

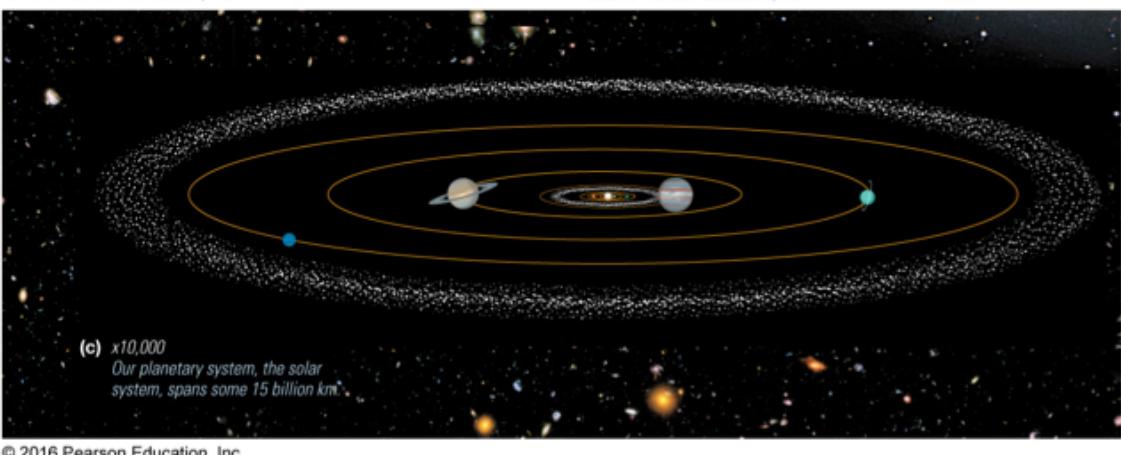
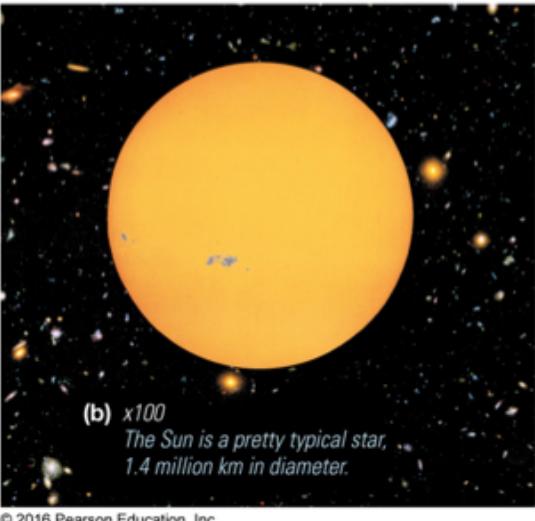
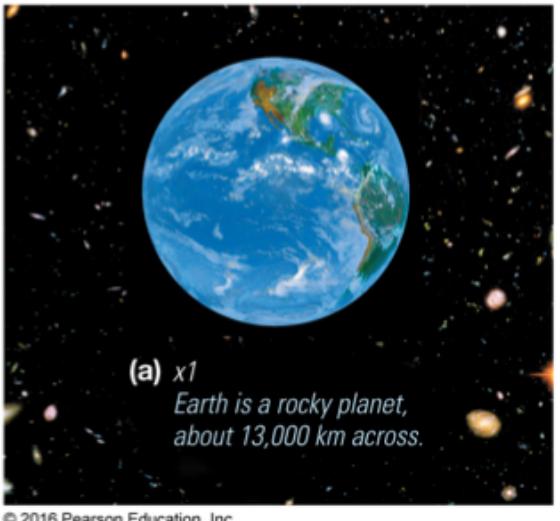
Chapter 1: The Night Sky

