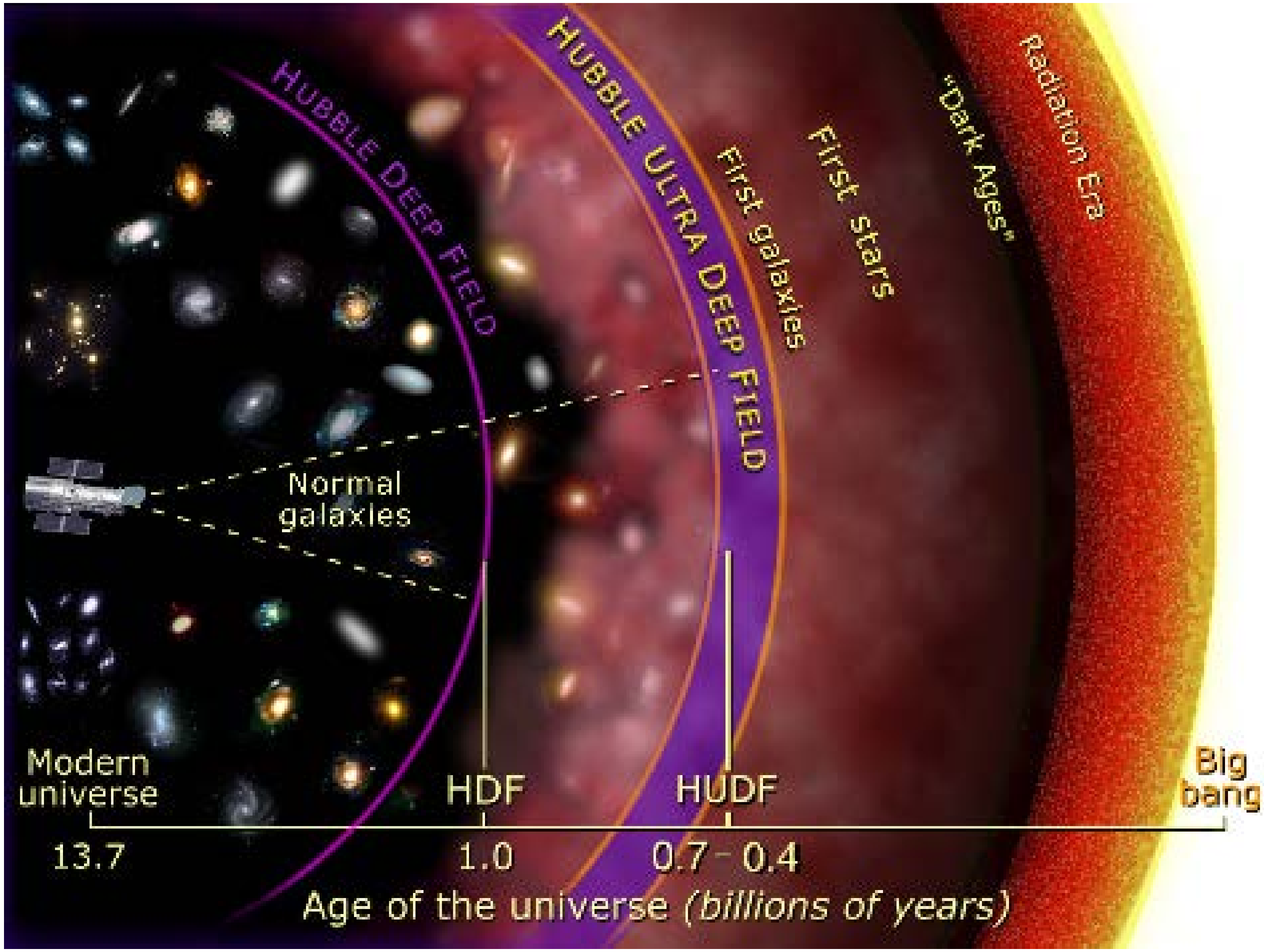
Dark Ages, after the Universe cooled off a million years after the Big Bang, before stars and Galaxies first formed half a billion years later

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 and superluminous supernovae 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.

From the Big Bang to Now