Topic E

Part 4. "Magnitudes"

(Web Version: 08-15-01)

Quick Magnitude Review

Recall astronomers use ***magnitudes***

Magnitude = ***brightness*** (not size)

Algebraically

- Small numbers = bright
- Large numbers = faint

Magnitude Scale*

Very bright objects: negative mag.

- Sun -27
- Full Moon -13
- Venus -4½
- Jupiter -2½
- ***Sirius*** -1½
- etc.

* See ***Study Guide*** Table 1

	:	Sun
	- 5.00	Venus
Very Bright	- 4.00	
	- 3.00	Jupiter
	- 2.00	
	- 1.00	***Sirius***
	0.00	
	+ 1.00	
	+ 2.00	***Polaris***
	+ 3.00	
	+ 4.00	
	+ 5.00	
Approx. Naked Eye Limit	+ 6.00	⇦
	+ 7.00	
	+ 8.00	
	+ 9.00	Neptune
	+10.00	
Very Faint	:	

Magnitude Scale

- Scale Definition

  If Difference = 5 mag,

  Brightness Factor (or Ratio) = 100 x

- Does not matter where difference taken

	-5.00
	-4.00
Difference = 5 mag, Brightness = 100 x	-3.00
	-2.00
	-1.00
	0.00
	+1.00
	+2.00
Difference = 5 mag, Brightness = 100 x	+3.00
	+4.00
	+5.00
Difference = 5 mag, Brightness = 100 x	+6.00
	+7.00
	+8.00
	+9.00
	+10.00

(We won't deal with mag. differences not exactly 5)

Quick Example

Star A: mag. = +4

Star B: mag. = <u>+9</u>

Difference: = 5 mag.

Result: A is 100x brighter

or B is 100x fainter

(i.e., B has 1/100 the brightness of A)

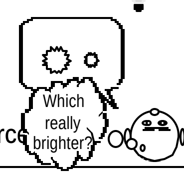
Difference = 5 mag, Brightness = 100 x

-5.00	
-4.00	
-3.00	
-2.00	
-1.00	
0.00	
+1.00	
+2.00	
+3.00	
+4.00	⇦A
+5.00	
+6.00	
+7.00	
+8.00	
+9.00	⇦B
+10.00	

Apparent Magnitudes

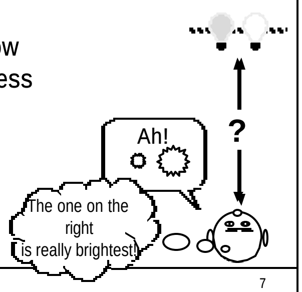
Until now have used magnitudes for ***observed*** brightness

- Designation — ***apparent*** magnitude
- Problem — value depends on distance between observer & source



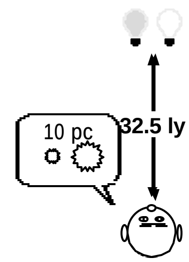
Finding Absolute Brightness

- Line up all stars at ***same distance***
- Observed magnitude now ***true measure*** of brightness
- What distance to use?
  - Doesn't matter (but we should agree on ***same*** value)



We Use Ten Parsecs

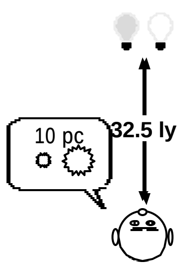
- Choose ***ten parsecs*** Know this! (about 32.5 light years)
- Ten parsecs just right!
  - Simple, small numbers
  - Most magnitudes positive
  - Few very large



Absolute Magnitude

- Definition

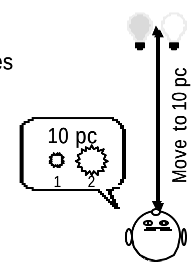
  The apparent magnitude ***if star ten parsecs away***
- Since most stars ***not*** at 10 pc, must ***move stars to 10 pc***



Finding Absolute Magnitude

- To find absolute magnitude
  1) Move stars to 10 pc
  2) Determine how brightness changes
- But how?

  Need a relation between distance and brightness!

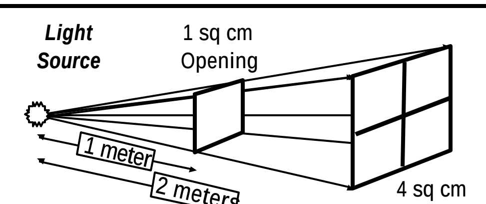


The Brightness Change

- How is brightness change found?
- Evaluated from

  "Inverse Square Law of Light Propagation"
- See ***Study Guide*** Figure 12 Do now!

Result



$B \propto 1/d^2$

Fig. 12

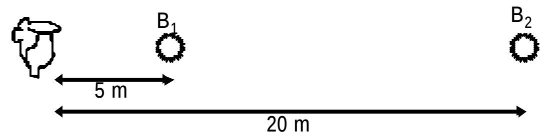
Brightness Change

"Inverse Square Law of Light Propagation"

Brightness of light source varies inversely as square of distance

B µ $1/d^2$

Example

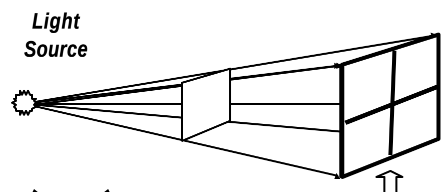


- Question: What is B_2 / B_1?
- Answer: $B_2 / B_1 = (5m / 20m)^2$
  $= (1/4)^2$
  $= 1/16$

Question

Can you think of a situation that might invalidate the inverse square law of light propagation?

