Stellar Luminosities

- Luminosity is the total amount of energy produced in a star and radiated into space in the form of E-M radiation.

How do we determine the luminosity of the Sun?

1) Measure the Sun's apparent brightness
2) Measure the Sun's distance
3) Use the inverse square law

Luminosity of the Sun

- Another way to look at this is to measure the amount of energy in sunlight falling on a unit surface area, then multiply by the number of unit areas on the surface of a sphere with a radius of 1 `AU'.
- One measure of the Sun's apparent brightness is the `Solar Constant':

$$1.4 \times 10^6 \text{ ergs/cm}^2\text{/second}$$

Interesting energy facts

- `erg' is not a joke, it is a unit of energy
- A black horse outside on a sunny day absorbs about 8×10^9 ergs/sec = 1hp
- A normal-sized human emits about 10^9 ergs/sec = 100 watts in the Infrared.

How big is the solar constant?

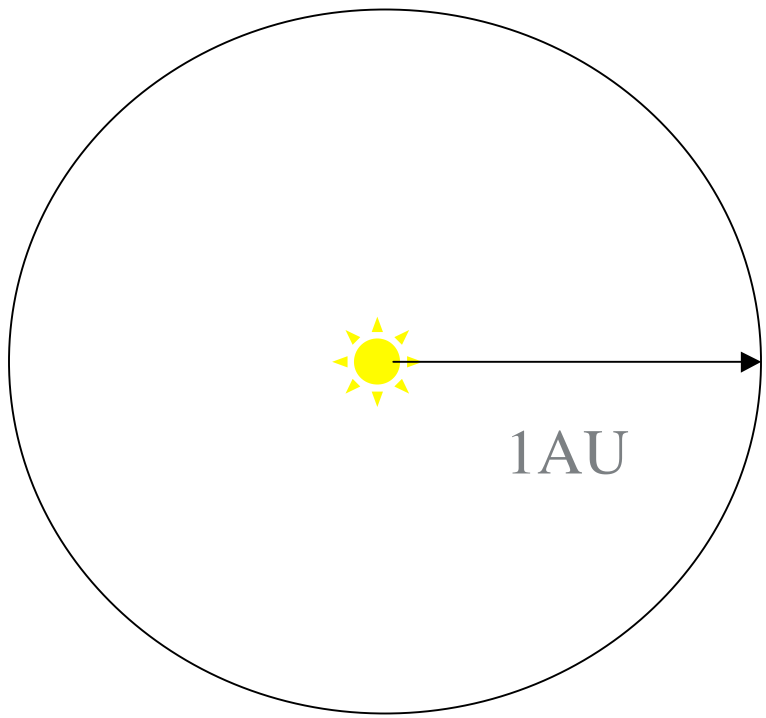
- On a sunny day, the amount of solar energy crashing into the roof of this building is the solar constant times the surface area of the roof.

$$1.4 \times 10^{6} \frac{erg}{cm^{2} \bullet \mathrm{sec}} \times 10^{8} cm^{2} = 1.4 \times 10^{14} \frac{ergs}{\mathrm{sec}}$$

- This is 14 MW (mega-watts). The total campus usage is 3.5 MW.

Solar Luminosity

- Given the solar constant, how do we find the total radiant energy of the Sun?



Surface area of sphere
With radius of 1 AU
Is given by $4\pi R^2$

Solar luminosity

- The surface area of a sphere centered on the Sun with a radius equal to the radius of the Earth’s orbit is:

$$4\pi R^2 = 4\pi(1.5\times10^{10}\,cm^2) = 2.8\times10^{27}\,cm^2$$

- The total energy flowing through this surface is the total energy of the Sun

$$1.4\times10^{6}\,\frac{ergs}{cm^2\bullet\sec}\times2.8\times10^{27}\,cm^2 = 3.9\times10^{33}\,\frac{ergs}{\sec}$$

