Wednesday, April 23, 2014

Fifth exam and sky watch, FRIDAY, May 2.

Reading for Exam 5: Chapter 9 – Sections 9.6.1, 9.6.2, 9.7, 9.8; 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 – all

Electronic class reviews now available. Please respond. We find the feedback very valuable.

Astronomy in the news:

Update on new “nearby” supernova SN 2014J in M82

I electronically edited the pdf of my colleagues manuscript yesterday and emailed it back to him in Munich.

SN 2014J revealed more evidence that the dust in supernova host galaxies is different than that in the Milky Way.

Why should long-lived Type Ia supernovae be related at all to the properties of their host galaxy, never mind the dust?

Supermassive Black Holes

Long suspected in quasars, active galactic nuclei: huge power from small volume, billion solar mass black hole could do it.

More recently, proof that many (even most! John Kormendy, UT) ordinary galaxies also have a supermassive black hole in their centers (dead quasar).

Again, do not yet see a "dark spot," but use Kepler's Laws, motion of many stars, gas ⇒ orbital period, separation

3.7 million $M_\odot$ black hole in our Galaxy [UCLA link - movie]

Center of Milky Way Galaxy in direction of constellation Sagittarius – (*find Sagittarius for sky watch*)

Up to billion $M_\odot$ black holes in quasars.

Jet from billion $M_\odot$ black hole in center of M87, large elliptical galaxy in the Virgo cluster (*find Virgo!*)

Surprising discovery:

It was long thought that supermassive black holes were somewhat incidental to galaxies.

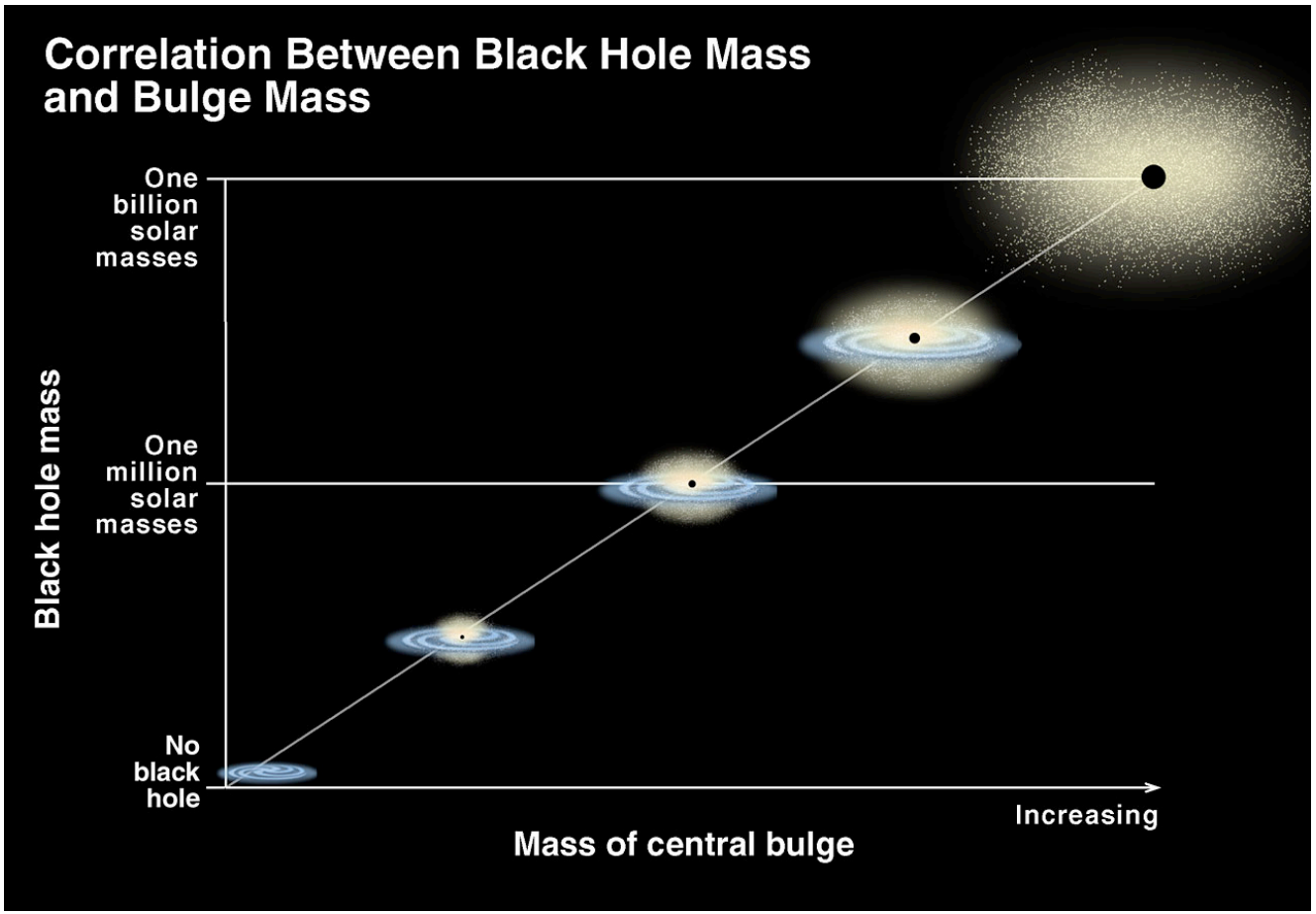
Formed of matter that somehow drained into the center of the galaxy, so galaxy could have large mass or small mass black hole depending on circumstances.

