Astronomy 150:
Killer Skies

This Class (Lecture 23):
Killer GRBs

Next Class:
Black Holes Are Fun

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

Music: *http://www.youtube.com/watch?v=XGK84Poeynk*

Exam 2

- Exam 2 in this classroom on Oct 30th
- 35 Multiple choice questions
- Will cover material from Lecture 12 to 22.
- 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
- Created and posted a study guide

1st Week of Nov

- Lecture is cancelled for the first week of Nov (2nd, 4th, and 6th).
- Instead of iclicker, we will do credit through a Compass discussion topic (before the 8th).
- 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

- So far, I am very happy with the posts and comments.
- Already seen some interesting links and discussions.

Questionnaire

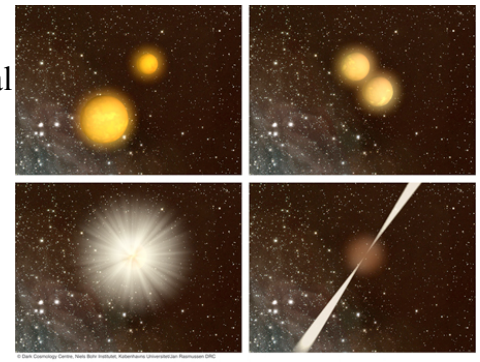
- Thanks for those of you who replied.
- General people were very happy with the class so far.
  - "Favorite class"
  - 'Best class ever"
  - "You da Man!"
- I did get some good negative comments, some of which I will work on,
  - "Stop being funny. You're not funny…Voice like a 10 year old girl"
  - "HW questions unclear"
  - "Exams not general enough"
  - "No reading the ppt slides, try more bullets"

Outline

- Short term GRBs, the threat
- Past Effects of GRBs on Earth

And Shorts?

- But what about neutron star-neutron star or neutron star-black hole mergers?
- Although not as rare as hypernova, since they don't have as much total energy in the burst, they are much less likely to cause death.
- So, keep them in mind but don't worry too much.

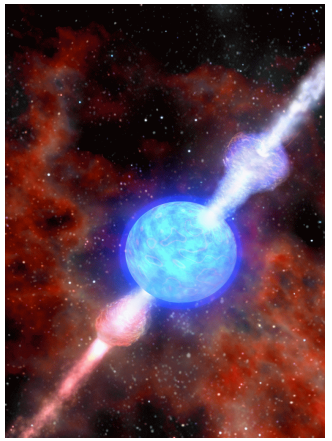


The Neutron Stars Merging Scenario

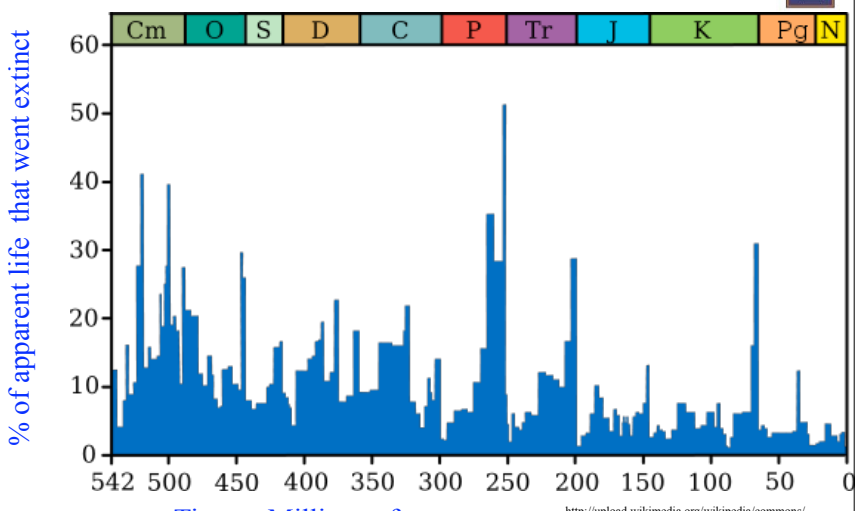
ESO PR Photo 32c/05 (October 6, 2005) © ESO

Rates?

- Based on the observed Universal rate of 1/day, we can estimate the GRB rate in the Milky Way.
- We expect about 1 burst per 100,000 or million years.
- But most are not beamed toward Earth.
- So about 1/billion years within 5000 light years.
- We have had ozone for two billion years, so any observable affect?



