

## “Astronomy is basically applied physics”

Paraphrased from memory from  
Steve Squyres' *Roving Mars*

## Agenda

- Announce
  - Moving Sun lab measurement
  - Ohm's Law labs due
  - Test a week from Thursday
  - Notification of extra credit offer due by test
- The Ozone Hole & Global Warming
- Some questions
- Light gets bent
- Gravitational Wave Astronomy
- Fractals
- Lab 4—Making an H-R diagram

## Ozone Hole

- Found in book (page 425)
- Good Ozone—high up, blocks UV radiation
- Bad Ozone—low down, reacts strongly with stuff and is toxic

The Atmosphere Theme Report of the Australia State of the Environment  
Report 2001

"Because of the very long lead time between exposure to UV radiation and the related occurrence of skin cancer, the increasing incidences of skin cancers in Australia (Figure 82) from 1980 to 1996 are thought to be associated primarily with behaviour in relation to exposure to UV radiation that presumably took effect before there was any significant depletion of the ozone layer. However, it is reasonable to assume that any increase in UV radiation as a result of ozone depletion has contributed, and will contribute, to increases in the incidence of skin cancer."

## Global Warming

- Deutsch had this position as NASA public relations specialist given to him by the current administration, and according to Dr. Hansen he used it to suppress information about global warming.
- (from BadAstronomy.com)

## From NYT

- The statement came six days after The New York Times quoted the scientist, James E. Hansen, as saying he was threatened with "dire consequences" if he continued to call for prompt action to limit emissions of heat-trapping gases linked to global warming. He and intermediaries in the agency's 350-member public-affairs staff said the warnings came from White House appointees in NASA headquarters.

### More NYT

- In October, for example, George Deutsch, a presidential appointee in NASA headquarters, told a Web designer working for the agency to add the word "theory" after every mention of the Big Bang, according to an e-mail message from Mr. Deutsch that another NASA employee forwarded to The Times.

### More from NYT

- The Big Bang is "not proven fact; it is opinion," Mr. Deutsch wrote, adding, "It is not NASA's place, nor should it be to make a declaration such as this about the existence of the universe that discounts intelligent design by a creator."
- It continued: "This is more than a science issue, it is a religious issue. And I would hate to think that young people would only be getting one-half of this debate from NASA. That would mean we had failed to properly educate the very people who rely on us for factual information the most."

### Question

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  1. Relativistic effects **more** pronounced
  2. Relativistic effects **less** pronounced
  3. Relativistic effects **no difference**

### Question

- Mike wakes up and finds himself floating in a spaceship with just a small, fixed telescope to look out of. Through the scope, he see Jackie wake up, lying on the floor.
- Two questions:
  - What does Mike think about their states of motion?
  - What does Jackie?

- Mike thinks:
  1. Jackie is racing away while accelerating
  2. Jackie is staying still and he's moving
  3. Jackie has a gravitational force on her (but not on him)
- Jackie thinks
  1. Mike is moving away from her at constant speed
  2. There's gravity holding her to her ship, and Mike's ship is in freefall

### Question

- What causes curvature of spacetime?
  1. Gravity
  2. Acceleration
  3. Matter
  4. Energy
  5. All of the above
  6. Matter & Energy

### Question

- What is “action-at-a-distance”?
  1. A complimentary phrase which says that a force is very strong
  2. A phrase which describes a force that acts over long distances (unlike the strong and weak forces)
  3. A derogatory phrase which describes a theory of a force which asserts changes in the force occur instantaneously

### Question

- Does the electromagnetic force suffer from “action-at-a-distance”? Why or why not?

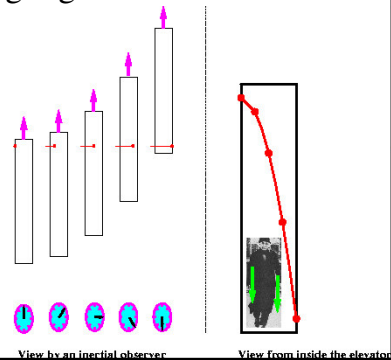
### Question

- Why is black hole called what it is?

### Activity

- What would a spacetime diagram look like of Lucy and Alex playing a game of “chicken” while flashing their lights?

