Astronomy 150:
Killer Skies

This Class (Lecture 23):
Killer Gamma-Rays Bursts

Next Class:
Compact Objects

HW7 due on Sunday!

Night Obs/Computer labs due in class on Nov 9th.
HW 2 due on the 7th.
Exam 2 on the 30th!

Music: *Kelly Watch the Stars*– Air

Question

Next Friday is Exam 2. How many questions should be on the exam?

a) 25
b) 30
c) 35
d) 40
e) 45

Exam 2

- Exam 2 in this classroom on Oct 30th
- 35 Multiple choice questions
- Will cover material up to and including today.
- May bring 1 sheet of paper with notes
  - Both sides
  - Printed/handwritten/whatever.. I don't really care
- Major resources are lecture notes, in-class questions, and homeworks
- Try to understand major points more than anything.
- Will create and post a study guide

1st Week of Nov

- Class is cancelled for the first week of Nov (2nd, 4th, and 6th).
- Instead of iclicker, we will do credit through a Compass discussion topic.
- To get full credit for the three days, you will have to:
  - Create 1 new post (a weblink relevant to class from a news source) and make a comment, plus make 2 relevant posts on someone else's post or post comment.
  - Or, make 5 relevant posts on someone else's post or post comment.

1st Week of Nov

- Class is cancelled for the first week of Nov (2nd, 4th, and 6th).
- Must place posts in proper discussion topic region, or it will not be graded.
- You will have until Nov 8th to do this.

Outline

- Long time GRBs– hypernova
- Short time GRBs– merging neutron/neutron or neutron/black hole
- Effects on Earth

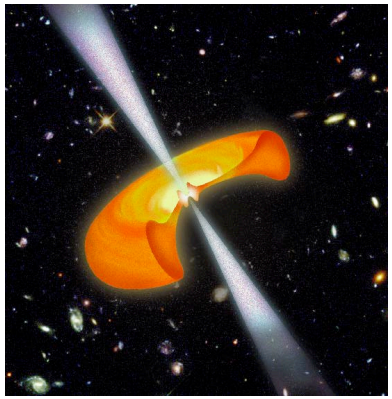
Hypernova or Collapsor

- The death of an exceptionally massive star, greater than ~50 solar masses!
- The core quickly collapses down to a black hole with accretion disk.
- Combination of magnetic field and temperature create a strong gamma-ray beam.

http://www.youtube.com/watch?v=npzgasXkHtk

The End

- Beams continue on to the edge of the Universe.
- Since the explosion is beamed, we only see a small fraction of them.
- So much rarer than normal core collapse supernova, or we'd see more.
- After the beam is gone, the supernova is still going on, which is where the optical afterglows come from.



http://www.youtube.com/watch?v=X6PLcM2dXmw&feature=fvw

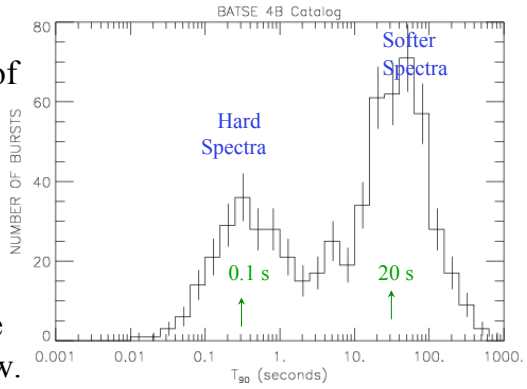
Question

Why are hypernova so bright?

a) They are supernova on steroids.
b) They are the biggest stars.
c) They are far away.
d) They are beamed.
e) They are isotropic.

More Than One Way

- Hypernovas or collapsors explain the long gamma-ray bursts, but what about the short ones?
- These are not seen in star forming galaxies.
- Seen in outskirts of galaxies or in old elliptical galaxies, which are no longer making stars.
- No supernova like emission afterglow.