Solar Luminosity

- L_o=3.9 x 10^{33}ergs/sec
- At Enron rates, the Sun would cost

  10^{20} $/second

Q. What is the Solar Luminosity at the distance of Mars (1.5 AU)?

A. 3.9 x 10^{33} ergs/sec

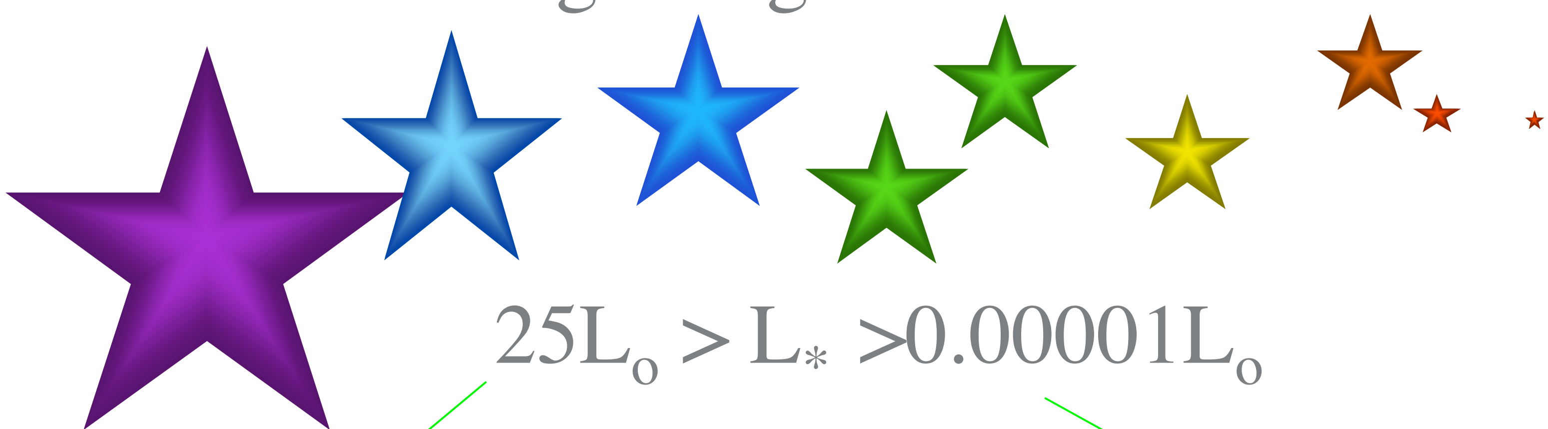
- What is the Solar Luminosity at the surface of the Earth?

- What is the Solar Luminosity at the surface of the Earth?
- Still 3.9×10^{33} ergs/sec!
- Luminosity is an <u>intrinsic</u> property of the Sun (and any star).
- A *REALLY GOOD* question: How does the Sun manage to produce all that energy for at least 4.5 billion years?

Stellar luminosities

- What about the luminosity of all those other stars?
- Apparent brightness is easy to measure, for stars with parallax measures we have the distance. Brightness + distance + inverse square law for dimming allow us to calculate intrinsic luminosity.

- For the nearby stars (to 100 parsecs) we discover a large range in L.



$$25L_o > L_* > 0.00001L_o$$

25 times the Luminosity of the Sun

1/100,000 the luminosity of The Sun

Stellar Luminosity

- When we learn how to get distances beyond the limits of parallax and sample many more stars, we will find there are stars that are stars that are *10^6 times* the luminosity of the Sun.
- This is an enormous range in energy output from stars. This is an important clue in figuring out how they produce their energy.

Q. Two stars have the same Luminosity. Star A has a parallax angle of 1/3 arcsec, Star B has a parallax angle of 1/6 arcsec.

a) Which star is more distant?

Star B has the SMALLER parallax and therefore LARGER distance

Q. Two stars have the same Luminosity. Star A has a parallax angle of 1/3 arcsec, Star B has a parallax angle of 1/6 arcsec.

b) What are the two distances?

$$d = \frac{1}{p}$$

$$d_A = \frac{1}{\left(\frac{1}{3}\right)} = 3\,parsecs$$

$$d_B = \frac{1}{\left(\frac{1}{6}\right)} = 6\,parsecs$$

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c. Compare the apparent brightness of the two stars.

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Star B is twice as far away, same L, If there is no dust along the the line of sight to either star, B will be 1/4 as bright.