Student's Choice #1

Bad movie physics
3D glasses
Sunscreen/UV damage
Life, other planets, galaxies
Unusual lights (black lights, neon)

Bad Movies (for physics)

- Though entertaining (and I like some of these), among the most guilty betrayers of physics are:
  - Armageddon! (at the top of the list for a reason)
  - Mummy movies
  - Tomb Raider
  - The Day After Tomorrow
  - The Core
  - Cliffhanger (couldn't even bear the previews)
  - Mission Impossible (any of them)
  - Speed (fun, but wrong)
  - Mel Gibson, Schwarzenegger, James Bond movies
- Interesting case study: Armageddon vs. Deep Impact
  - Deep Impact hired science consultants and *did okay*

Themes of physics misrepresentation

- Everything goes BOOM, and explodes in huge fireball
  - Real life more often just *crunches* (we're not loaded with dynamite)
- Momentum seldom conserved
  - Bullet sends victim flying out window, shooter remains motionless
- Hearing sound in space
  - no air to carry sound waves
- Seeing laser beams in space
  - What are they reflecting off of? Is it smoky?
- Aerodynamic spaceships, airplane-like maneuvering
- Exploding rather than imploding submarines
- Fake props: wrong inertia properties
  - Raiders of the Lost Arc: swiped huge gold statue like it was nothing!

Movie Examples…

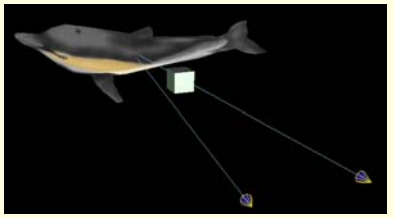
- *Goldeneye*, catch up to airplane
  - Terminal velocity of human: 50 m/s, up to 70 m/s if you reduce your effective area by a factor of two
  - Terminal velocity of plane in dive configuration: about 90 m/s (more with engine at full power)
  - Got a late start, too…
  - Also problem pulling out of dive!
  - Plane terminal velocity:
    - given best glide 10:1 at 30 m/s (on the slow side):
      - drops at 3 m/s = $v/10$, so $mgh \rightarrow mgv/10$ Watts expended
      - drag force F over v m/s $\rightarrow F{\cdot}v$ Watts = $mgv/10$
      - $F = mg/10$ at best glide speed
      - F proportional to v^2, so $F = mg$ terminal velocity condition is met at about 3 times best glide speed → > 90 m/s

Examples, continued

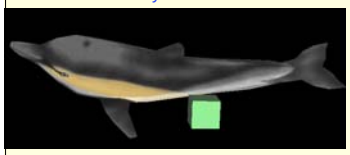
- *Speed*, bus jump
  - 150-200 ft, level (call it 45 m)
  - bus at 30 m/s (67 mph): takes 1.5 seconds to cross
  - drops 11 m (36 ft) in 1.5 s
  - *could* work, at 15-20 degree launch angle, no air drag

- Websites
  - www.pbs.org/teachersource/whats_new/science/aug01.shtm
  - www.space.com/opinionscolumns/opinions/plait_000217.html
  - www.badastronomy.com/

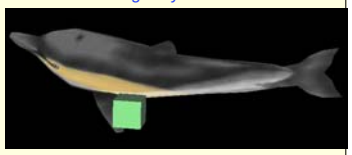
3D glasses: Stereo Vision



left-eye view



right-eye view



 from http://en.wikipedia.org/wiki/Stereo_vision

Putting it together

- 3D films are shot with two cameras side-by-side mimicking your eyes
- If projected on the same screen, must somehow let your left eye know to pay attention to left image, and right eye know to pay attention to right image
- Can use color:
  - blue image/blue filter for one eye, red image/red filter for other
  - but can't do this for color movie!
- Can use polarization:
  - could do vertical for left, horizontal for right
  - or 45° one way vs. the other way
  - glasses will appear gray
- In both cases, projection and detection must be separated into different "channels"

3D Glasses

- Example red/blue scheme
  - actually, the glasses pictured below go the wrong way:
  - the right eye wants to see red
  - how do we tell? Look at the left ear: for which eye is the background more blocked?