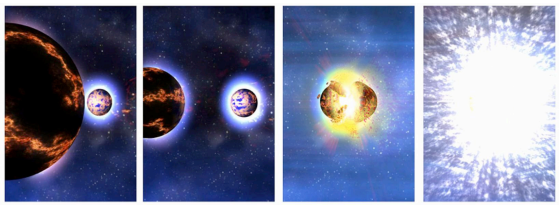


More Than One Way

- Although, astronomers are not actually sure, the most popular idea is an neutron star-neutron star merger or neutron star-black hole merger.
- Multiple systems are common, so we need a binary system with two 10-30 solar mass stars,
- The most massive star goes supernova, then the next.
- We're left with two compact objects in orbit.

Double Neutrons

- Over billions of years, the orbits decrease.
- The neutron stars get closer and closer together
- They quickly rip apart and merge with enough mass to turn into a blackhole.
- If enough material left over, it can form a black hole with accretion disk too.



- Fast and no supernova light expected.

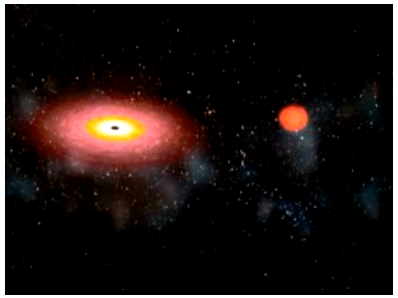
Double Neutrons

- Very similar to the hypernova
- Accretion disk, magnetic fields, powerful gravity creates twin beams of death.
- Expected to be shorter and higher-energy gamma-rays, and that is seen.

- Although hard to detect and rare, we do know of existing examples of close pairs in our Galaxy.

Neutron/Black Hole Merger

- Or, similarly, a neutron star mergers with a black hole.
- Again, accretion disk with possibility of GRB.
- We don't know of any, but rare and very hard to detect.



- Good news is that the total energy in all of these objects is smaller as they are so short in time.

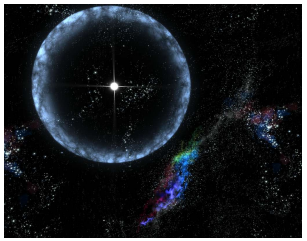
Question

Why does colliding/merging two 2 solar mass neutron stars create a black hole?

a) The total mass is greater than what can be supported by neutron degeneracy.
b) It doesn't.
c) The temperature at impact is so hot that only a black hole can be created.

Magnetars

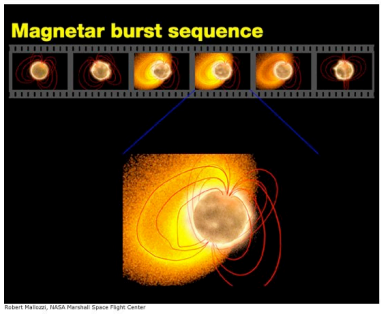
- Magnetars (high magnetic field neutron stars) also can produce GRB-like bursts, called magnetar flares.
- Stellar quakes from the twisting magnetic fields similar to solar flares.
- In Dec 2004, one was so bright (equal to 100,000 yrs of Sun output) that it blinded all gamma-ray satellites.



- It impacted the Earth's atmosphere, puffing up the Earth's ionosphere.

Magnetars

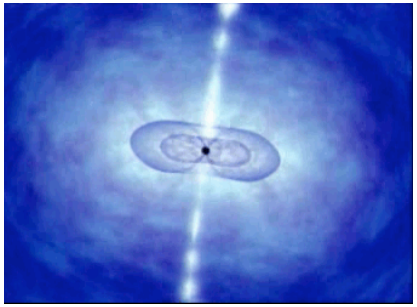
- The Dec 2004 magnetar was 50,000 light years away!
- If it was within 10 light years, it would have destroyed our ozone layer.
- No known magnetars within 13,000 light years.



http://www.youtube.com/watch?v=L73hXWxdKM8
6:00-8:30

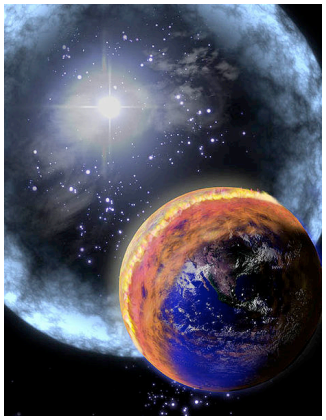
GRB Damage

- GRBs are similar to supernova, BUT they can be dangerous from further away, much further away.
- Let's play with a GRB beamed at the Earth from only 100 light years away.
- The beam will encompass the entire Solar System, but it will only last about 10 seconds.
- On the Earth, only one hemisphere will be in danger a first.