Prof. Douglas Laurence

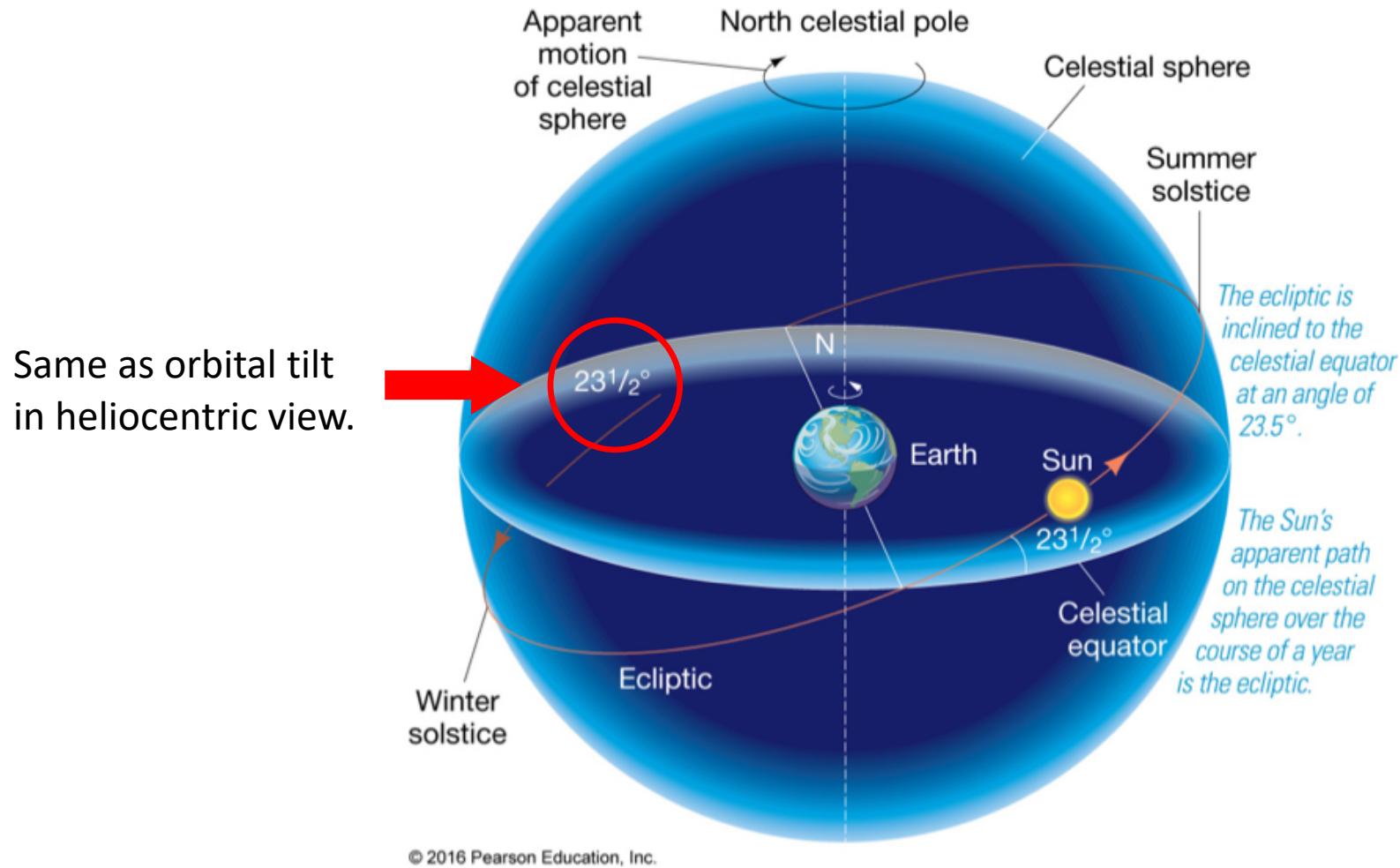
AST 1002

Spring 2018

Order of Magnitude



Geocentric View



Constellations

This is a real photo of the Orion constellation . . .