Recent work by John Kormandy and Karl Gebhardt (UT) and others has shown that even stars so far from the center that they cannot possibly feel the gravity of the black hole *now* are moving in such a way that ***the larger the mass black hole, the higher the speed of the stars!***

Andromeda
M31

Correlation Between Black Hole Mass and Galaxy Bulge Mass

Mass of Black Hole



Mass of Central Bulge of Galaxy

The implication is that the mass of the galaxy (at least the inner portions, the Bulge) is always close to 800 times the mass of the black hole.

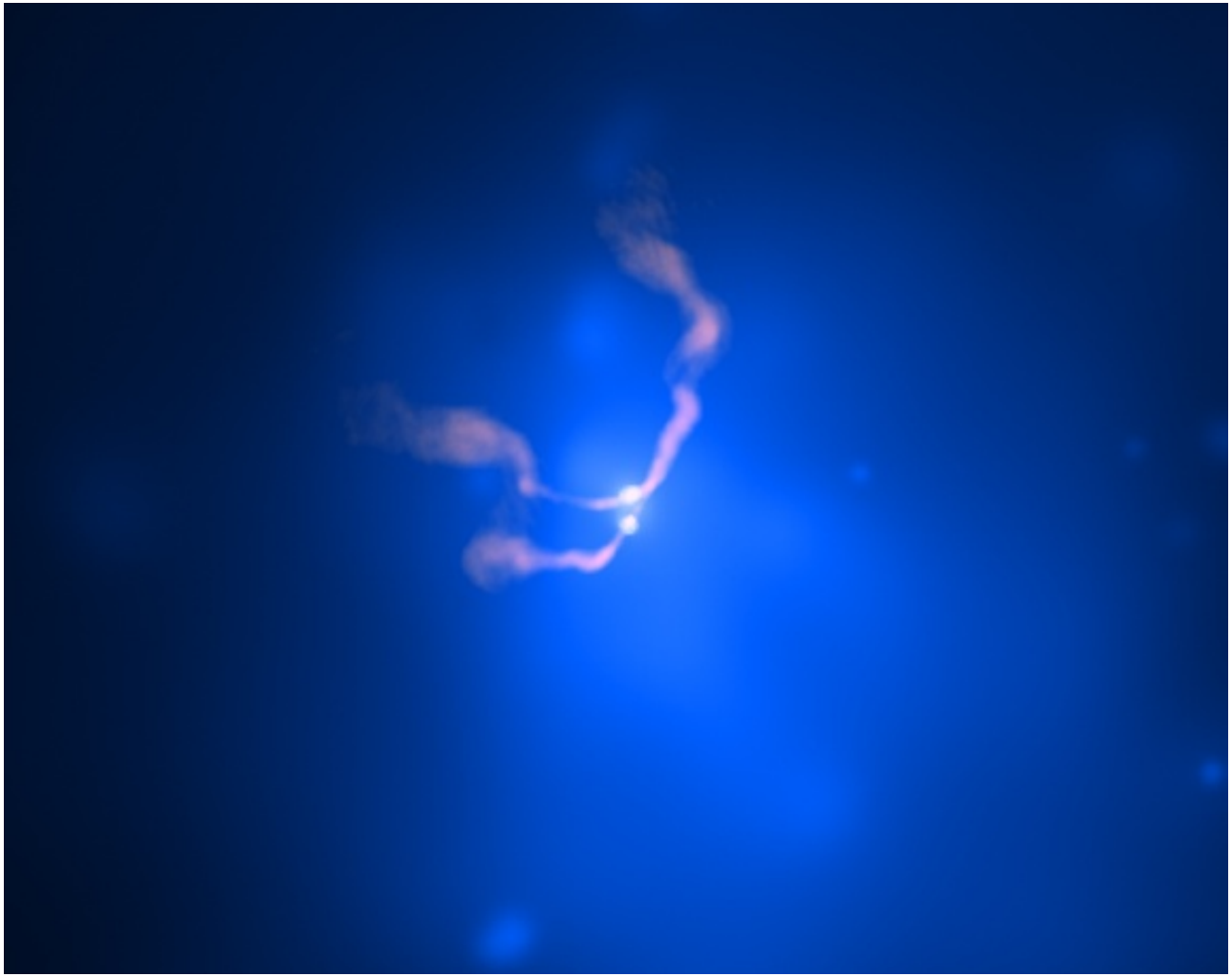
This means that ***the formation of the black hole is somehow intimately connected with the formation and structure of the whole galaxy.***

Galaxies "know" how big a black hole to make.

Mechanism uncertain: Does the galaxy control the black hole or the black hole somehow control the galaxy?

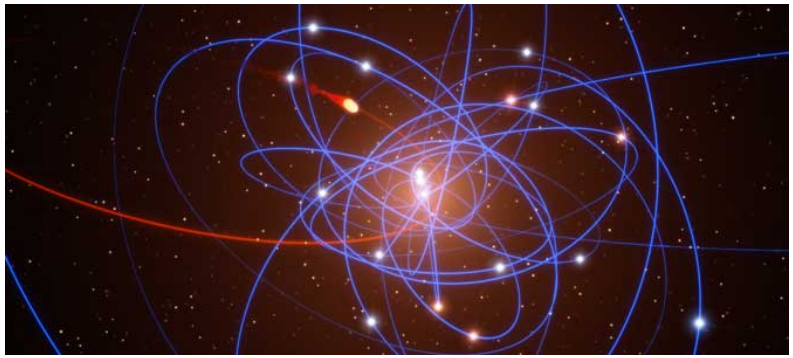
Most popular current idea: energy from accretion of matter into disk around black hole feeds back to the surrounding galaxy, blowing excess galaxy gas away when galaxies are young and growing.