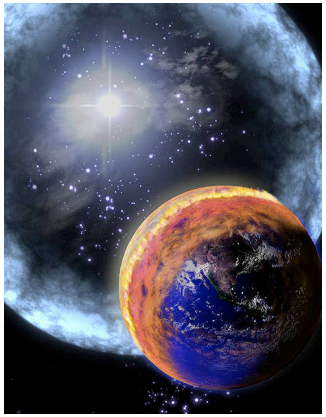
GRB Damage

- The energy dumped on the Earth's surface is staggering.
- It's like blowing up a 1 megaton nuclear bomb on every square mile of the surface.
- Probably not enough energy to boil away the ocean or strip away the Earth's atmosphere.
- But, this is still something that is 600 trillion miles away!



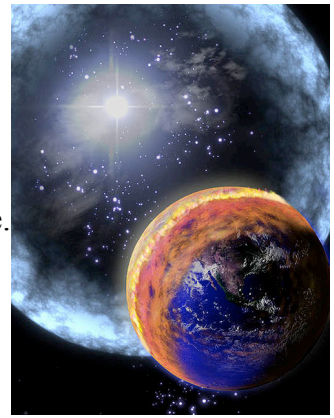
GRB Damage

- For a GRB that close, if you looked at the burst, you would be blinded.
- Outside, the heat would roast you.
- Then influx of UV would give you lethal sunburn



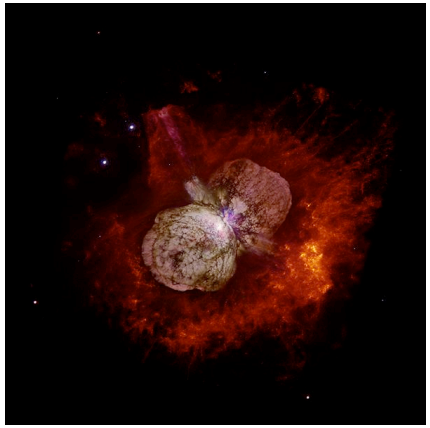
GRB Damage

- The ozone layer instantly destroyed.
- The Earth's surface would be sterilized, even underwater to a few meters.
- Perhaps best not to mention x-rays and gamma-ray exposure.



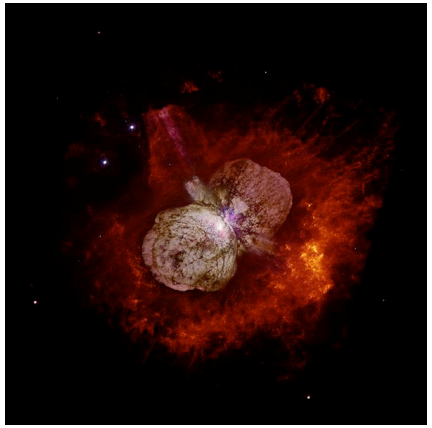
What's Nearby

- Okay, that was fun to speculate, but no likely candidates for GRB that close.
- They are more rare than supernova.
- So what is the possible nearest GRB candidate?
- One of the most massive stars in our Galaxy Eta Carinae, about 7500 light years away, in Southern Sky so can't see it from Urbana.