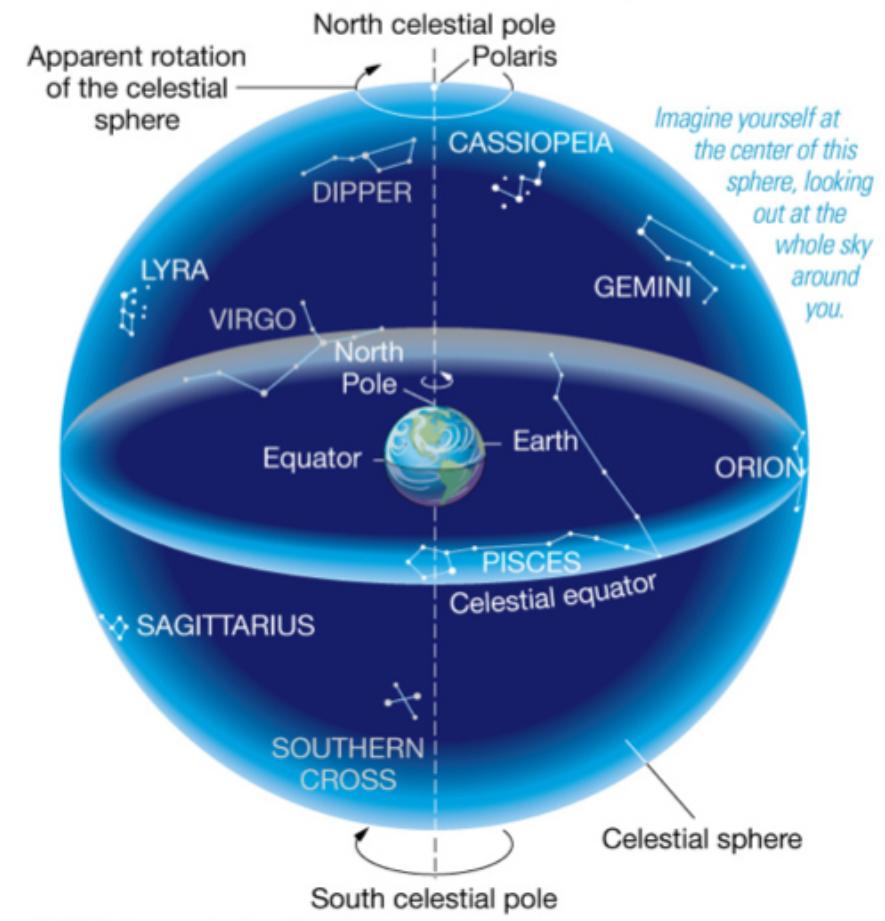
(a)

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. . . and this is a mapped interpretation, to exactly the same scale.

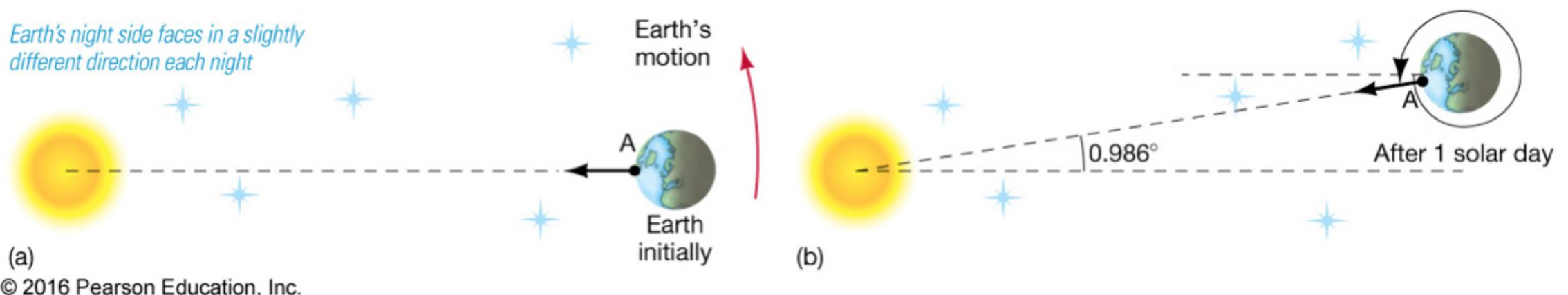


(b)



