## *Astronomy 150:*
# *Killer Skies*

This Class (Lecture 12):
Why is the Sun Yellow?

Next Class:
Stellar Temperatures

**Exam 1 on Friday!**

**Music: *The Sun Always Shines on TV*– A-Ha**

# *Email*

Just to let you know, your quiz [HW3] was near impossible. I took it 32 times. …..still managed to scrape an 88%.... Was it rigged? Was that some sick joke?

Yes, as I let students try as many times as they want, I did make it a little trickier than usual. Sorry if it drove you nuts.

The HW questions are not meant to be rigged, but the wrong answers often had correct portions, which probably confused you. The reason I do that on the HW (thankfully the exams are less tricky) is that it makes you think about the topic, and not just get the right answer.

# *HW3: Questions*

The most dangerous asteroid today is

a) 2010 T1
b) Ceres
c) 1950 DA
d) Yomamma
e) Apophis

Apophis has a 1 in 45,000 or 0.0022%

1950 DA has a 0.33% chance.

Lecture 7, page 11.

# *HW3: Questions*

When were meteorites formed?

a) Constantly.
b) 14.7 billion years ago, right after the Big Bang.
c) We don't know.
d) Early on during the formation of the Sun.
e) 1 billion years ago, during the period of Heavy Bombardment.

Formed during the Sun's formation.

Heavy bombardment was 4 billion years ago.

## HW3: Questions

The likelihood of you dying due to impact is

a) not relevant for this generation, but your kids better watch out.
b) higher than dying from a shark attack.
c) not calculable.
d) zero.
e) higher than dying from a lightning strike.

Lecture 10, from the chart of Chapman.

## HW3: Questions

What causes a meteor to shine?

a) sunlight.
b) friction.
c) fusion.
d) fission.
e) ram pressure.

Lecture 7.

## Exam 1

- Exam 1 in this classroom on Sept 25th
- 35 Multiple choice questions
- Will cover material up to and including last Friday.
- 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.
- Have created and posted a study guide

## Night Obs

- Dates:
  - Monday, Sept. 21st
  - Tuesday, Sept. 22nd
  - Wednesday, Sept. 23rd
  - Thursday, Sept. 24th
  - Monday, Sept. 28th
  - Tuesday, Sept. 29th
  - Wednesday, Sept. 30th
  - Thursday, Oct. 1st

Go to assignment page on class website for more info.

You **MUST** download worksheet before you go.

Can be cloudy, so check webpage before you go.

## *Computer Labs*

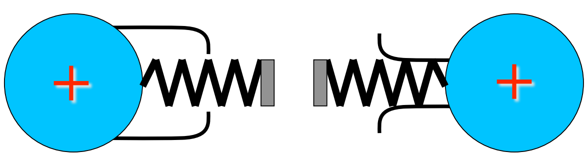
- Computer labs to look for real killer asteroids.
- Dates:
  - Monday Sept 28th
  - Monday, Oct 5th
  - Monday, Oct 12th
- Places:
  - Nevada Labs
  - Oregon Labs
- Limited space each day, so you ***MUST*** have a reservation for that day and that lab!
- See Assignments webpage for more info and to sign up!
- Lectures are cancelled for those dates.

## *Outline*

- Neutrinos prove nuclear fusion
- To understand the death of our Sun, we have to look at other stars…
- Stars are Suns too…
- Color me.. The different colors of stars..
- Brightness depends on distance.

## Why Nuclear Fusion Doesn't Occur in Your Coffee

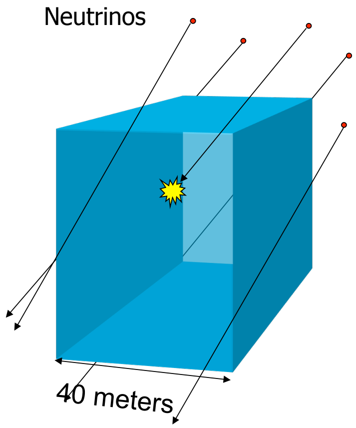
- Fusion requires:
  - High enough temperature (> 5 million K)
  - High enough density
  - Enough time