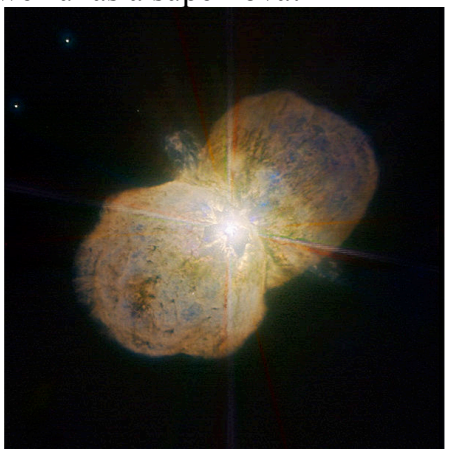
Eta Carinae

- Binary system, the most massive component of which is 4 million times brighter than the Sun!
- It give off more energy in one second as the Sun does in 2 months!
- About 100 solar masses!
- In 1843, Eta Carinae did something weird.



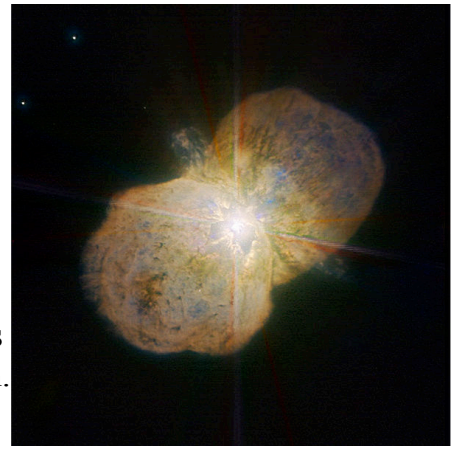
Eta Carinae

- It had a violent spasm, blowing off huge amounts of material, almost as powerful as a supernova!
- It was the second brightest star in the sky!
- It lost about 10 times the mass of the Sun, moving at a million miles per hour.
- Today, we see the aftermath as two huge lobes of material.



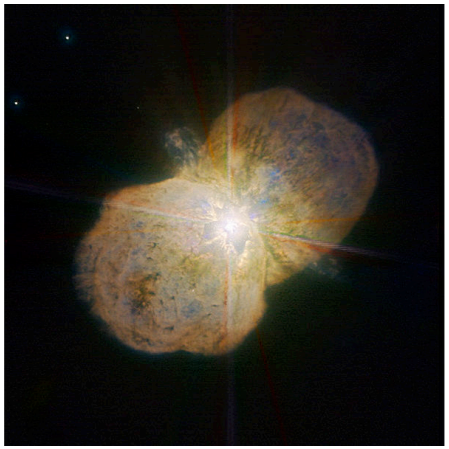
Eta Carinae

- These supernova impostors are seen in other galaxies too.
- We don't know when it will blow– today or in a million years.
- It might be a hypernova, or GRB, but maybe not.
- Regardless, the current orientation of the star (note, the lobes) suggests that it will miss the Earth.
- Can change though.



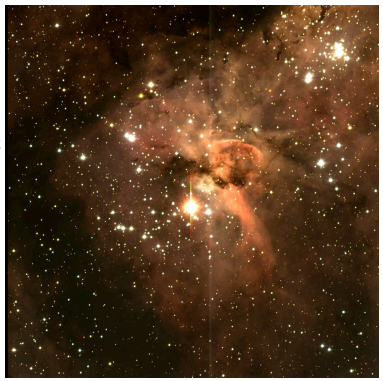
Eta Carinae Damage

- Let's play with what would happen if Eta Carinae did hypernova with the Earth in the beam.
- Even at 7,500 light years bad things will happen.
- Would be about 10 times brighter than the full Moon.
- The UV light from it would probably give a sunburn.



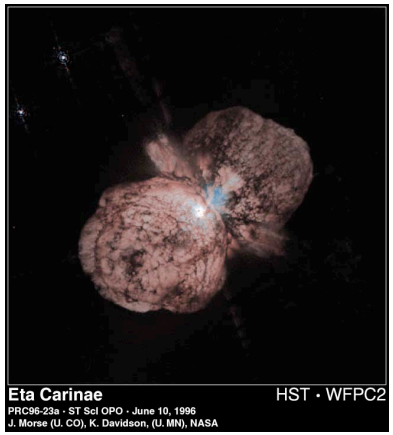
Eta Carinae Damage

- But the gamma-rays and X-rays?
- Absorbed by the atmosphere, but worse affects than nearby supernova.
- There would be a strong EMP (electromagnetic pulse) that would wipe out electronic devices for facing hemisphere
  - Computers
  - Power grids
  - Airplanes
  - Cars (emergency vehicles too)
- All fried!