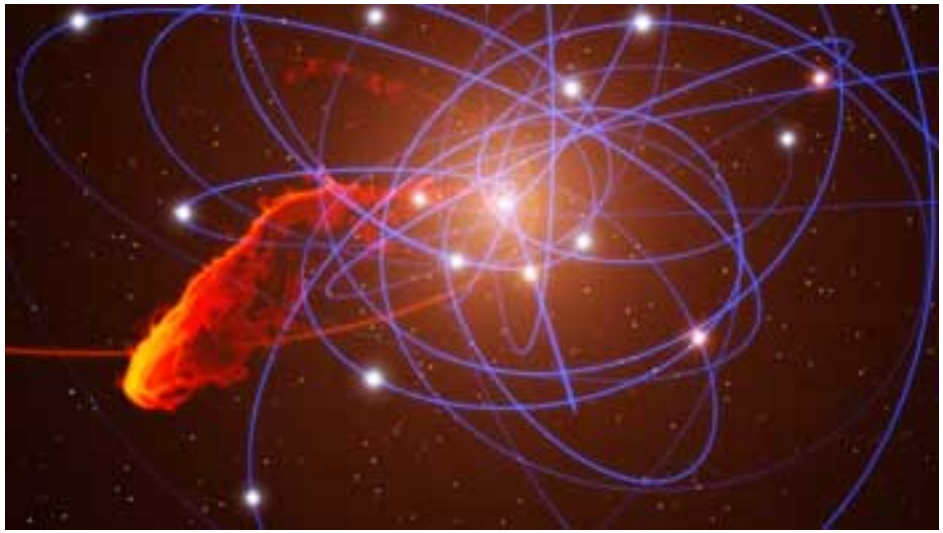
Colliding black holes in 3C75, feed energy back into the stars and gas of the colliding galaxies.



Late news- astronomers have discovered G2, a cloud of gas being pulled into the black hole in the center of the Milky Way. Was to hit in 2013. Latest report, April 4, 2014, still no X-rays.

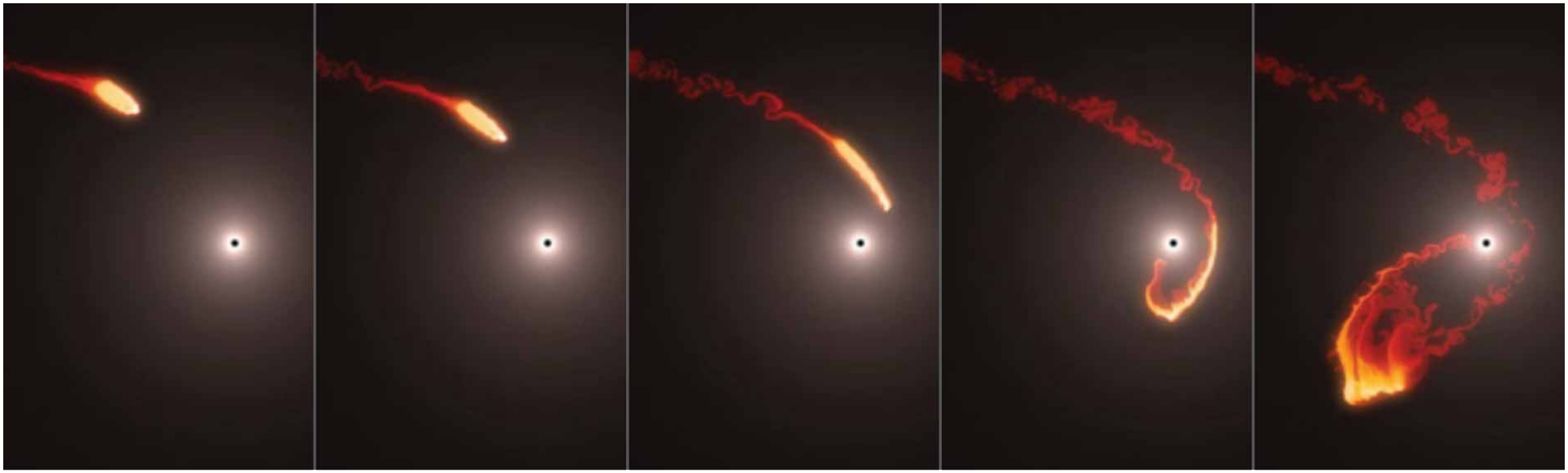
Cloud trajectory in red





Cloud after interaction, noodleized

Video at http://www.space.com/13933-monster-black-hole-gas-cloud-milky.html 4 minutes

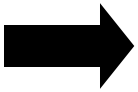


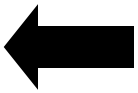
2011 2012 2013 2014 2016

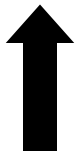
Predicted disruption of G2

One Minute Exam

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

 Look for X-rays

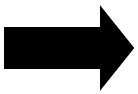
 Look for gamma-rays

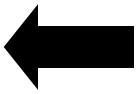
 Look for jets

 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?