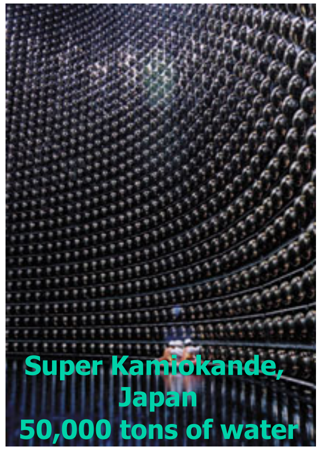


## *Sneaky Little Neutrinos*

- If we could detect them, we would prove that the Sun is a thermonuclear reactor.
- Matter is almost transparent to neutrinos
- On average, it would take a block of lead over a quarter of a light-year long to stop one
- Roughly 1 billion pass through every square centimeter of you every second!

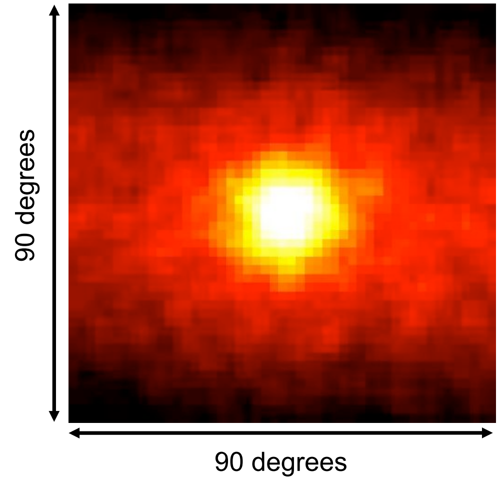
## Detecting Neutrinos




## The Sun in Neutrinos

- **Confirmation** that nuclear fusion is happening in the Sun's core
- 500 days of data
- As they can only be produced by nuclear processes, our energy source concept must be fundamental
- Proves nuclear burning!




## Cosmic Gall

very little
hardly

NEUTRINOS, they are very small.
They have no charge and have no mass
And do not interact at all.
The earth is just a silly ball
To them, through which they simply pass,
Like dustmaids down a drafty hall
Or photons through a sheet of glass.
They snub the most exquisite gas,
Ignore the most substantial wall,
Cold shoulder steel and sounding brass,
Insult the stallion in his stall,
And scorning barriers of class,
Infiltrate you and me! Like tall
and painless guillotines, they fall
Down through our heads into the grass.
At night, they enter at Nepal
and pierce the lover and his lass
From underneath the bed-you call
It wonderful; I call it crass.

Telephone Poles and Other Poems, John Updike, Knopf, 1960

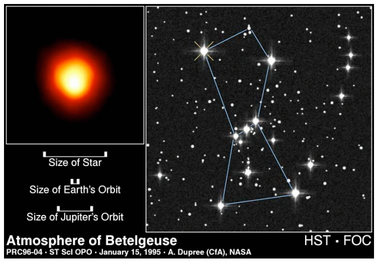
## Question

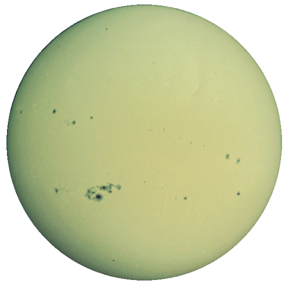
If we could sustain fusion in the lab we could meet humankind's energy needs forever! Why is it so difficult to achieve this, when stars do it every day?

a) Need a lot of hydrogen, more than we can find on Earth.
b) Need freaky high temperature and pressure to overcome the natural repulsion of protons, which are hard to make on Earth.
c) Need exotic mass particles, neutrinos, to glue the protons together, which don't exist on Earth.
d) Need a really hot cup of really good tea, and that is hard to do.
e) Beer and Wurst don't work.

## *Stars as Suns*

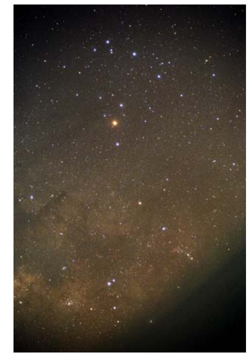
- The Sun is a nuclear reactor, but I'm saying much more than that: Sun is a typical star
- So all stars are run by thermonuclear fusion
- Night sky, Universe lit up ultimately by dense nuclear furnaces scattered everywhere
- How do we know Sun is typical?