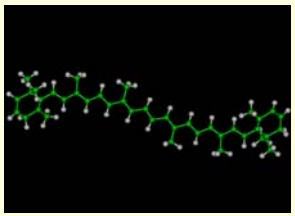
What does UV do that's so bad anyway?

- Light comes in little bundles called photons
- The energy of a photon is proportional to its frequency
- UV is short wavelength, thus high frequency
  - thus high-energy
- UV photons have enough energy to destroy chemical bonds
  - changes chemistry
  - pigments broken up → colors fade
  - can cause cancerous change to DNA in skin cell
  - used in autoclaves to sterilize equipment (UV kills microbes)

Sunscreen

- A coating of highly UV-absorbing molecules
  - UVB: 290–320 nm: sunburn
  - UVA: 320–400 nm: long-term skin damage/aging
- SPF: protection factor
  - if you burn in half-hour, SPF 10 will protect you for 5 hours
  - a thin, white t-shirt may be only SPF 4 or so
  - sitting in shade but with lots of blue sky exposure may be SPF 4
- All that absorption in such a thin layer?!
  - Ozone is already SPF 10, and only 3 mm thick (if concentrated to one layer) in our atmosphere
    - if you burn in 30 minutes, that'll be 3 minutes in space!
  - put in liquid form (density) and now only 3 microns thick!

What's responsible for selective absorption?

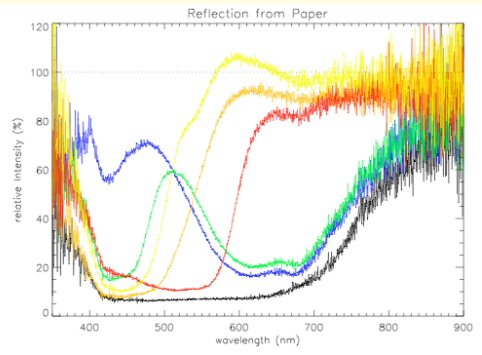


- Carotene
  - makes carrots orange, tomatoes red, daffodils yellow, leaves turn
  - must absorb blue light
- Long, organic molecular chain
  - most dyes, pigments are such
  - resonances in optical light

Sunscreen works the same way: the molecules contained in sunscreen have a resonance absorption in the ultraviolet

The absorbed UV turns into molecular vibration → heat

Paper Analog to Sunscreen



white paper would be a flat line at 100%

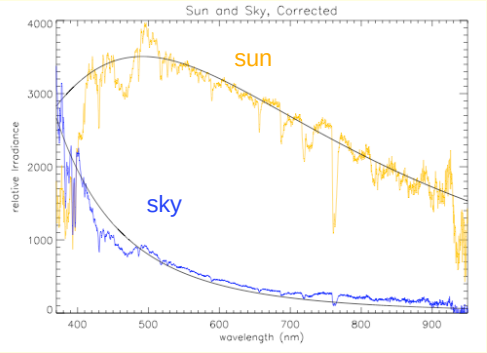
Reflected light (in this case, sunlight) off of paper appearing:

blue
green
yellow
orange
red
black

Note pigment in yellow paper is good at absorbing 400–500 nm

Sunscreen is similar, but optimized for UVA + UVB

The UV sky



The blue sky has ever-more flux at UV wavelengths, so that it is not a negligible source of sunburning light.

On top of the blue sky spectrum is plotted a theoretical $1/\lambda^4$ model for molecular scattering, which fits reasonably well.

This means the sky is 16 times brighter at UVB (300 nm) than at 600 nm

Though not in words, this explains why the sky is blue!

The Place of Humans in the Cosmos

Life in the Universe?