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


The larger the mass of the galactic bulge, the smaller the mass of the black hole


The larger the mass of the galactic bulge, the larger the mass of the black hole


The larger the radius of the galactic bulge, the larger the mass of the black hole

Goal:

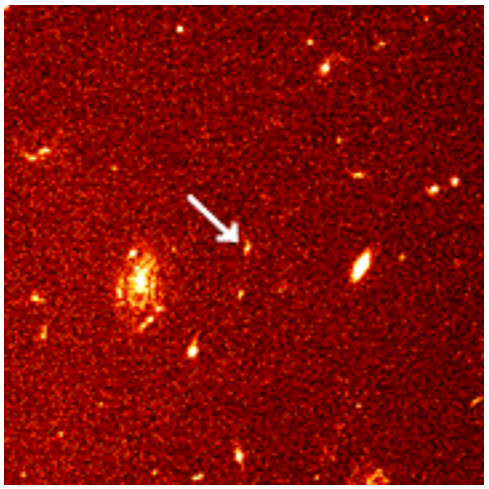
To understand the nature of cosmic gamma-ray bursts, how they may represent the birth of black holes or magnetars, and how they are connected with Type Ic supernovae.

Gamma-Ray Bursts (Chapter 11)

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

Swift satellite

Seen across the Universe.



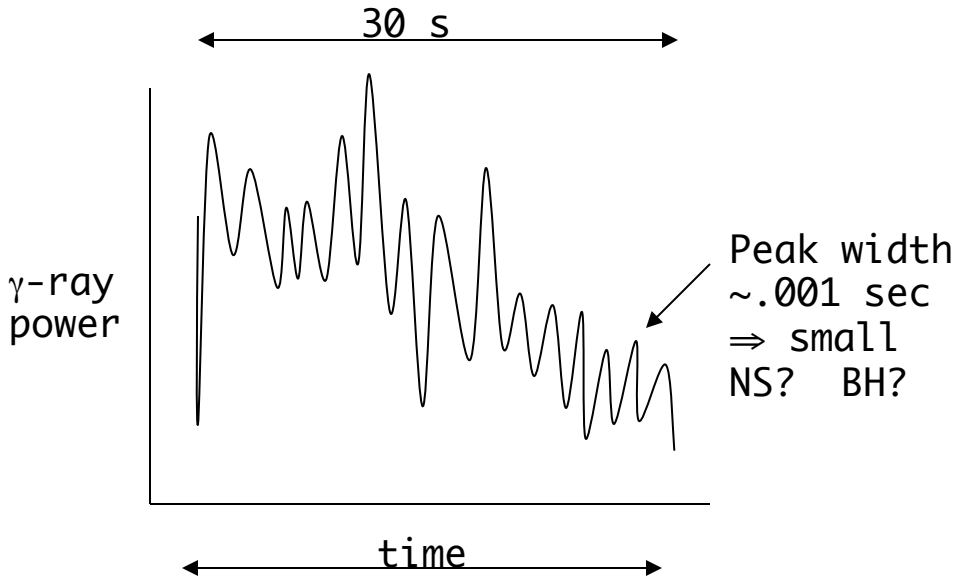
Energy is expelled in narrow jets.
Energy comparable to that of supernovae, but all in gamma-rays, with later ***afterglow*** in X-ray, radio and optical radiation.
Birth of a black hole or Magnetar?

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.