### Light gets bent





## Expectations of Understanding

- Physics specialist – figure things out, connect ideas, compute predictions, can critically evaluate arguments (e.g. could reject)
- You
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- Physics specialist – figure things out, connect ideas, compute predictions, can critically evaluate arguments (e.g. could reject)
- You—understand the ideas, understand the basis for the argument (even if not enough to critically evaluate), understand the context
- Non-science lay person – vague idea of concepts, no basis for evaluation

## Important Issues/Questions

- mathematical
- (astro)physical
- cosmological
- Global Existence of PDEs
  - Black Hole Critical Phenomena
  - Hoop Conjecture / Cosmic Censorship
  - No Hair Conjectures
  - **Gravitational Wave Observations**
  - Astrophysical Jets
  - Gamma Ray Bursts
  - Exotic Stars (Solitons, Gravastars, Quark)
  - Extra Dimensions / Black String Stability
  - (Topological) Inflation
- 
- 

## A Quick Intro to Gravitational Waves

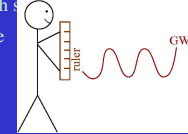
Electromagnetic waves communicate movement of charge  
Gravitational waves communicate movement of mass

$$F_{\text{Newton}} = \frac{GM_{\text{Sun}}m_{\text{Earth}}}{r^2}$$

Both travel at speed of light

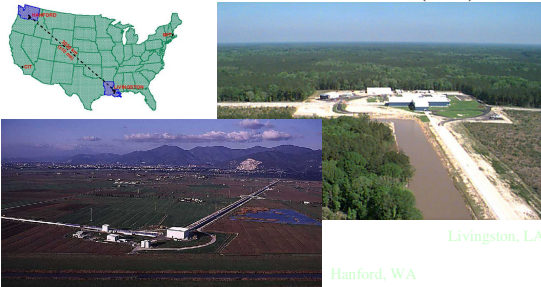
- If Sun disappeared, Earth shouldn't know for 8 minutes
- Propagate largely undisturbed through
- Represent small changes in spacetime

Very small:  $\frac{\Delta L}{L} = 10^{-21}$

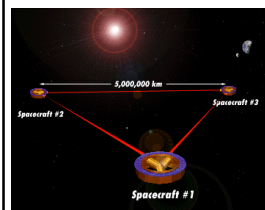


## LIGO: Laser Interferometer Gravitational Wave Observatory

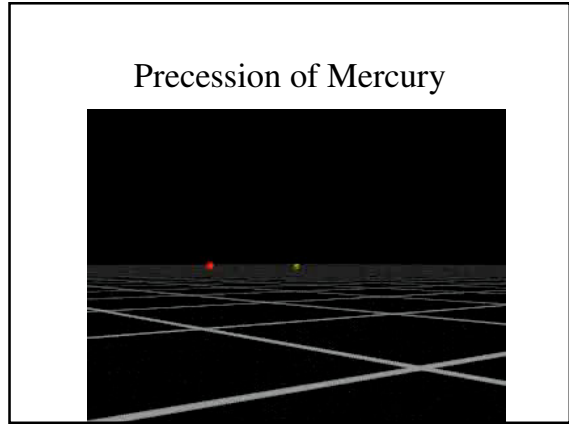
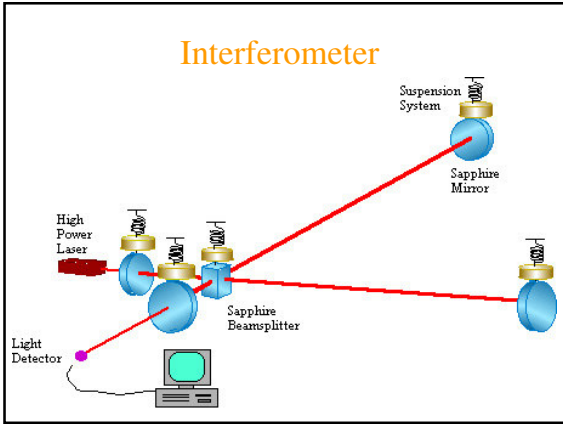
- 2 detectors to observe Grav. Waves (GW)