Our Place in Space

- The universe is unimaginably big
  - our galaxy is one of > 100 billion visible to us
  - our sun is one of ~100 billion stars in the galaxy
  - if earth is the size of a BB, the sun is a beach ball 100 m away, and the next star is 3/4 of the way around the earth
  - even in the solar system, earth is only a grain
  - earth mass is <0.0003% of solar system mass
  - and humans are tiny compared to the earth
- We are not at the center of:
  - the solar system
  - the galaxy
  - the universe
  - attention

Our Place in Time

- Modern humans have been around maybe 200,000 years
- This is about 0.001% the age of the universe
  - $2\times10^5/2\times10^{10} = 10^{-5}$
  - flash in the pan
- Compared to distance scale, this is sort-of like the size of a galaxy compared to the size of the whole universe
- Feeling Insignificant?

Are We Alone?

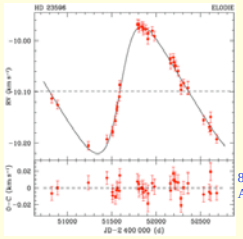
- Hard to believe that we are
- Assumptions (restrictive version):
  - must have solid planet to start life
  - planet must be in habitable zone (liquid water)
  - >10% of stars have planets
    - already see >5%, and just getting started
  - life forms given energy input and non-destructive environment
    - no supernovae nearby, no heavy comet bombardment, etc.

The Numbers

- 100 billion stars in Milky Way
- 10% with planetary systems
  - 10 billion planetary systems
- Say 1% of planetary systems have habitable planets
  - 100 million planets
- Pick very long odds for life formation: one-in-a-million
  - now 100 life-bearing planets in Milky Way
- Now multiply by 100 billion galaxies in *visible* universe
  - 10 trillion life-bearing planets in visible universe
- How many have (or have at one time had) *intelligent* life?
  - very difficult to know—related question: how long does intelligent life persist?
- Why don't they visit?
  - same reason we haven't gone farther than our own moon: space is *way too vast*
  - we may never venture even to the nearest star

Planetary systems known to date

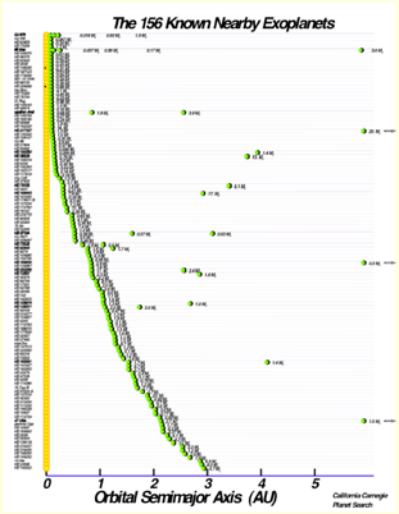
- 146 planetary systems discovered in last 10 years
  - 170 planets total
  - 18 multi-planet systems
- Discovered by seeing star wiggle under gravitational influence of planet
  - tends to find BIG planets CLOSE to the parent star (biased)



red points are individual measurements (with error bars)

black line is best-fit elliptical orbit

8 M_{JUP} at 2.88 A.U., 0.29 ecc.



http://exoplanets.org

UCSD: Physics 8; 2006

Galaxies: Islands of stars

Andromeda Galaxy: our closest "big" neighbor

Central Virgo Cluster

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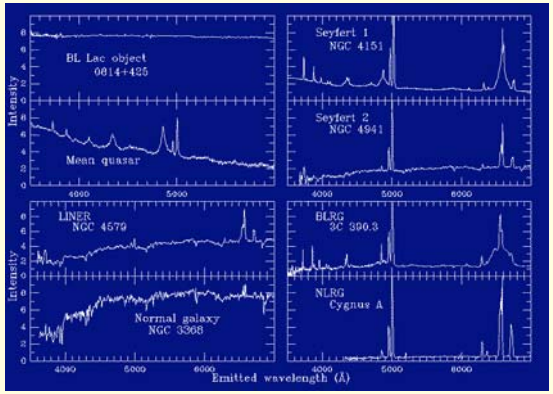
How do we know: by their *spectra*