Answer?



~~B µ 1/d^2~~

Hint: What might dim this even more?

Interstellar Dust Clouds

- Fine dust in interstellar clouds can dim stars
- Effect greatest for distant stars
- Extinction can be many magnitudes

Stars hidden behind interstellar dust!

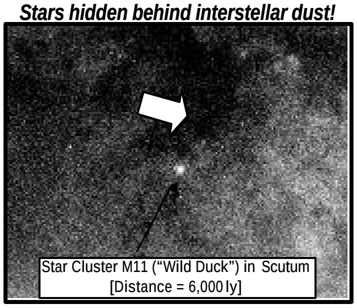


Photo Cred. Jason Ware (http://www.galaxyphoto.com/jwm11.jpg), Meade Schmidt Camera

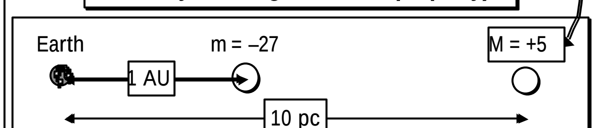
Sun's Absolute Magnitude

One AU: Apparent magnitude = – 26.7 } Apply inv. sq. law

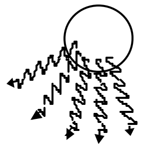
⇨ Ten pc: Absolute magnitude = + 4.8

Know! ⇨ » (+ 5) (approx.)

Sun only 5th mag. star at 10 pc (32 ly)!

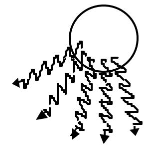


Luminosity (L)



- Absolute magnitude (M)
  - Apparent magnitude if star at 10 pc
  - Measure of intrinsic (real) brightness
- Luminosity (L) ← ***Alternately***
  - M stated as a brightness (light) ratio
  - Also measure of intrinsic (real) brightness
  - L = energy radiated per second

Luminosity (*L*)



- Absolute magnitude of Sun (s) :

  M_s = + 5 (approx.)

- Compare Luminosity with Sun

  Set Sun's luminosity = One solar luminosity

  or L = 1 L_s

Example

WHY?

- Sun: M_s = +5
- Arcturus (Alpha Bootis): M = 0

5 mag. difference is 100x

- Question:

  How many times more luminous than Sun?

- Answer: L = 100 L_s

  (Arcturus emits 100x more radiation than Sun)

See *Study Guide* Table 9

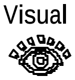
- See Columns 2, 12 & 15
- Has example apparent & absolute mag., and luminosities

But what is this? (→ L_{Sv})

Star	m_v	M_v	L_{Sv}
Sun	-26.7	+4.8	1
Sirius A	-1.5	+1.4	20
Polaris	+2.0	-4.5	5,200
Rigel Kentaurus	0.0	+4.4	1.5
Betelgeuse	+0.04	-5.7	16,000
Barnard's Star	+9.5	+13.2	0.0004

Types of Luminosity

- Visual — Energy radiated only in ***visible***

  (Eye sees only this)

- Bolometric — Total energy radiated over ***entire spectrum***

  GR, XR, UV ← → IR, MW, Radio

(Recall: "Stefan-Boltzmann Law" uses this)

$E_T \propto T^4$ — The ***bolometric luminosity***

See *Study Guide* Table 9

- See also Columns 14 & 16
- Has example ***bolometric*** absolute mag. & luminosities

Star	m_v	M_v	L_{Sv}	M_{bol}	L_{Sbol}
Sun	-26.7	+4.8	1	+4.7	1.0
Sirius A	-1.5	+1.4	20	+1.1	30
Polaris	+2.0	-4.5	5,200	-4.6	5,250
Rigel Kentaurus	0.0	+4.4	1.5	+4.3	1.5
Betelgeuse	+0.04	-5.7	16,000	-7.6	83,000
Barnard's Star	+9.5	+13.2	0.0004	+10.9	0.003

See *Study Guide* Table 9

- See also Columns 14 & 16
- Has example ***bolometric*** absolute mag. & luminosities

Star	m_v	M_v	L_{Sv}	M_{bol}	L_{Sbol}
Sun	-26.7	+4.8	1	+4.7	1.0

Little difference (G type) because most energy in visible

See *Study Guide* Table 9

- See Columns 14 & 16
- Has example ***bolometric*** absolute mag. & luminosities

Very cool stars (M type) — much radiation in IR

Star	m_v	M_v	L_{Sv}	M_{bol}	L_{Sbol}
Betelgeuse	+0.04	-5.7	16,000	-7.6	83,000
Barnard's Star	+9.5	+13.2	0.0004	+10.9	0.003

Compare