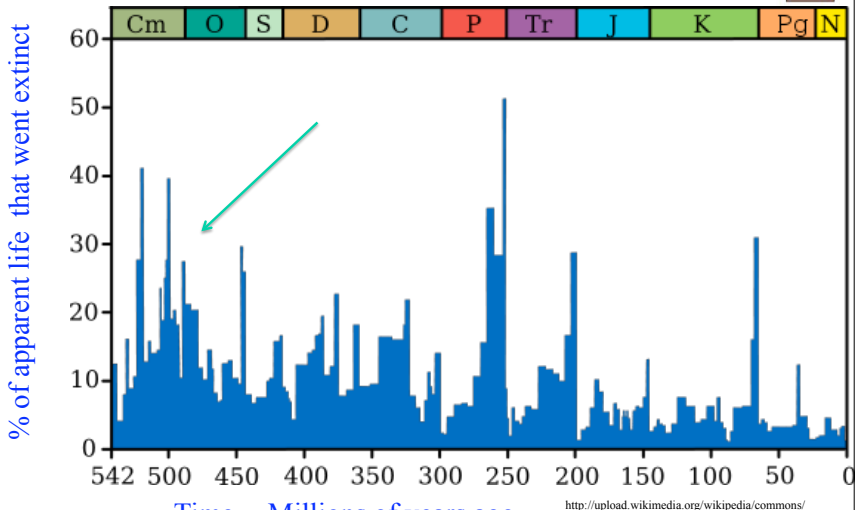
Extinction Events -- how many are due to GRBs?



GRBs and Mass Extinctions

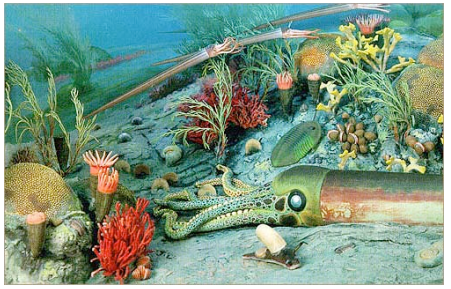
- Many possible causes for mass extinctions (remember impacts), but gamma-ray bursts (GRB) may also have contributed.
- A beamed GRB within our own galaxy could do considerable damage to the Earth's biosphere.
- And, a number of nearby GRB have irradiated the Earth since life originated.
- The late Ordovician event shows many characteristics that would be expected if it were initiated by a nearby GRB.

Extinction Events -- how many are due to GRBs?



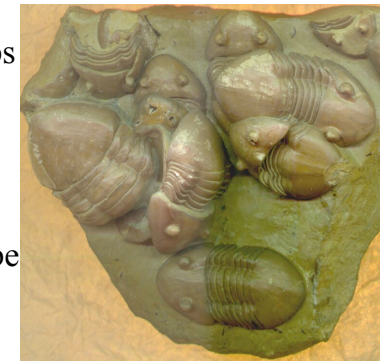
Patterns of Ordovician Extinction

- The late Ordovician is one of the largest mass extinctions in terms of its scale and scope.
- Two large, abrupt extinction events, separated by 0.5-2 million years.
- All major marine invertebrate groups show high rates of extinction during this interval.



Patterns of Ordovician Extinction

- The late Ordovician is unusual in that many groups like the trilobites, important Ordovician animal groups in terms of their relative abundance, diversity, and geographic range, go extinct while the more restricted groups persist.
- This is counterintuitive; one might predict that (due to stochastic factors) widespread, more abundant groups should be more extinction resistant.



Depth Dependence of Late Ordovician Extinctions

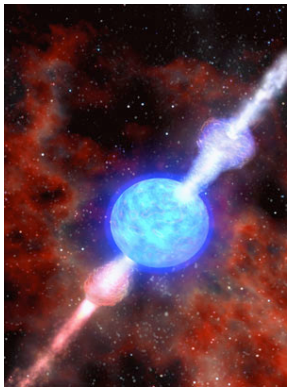
- Extinction of trilobites correlates with the amount of time spent in the water column.
- Young trilobites are plankton-like larva.
- Such animals were more likely to cover a broad geography, but they were more likely to go extinct during this time.
- During the late Ordovician, species dwelling in shallow water were also more likely to go extinct than species dwelling in deeper water.

Global Cooling and the Ordovician Extinction

- Extinction has been related to alternating global cooling and warming correlated with the two pulses of the late Ordovician mass extinction.
- There may be a link between GRB and global cooling.
- As mentioned before, GRBs produce atmospheric nitrogen dioxide, which initiates global cooling.
- Climate models of the Ordovician show that it is difficult to initiate glaciation without a forcing impulse, such as a period of reduced sunlight.

Ordovician/GRB Connection?

- Extinction could have been initiated by a nearby GRB.
- Ozone layer destruction followed by greatly increased solar UV would be catastrophic.
- And GRB could have triggered the global cooling: a one, two punch for life on the planet.
- Notably, the kind of water depth dependence found in the late Ordovician extinction pattern would emerge naturally from the attenuation of the UV radiation.



Predicted as GRB Effects	Observed in late Ordovician
Extinction of shallow (not deep) water organisms	Yes
Extinction of free-swimming organisms	Yes
Extinction of surface floaters (plankton) and organisms with planktonic larval forms	Yes
Nitric acid rain	Productivity oscillation in biosphere possibly related to nitrate boost
Reduction of solar radiation – cooling	Yes – glaciation needed "kick"

Extinction Conclusion

- A strong GRB irradiation of the Earth is probable during the time interval since O_2-enrichment of the atmosphere.
- Such an event would destroy the ozone layer, exposing organisms to dangerous levels of solar UV.
- At least one mass extinction shows characteristics compatible with GRB effects.