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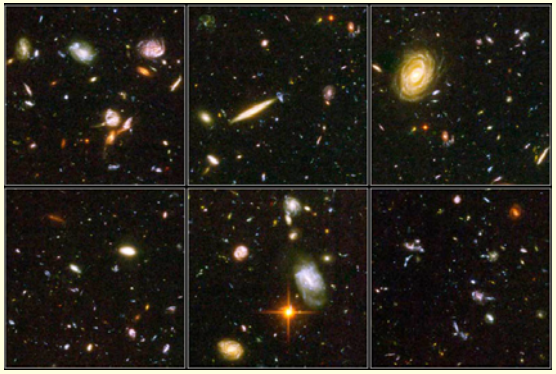
Galaxies as far as the "eye" can see



Montage of the Hubble Ultra-Deep Field: ALL are galaxies!

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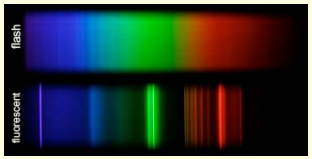
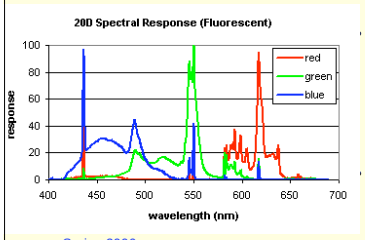
Fluorescent lights





- Fluorescent lights stimulate emission among atoms like argon, mercury, neon
  - they do this by ionizing the gas with high voltage
  - as electrons recombine with ions, they emit light at discrete wavelengths, or *lines*
- Mercury puts out a strong line at 254 nm (UV)
  - this (65%) and other lines hit the phosphor coating on the inside of the tube and stimulate emission in the visible part of the spectrum
- A neon light simply has neon gas in the tube
  - spectrum is characteristic of neon

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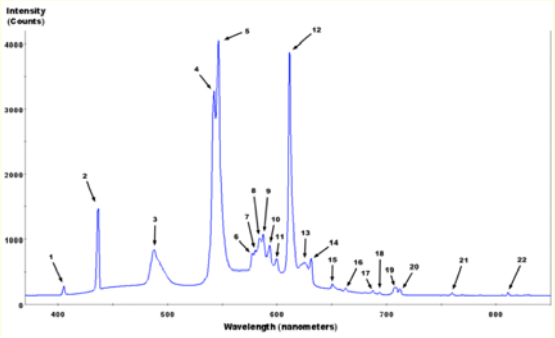
Fluorescent Spectrum

- http://mo-www.harvard.edu/Java/MiniSpectroscopy.html
- http://en.wikipedia.org/wiki/Image:Fluorescent_lighting_spectrum_peaks_labelled.gif

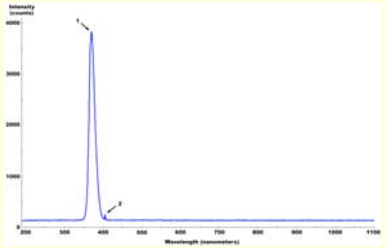


1. Hg
2. Hg
3. Tb
4. Tb
5. Hg
6. Hg
7. Eu
8. Tb
9. Eu
10. Eu
11. Eu
12. Eu

Hg: mercury; Tb: Terbium; Eu: Europium

Black Lights

- http://en.wikipedia.org/wiki/Black_light
  - standard Hg-driven flourescence
  - single europium-based phosphor ($SrB_4O_7F:Eu^{2+}$)
  - also uses glass that blocks visible light > 400 nm
  - many objects absorb the UV light and themselves fluoresce



1. Eu
2. Hg

Assignments

- HW8 due 6/8: 14.E.3, 14.E.8, 14.E.10, 14.E.11, 14.E.12, plus additional required questions accessible on website
- EC due by Thursday (start today if not already!!)
- Q/O # 5 due Friday 6/9
- Final Exam Wed 6/14 3-6 PM WLH 2005
  - #2 pencil and light-green scantron form required
  - calculator okay
- will have study guide and review session as for midterm