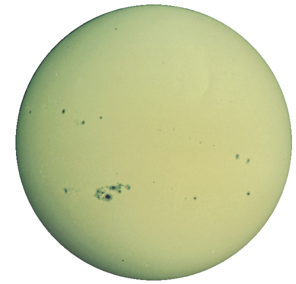


## *Why is the Sun Yellow-ish?*

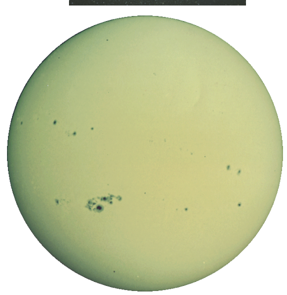
- If you look at the stars, you may notice that the stars have different colors.
- Blue, red, yellow.. etc..
- Why?



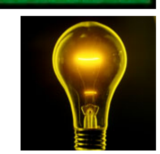
## *Why is the Sun Yellow-ish?*

- They are all powered by nuclear fusion, so why so different?

## *Glowing Bodies*

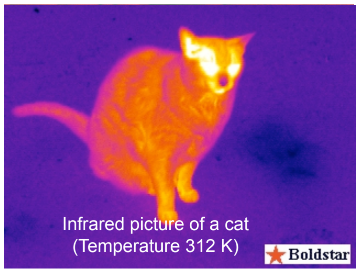
- Everything we know is in fact giving off light– as long as it has a temperature (T > 0 K), it is glowing.
- The higher the temperature the shorter the wavelength it glows in– compare the person on the right (in the near infrared) and a light bulb (in the visible).

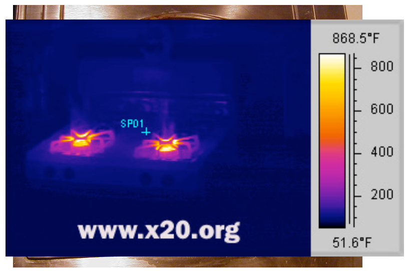
http://www.x20.org/thermal/thermal_weapon_sight_TIWS320.htm

# Blackbody Radiation

- Light that objects emit because of their temperature is called **blackbody radiation**
- Blackbody radiation is composed of a continuous spectrum of wavelengths
- The **hotter** an object gets, the **more intense** and **shorter wavelength** (blue-er) its blackbody radiation becomes




Infrared picture of a cat
(Temperature 312 K)



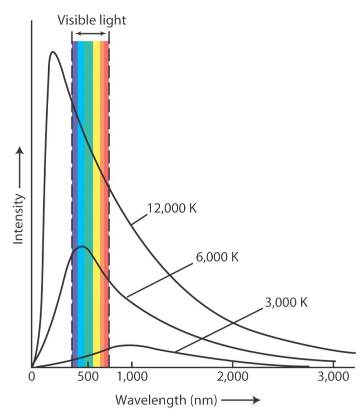

Visible-light picture of a stove element
(Temperature ~ 400 K)

# *Define Blackbody*

- A body that re-emits radiation according to its temperature
- Therefore, “blackbody radiation" = thermal radiation
- Usually, most familiar objects are well approximated as blackbody radiators
- A clear exception is a laser pointer.
  - Why?
- The spectrum of this ideal, only depends on its temperature!

# *The Spectrum of Blackbody Radiation*

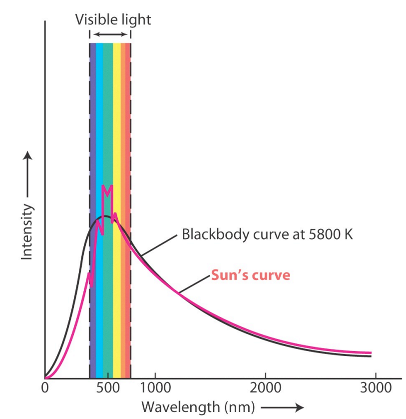
- For higher temperature objects the maximum occurs at shorter wavelengths.
- For lower temperature objects the maximum occurs at longer wavelengths.




# *The Spectrum of Blackbody Radiation*

The Sun’s spectrum looks almost like a 5800 K blackbody.