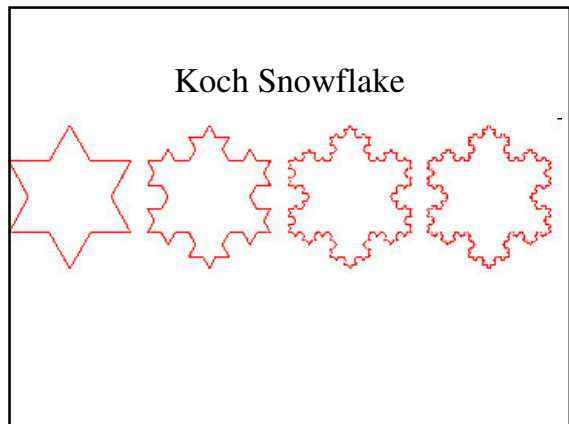
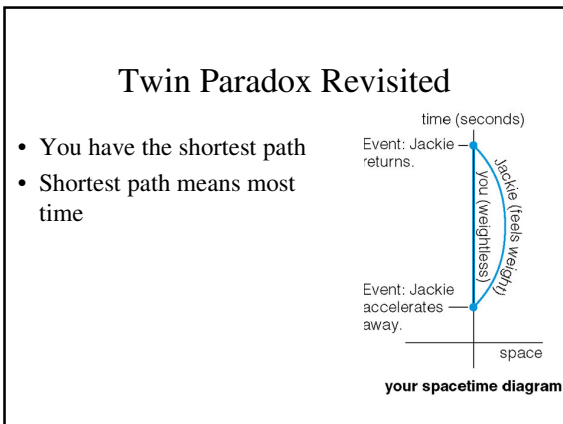
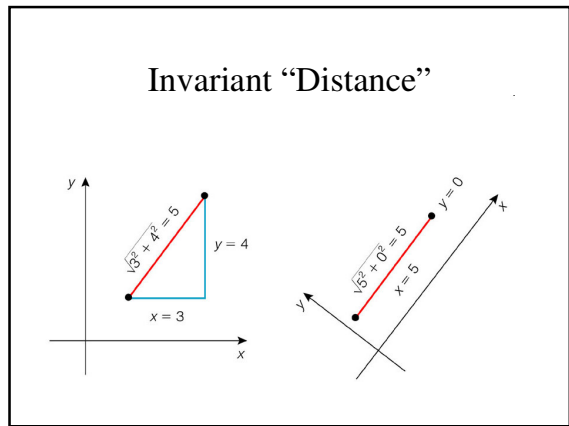
## LISA: Laser Interferometer Space Antenna

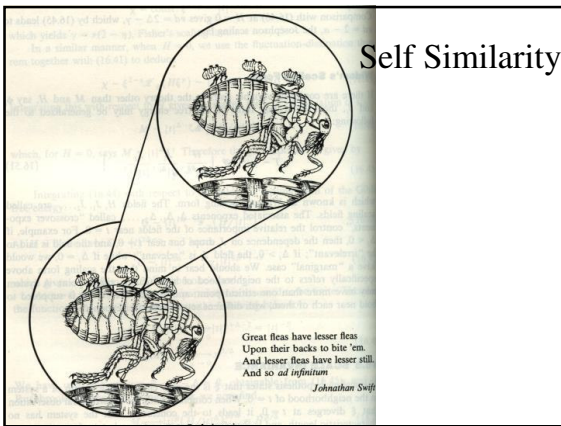
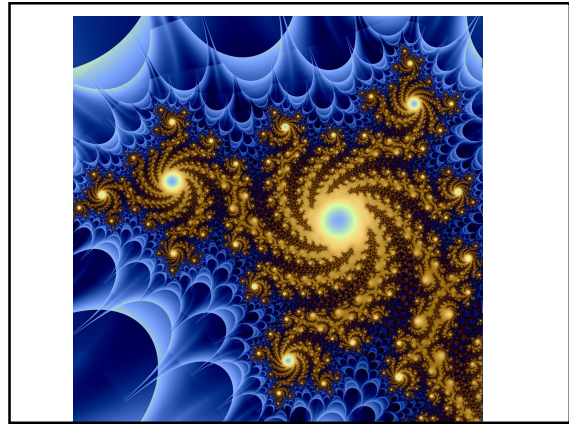
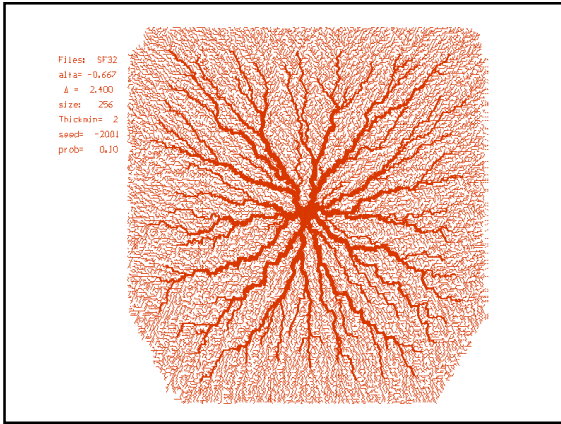


- NASA/ESA
- If approved, start 2005
- ~~Launch date 2008~~
- Space-based detector
- Low-frequency...not possible on Earth



- ### What's relative?
- How far is JFK?
  - We'll all take different paths and get different distances
  - We'll hit different amounts of traffic and get different times
  - Is there anything we can all agree on?





### How do you get fractional dimensions?

- Double each side of a cube and volume goes up by  $2^3$
- The 3 is the dimension
- Do the same for Sierpinski triangle..double it and get 3 times as many triangles
- 3 is not  $2^1$  (1D) or  $2^2$  (2D) but **somewhere in between**