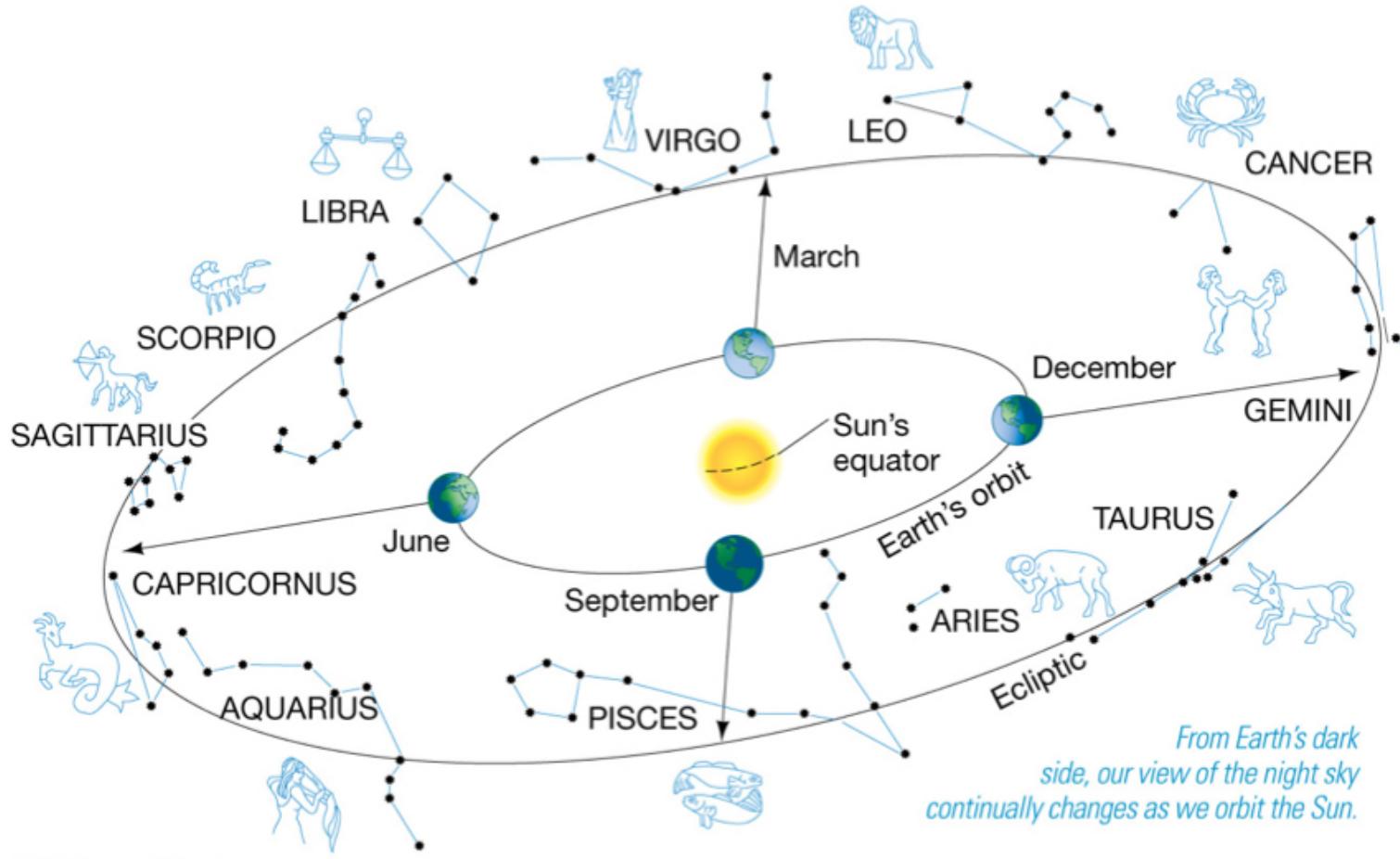
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Sidereal vs. Solar Time