Color ⇔ Temperature!



## Think

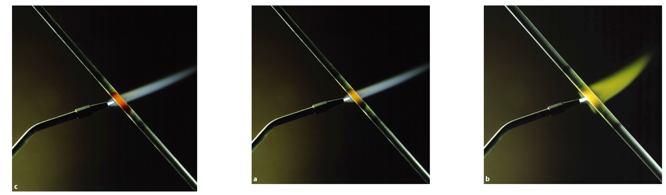
Which star is hotter?

a) Vega (blue)
b) Capella (yellow)
c) Antares (red)
d) Whatsit (striped)
e) Bang (polka-dots)

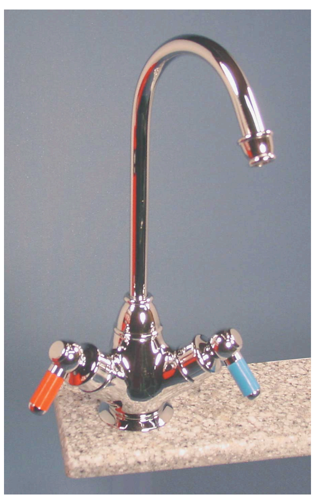
Note: It doesn't matter how far away the star is!


## Red Hot?

- Actually Red hot is not too hot.
- Blue hot is hot.
- White hot is even hotter.

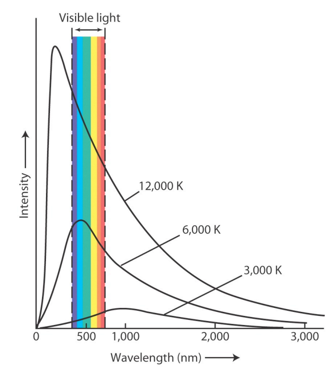


## Common Error?



## Blackbody Flux-ed

- Flux is the energy flow, or how rapidly energy flows out of the blackbody.
- The total flux from a blackbody is found by adding up the intensity in the spectrum.
- Do you think it depends on temperature?

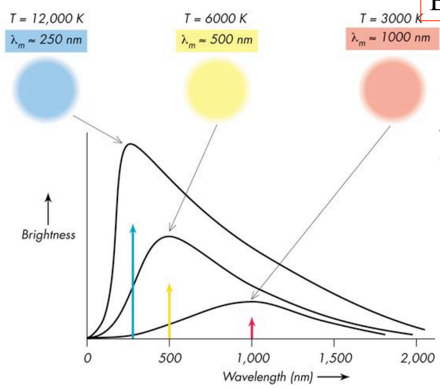


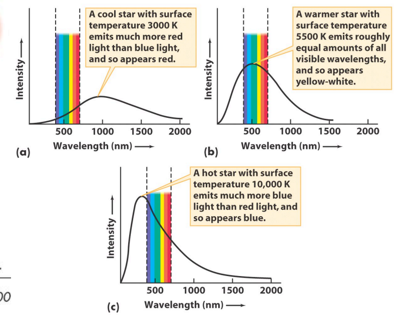

a) Yes
b) No

## Stellar Colors

- Higher temperature → brighter, bluer
- Lower temperature → dimmer, redder

Brightness assumes same radius




## Color me..

White hot Sirius to a red supergiant Betelgeuse


## Still Why Different Colors

So, stars have different colors, thus temperatures.

Why different temperatures?

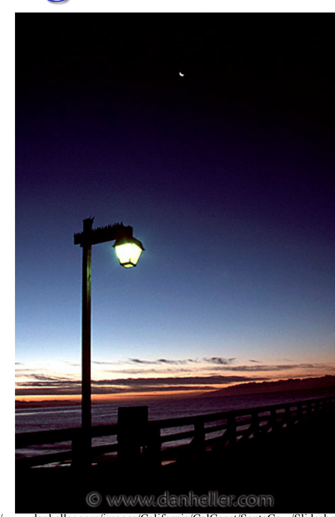
Stay tuned….

What about the brightness of stars?