We have no smoking gun.

http://www.youtube.com/watch?v=rG-sdxd899A 1:23
http://www.youtube.com/watch?v=0YQof5_E7sk 1:50
http://www.youtube.com/watch?v=zdCxV9Frw9s

Question

Looking back through the mass extinctions of Earth, the Ordovician appears to be a possibility for a GRB. Which of the following facts was not observed in the Ordovician extinction?

a) Extinction of shallow (not deep) water organisms.
b) Extinction of surface floaters (plankton) and organisms with planktonic larval forms.
c) Mutations from gamma-rays.
d) Cooling.

Mitigation

- Not much… there would be no warning.
- Only chance is to know about them.
- Although dangerous GRBs can be far away, we could examine them as necessary with best telescopes to determine danger levels…
- With time our civilization should travel to the stars to provide better chance of sudden death.
- But, remember GRBs are rare and unusual, so unlikely to happen.
- Don't worry, be happy.

Imagine

- The beam comes without warning.
- You're walking downtown, hanging out, suddenly, an incredibly bright light in the sky!
- It hurts to look at it at first, then it begins to dim.
- Hours later, silent subatomic particles slam into the Earth's atmosphere.
- No matter if people were inside or not, a large fraction of the Earth is exposed to lethal radiation.
- 60% of the population of the world starts dying from the high dose.

Imagine

- The ozone layer has been dramatically damaged, and solar UV radiation will kill off the food chain.
- A thick layer of smog forms and the sky turns a dark reddish-brown. Plants begin to die, then the acid rain starts.
- A new ice age begins.
- Survivors realize that the supermassive star Eta Carinae exploded.
- As you die, you wonder how a star trillions of miles away killed you, and why didn't Leslie talk about it in class?

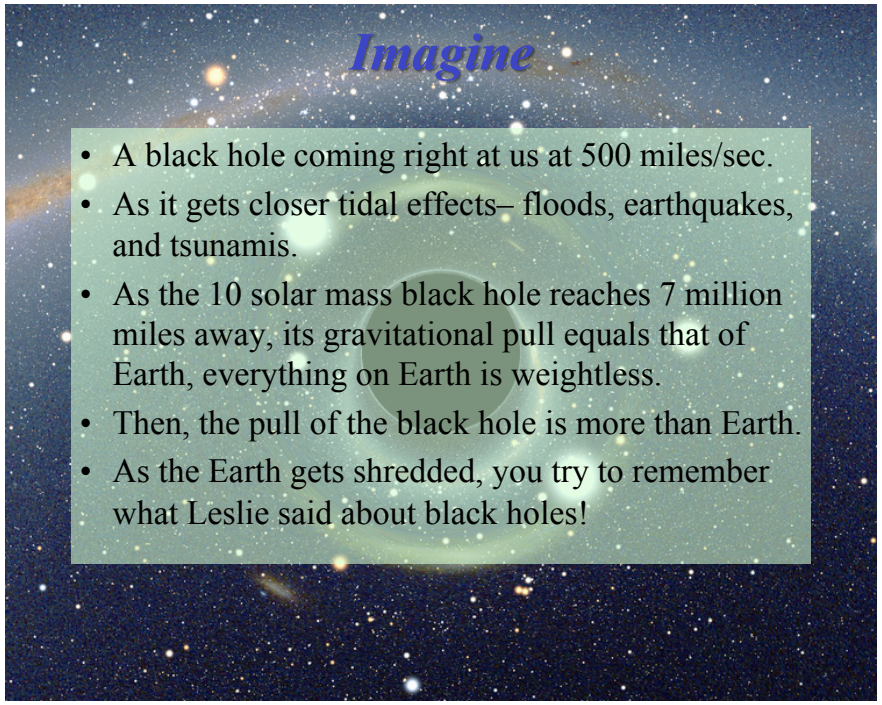
What about All those White Dwarfs, Neutron Stars, and Black Holes?

Could the large number of compact objects left over from stellar evolution cause any problems?

Would I be asking that question in this class if they couldn't?

Imagine

- An amateur astronomer trying to see Uranus is the first to notice. It's in the wrong place!
- Later, Jupiter is in the wrong place, then Mars!
- Even the Sun has moved!
- What is happening?! Oh, the Earth has moved.
- Panic spreads as scientist realize that a compact object has entered the Solar System and its mass is throwing off the orbits!
- Once the orbit was fixed for the object, telescopes looked for the object, but nothing– a black hole!



Top 10 Ways Astronomy Can Kill you or your Descendents

6. Rogue compact objects–White Dwarfs/Neutron Stars/Black Holes.

   Black Holes don't suck, but if they hit you it sucks.

A non-accreting black hole is nearly impossible to detect. Since the beginning of time all massive star's dead bodies litter the Galaxy. But still massive stars are not very common. Neutron stars and especially white dwarfs are more common, and if old enough, these will be hard to detect.

http://www.youtube.com/watch?v=ou3TukauccM&NR=1