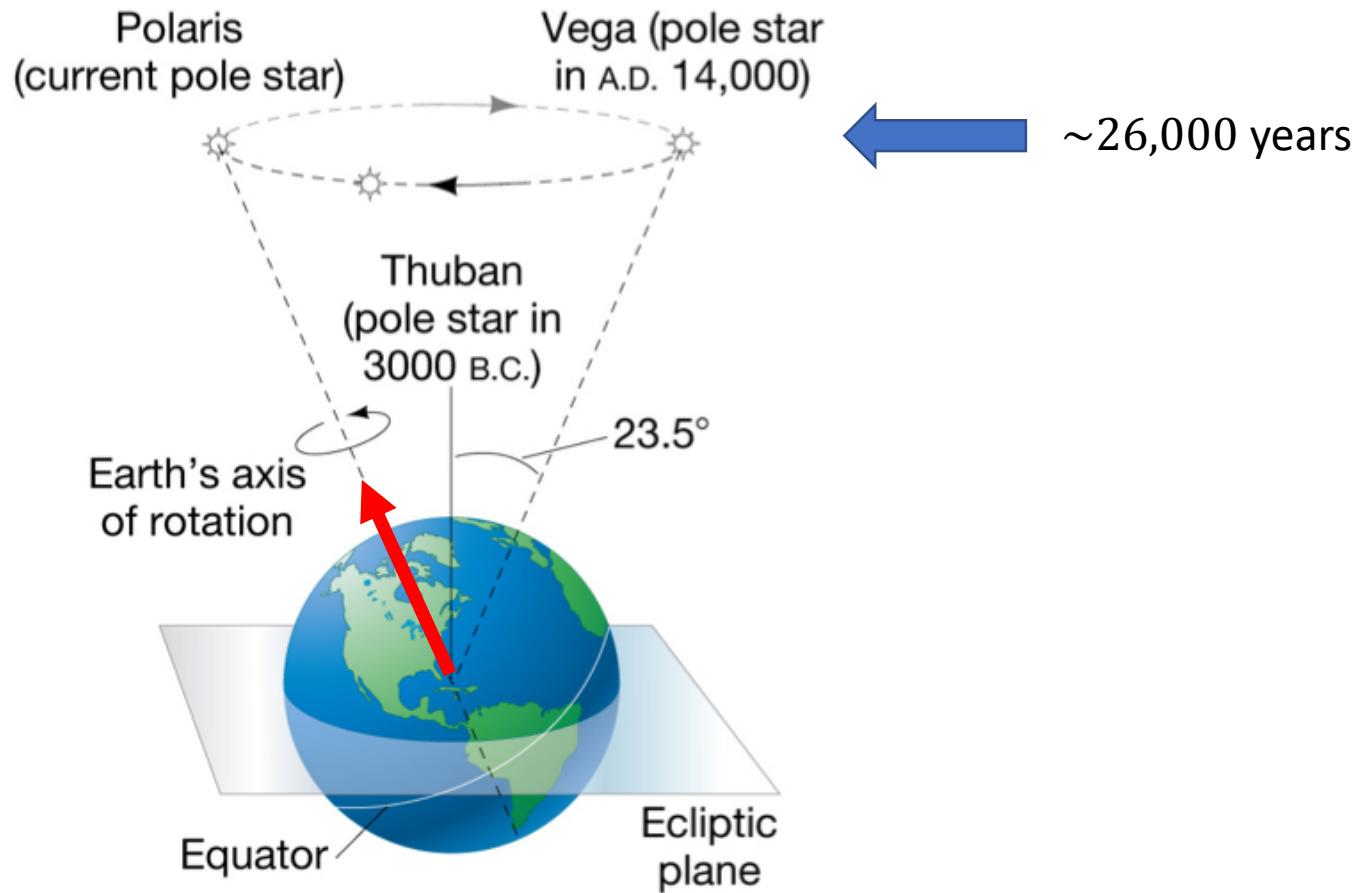
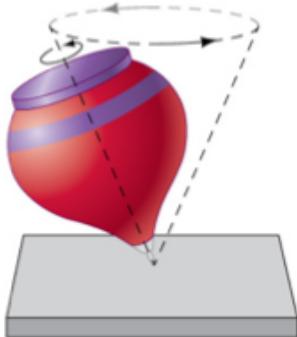
$$24 \text{ solar hours} = 23 \text{ h } 56 \text{ min sidereal time}$$