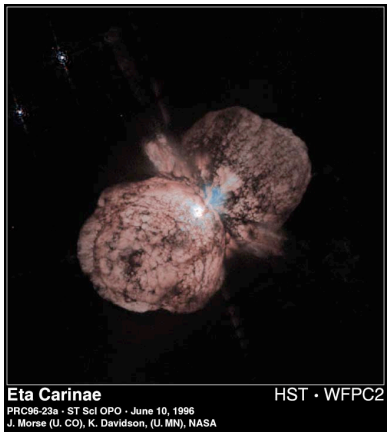
Eta Carinae Damage

- But, perhaps all that doesn't matter as the atmosphere is already feeling the affects.
- Ozone layer devastated
- Would take a decade to recover.
- Base of the food chain hurt badly.
- Create reddish-brown nitrogen dioxide, which will reduce the light, ice age anyone?



Eta Carinae Damage

- Nitrogen dioxide will also cause acid rain.
- In addition to light, the GRB will send out subatomic particles, creating a shower of muons (heavy electrons)
- That may imply something like 10 times a lethal dose!
- And muons can penetrate about ½ mile into rock, so everyone on that hemisphere is toast.
- 7500 light years is 50 quadtrillon miles away!



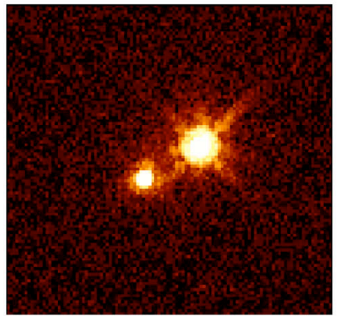
Question

Why is it thought that Eta Carinae will probably not kill us all?

a) It doesn't have a gun.
b) It will not go supernova.
c) We don't think the lobes are pointed our direction.
d) It will likely turn into a planetary nebula.

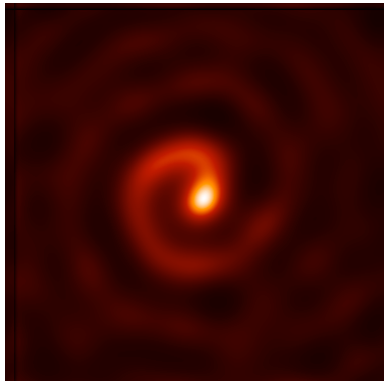
May I have another Sir?

- WR 104 has gotten considerable interesting as of late.
- It is a massive star about 7000 light years away toward the Galactic center.
- Again, a binary system.
- With deep Keck images, it looks more interesting.



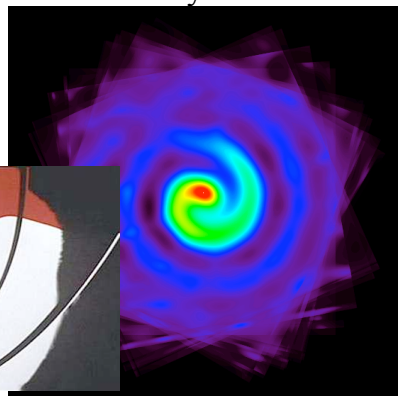
May I have another Sir?

- When you put together 8 months of images you see this.
- The two stars are orbiting.
- It looks like their rotation axis is pointing right at us!
- Down the barrel of a GRB gun?



May I have another Sir?

- The most massive of the pair is in the last stage before a supernova, so it could blow at any time up to probably hundred thousand years!



May I have another Sir?

- But, bottom line is we don't know if this star will be a GRB.
- Most GRBs are happening in distance past, so the increased metallicity of stars today (from supernova) may make it impossible to make GRBs today.
- New observations (different models) suggest that WR 104 is not pointed at us.
- Need more observations!