

CLASSNOTES 6

Brightness, Luminosity, Distance

- Brightness (apparent magnitude) refers to the energy collected by our eyes/telescopes. (B)
- Luminosity (intrinsic brightness, absolute magnitude) refers to the energy emitted by an object. (L)

If space is totally transparent, B and L are related by the formula

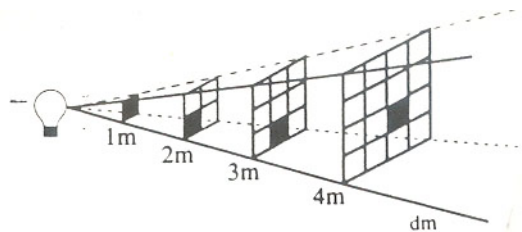
$$B \propto \frac{L}{D^2}$$

where D is the distance between us and the object.

Proof of the Inverse-square Law

Here are two proofs:

1. Suppose a light bulb illuminates the series of transparent screens shown in this diagram



ALL of the emitted light (luminosity) passes through each screen. The screen at 2m is **four** times the area of the one at 1m, the screen at 3m is **nine** times the area of that at 1m. And the one at dm from the lamp has an area **d²** that of the one at 1m.

Now imagine your eye/telescope has an area that enables it to capture all of the light passing through the screen at 1m. This same eye/telescope moved to greater distances will capture less than all of the

light passing through the screen at 1m; the brightness of the lamp will decrease as you move to greater distances.

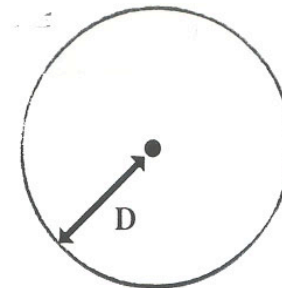
The eye/telescope captures:

- 1/4 of the light at 2m
- 1/9 of the light at 3m
- 1/16 of the light at 4m
- 1/d² of the light at dm

That is

$$B \propto \frac{L}{d^2}$$

2. The second proof is, perhaps, simpler. In very succinct form (I leave you to supply the missing words):



- Energy crossing surface of sphere is L (= Luminosity of star)
- Brightness (B) at Distance D is energy crossing unit area
= L ÷ total area of sphere's surface

$$\propto \frac{L}{D^2} \quad \boxed{B \propto \frac{L}{D^2}}$$

In reality, space between stars is not fully transparent. Minute interstellar dust grains scatter/absorb light → Dim **and** Redden light. Dust is concentrated in the Milky Way.

Olbers' Paradox (Seeds pp. 379-381)

Although Olbers presented his paradox long after the invention of the telescope, it is a paradox that could and was appreciated before the introduction of the telescope. Indeed, it was by the Englishman Thomas Digges in 1576.

Olbers' Paradox will be discussed in class. The key to this discussion is either of the two proofs of the Inverse-square Law.

Reminder: No detailed understanding of magnitudes is needed. No problems involving magnitudes will be set.

It will suffice if you remember:

- the difference between apparent and absolute magnitude
- larger magnitudes apply to fainter (less luminous) stars.