Seasons and the Night Sky

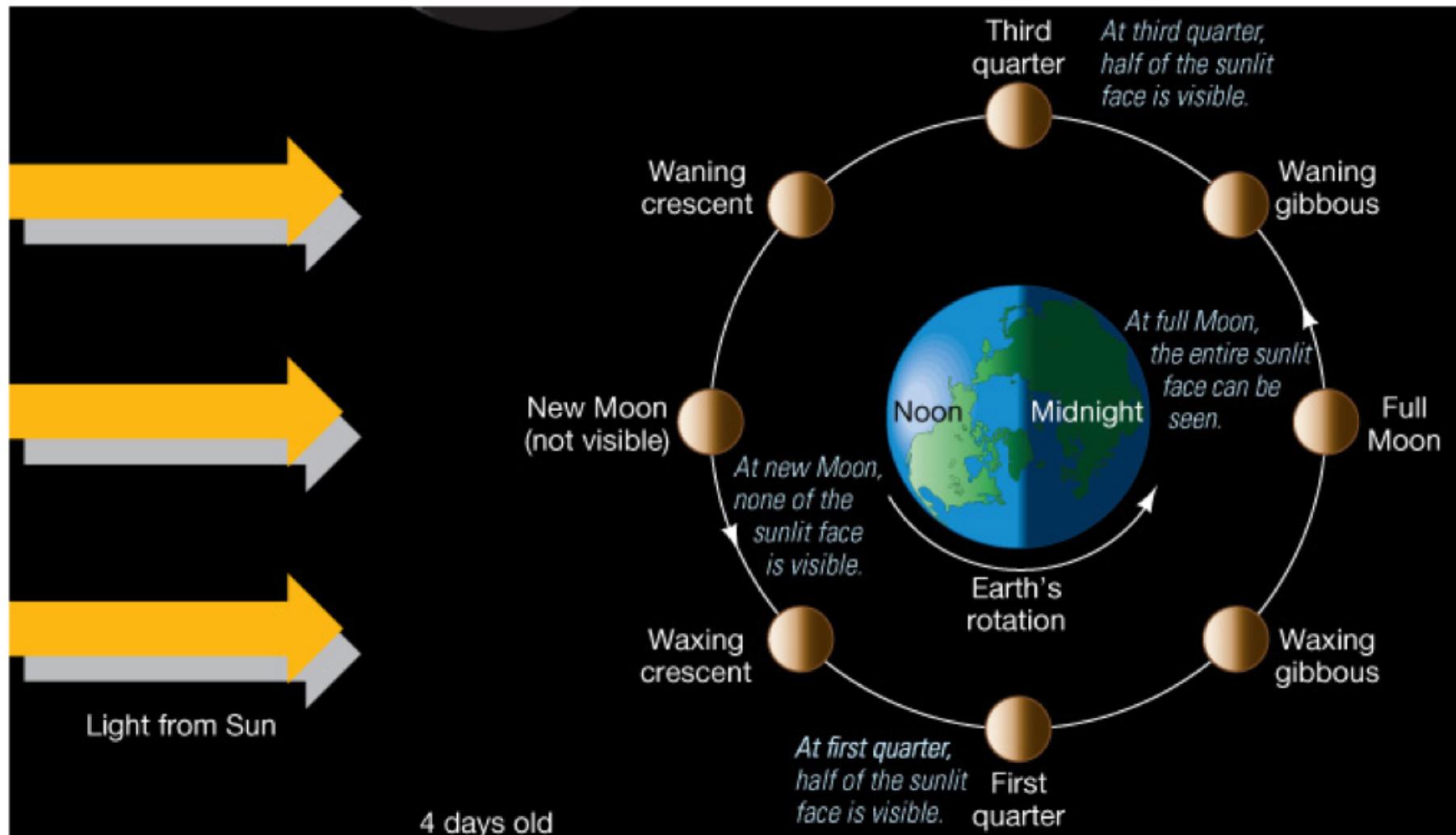


Orbital Precession

Earth precesses like a top, but very, very slowly.