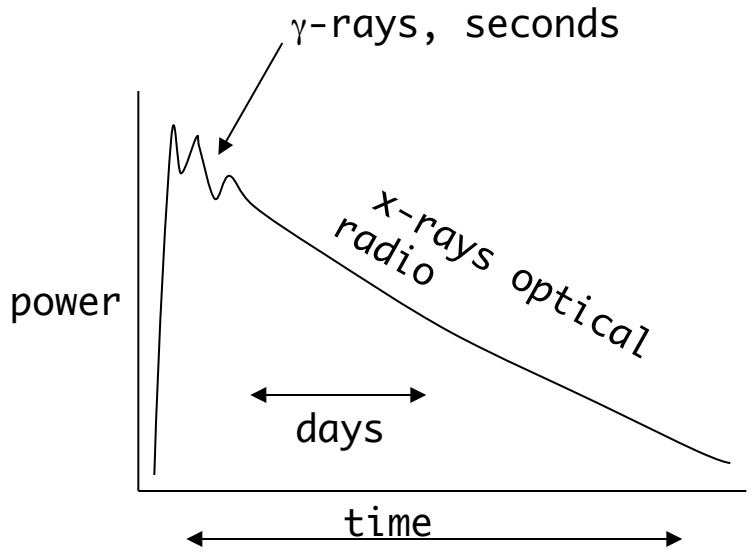


Did not know the distance: guesses ranged from within the Solar system to cosmologically distant

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:

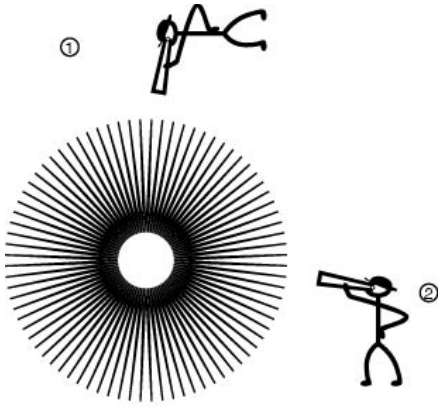
To understand the energy in gamma-ray bursts and why it is important that the energy is “beamed.”

BUT

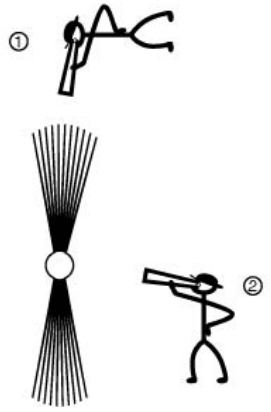
Light bulb versus laser pointer or flash light

Bursts do not radiate in all directions!

They are strongly focused into jets!



Bursts are focused into only about 1/100 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

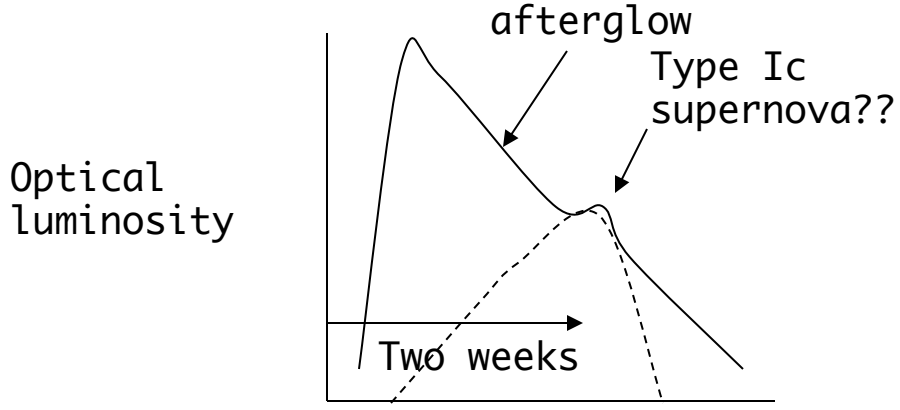
They explode ~100 times more often than observed (could observe about 2 per day if looked in all directions, all the time) because most have the jet aimed away from us.

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