## Which is Brighter?

a) Moon
b) Streetlamp

- Why?
- *Apparent brightness* and *luminosity* difference.




http://www.danheller.com/images/California/CalCoast/SantaCruz/Slideshow/img13.html

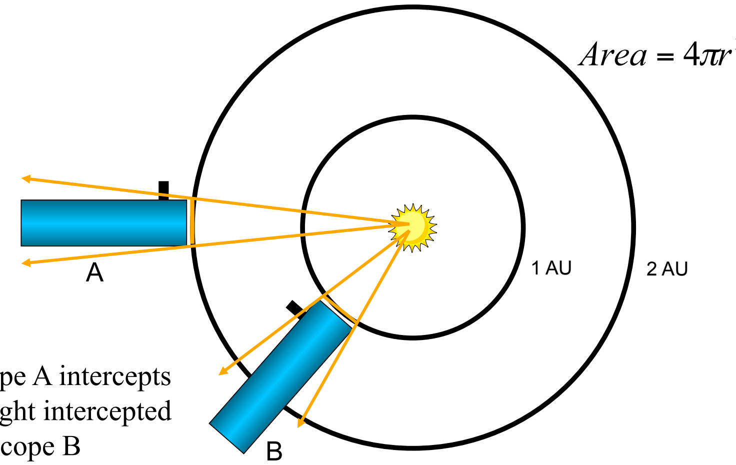
# *Which is Brighter?*

- Apparent brightness (flux) will depend on distance, but…
- Luminosity measures how much energy object emits per second, which is independent on distance.


http://www.danheller.com/images/California/CalCoast/SantaCruz/Slideshow/img13.html

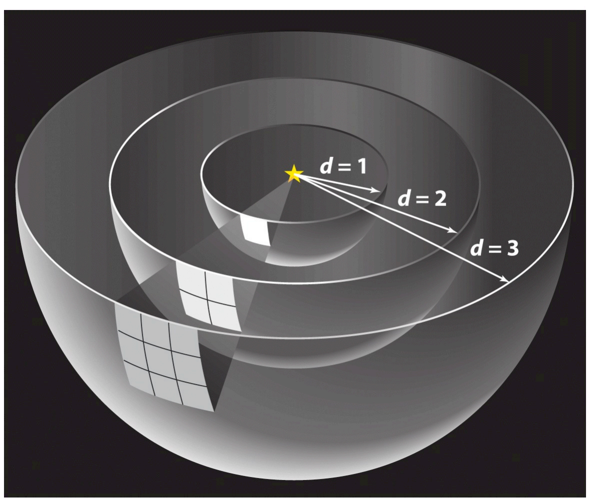
## Why do more distant objects look so much fainter?

- More distant stars of a given luminosity appear dimmer
- Apparent brightness drops as square of distance



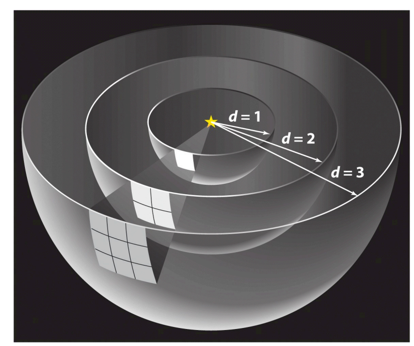

Telescope A intercepts ¼ the light intercepted by telescope B

# *Same number of Photons, but more area.*




# *Luminosity*

- Apparent brightness ≠ luminosity!
- Apparent brightness depends on distance away.
- The farther, the dimmer.
- That's why it's called apparent brightness.



## *Luminosity and Size*

$$L \propto 4\pi R^2 T^4$$

A star's intrinsic brightness (luminosity) depends on its temperature and its size.

A small hot star can be less bright than a huge cool star.

## *In Hawaii*

## *Energy, Temperature, and Surface Area*





Which has more energy output?

## *Maybe not in All Galaxies?*

http://img.photobucket.com/albums/v480/punkboi/Parno2/lava_surfers.jpg

# *Compare to Other Stars*

- We can’t wait for our Sun to die to get an accurate measure of what it’ll go through, so we have to look at other stars.
- How does our color (temperature), output Luminosity (Energy) compare to other stars?
- It’s hard to talk about the differences of stars, when they are so far away, and live astronomical time scales.
- We have to put them all on one diagram.
- We have to get physical.