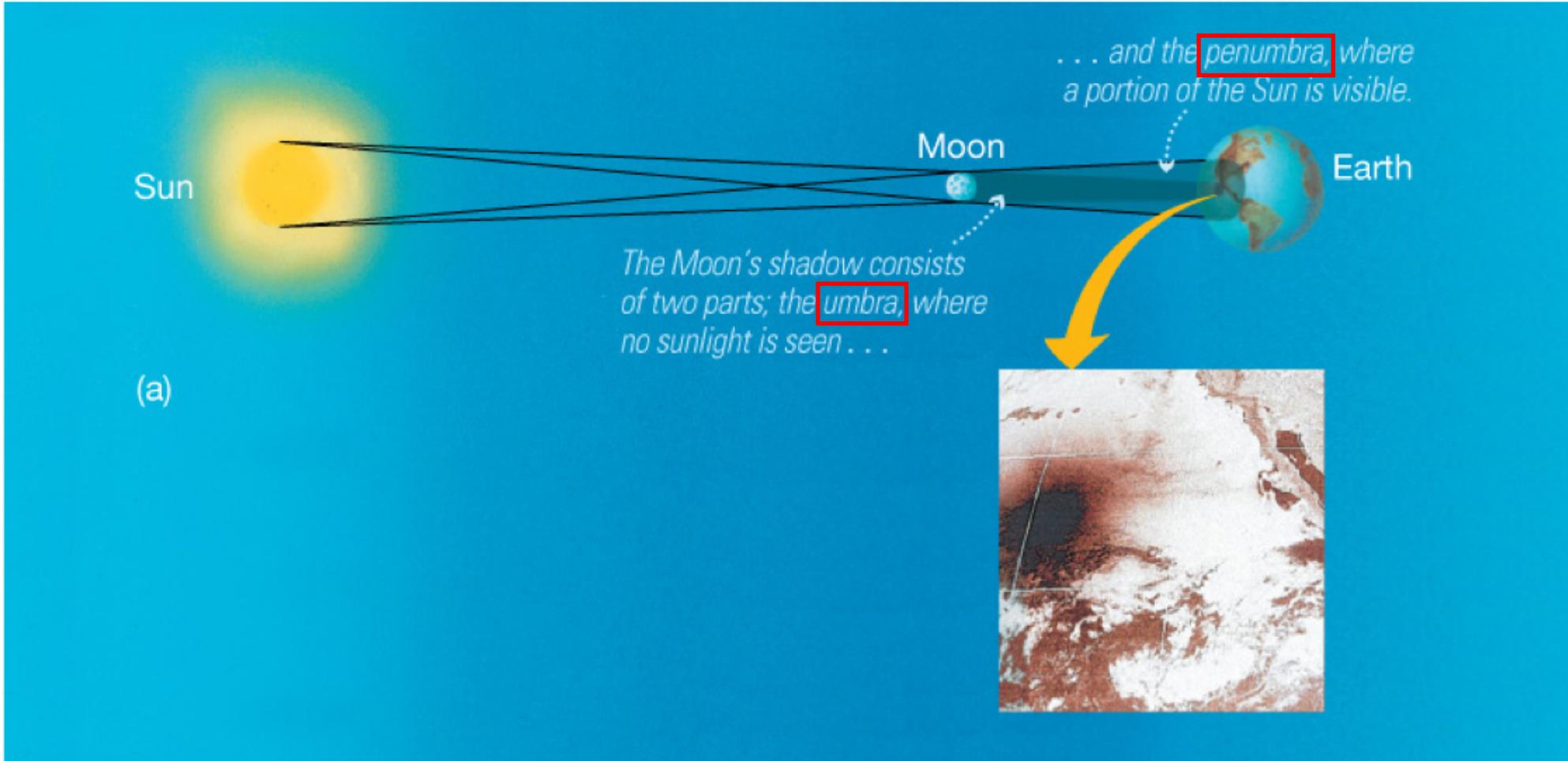
Phases of the Moon



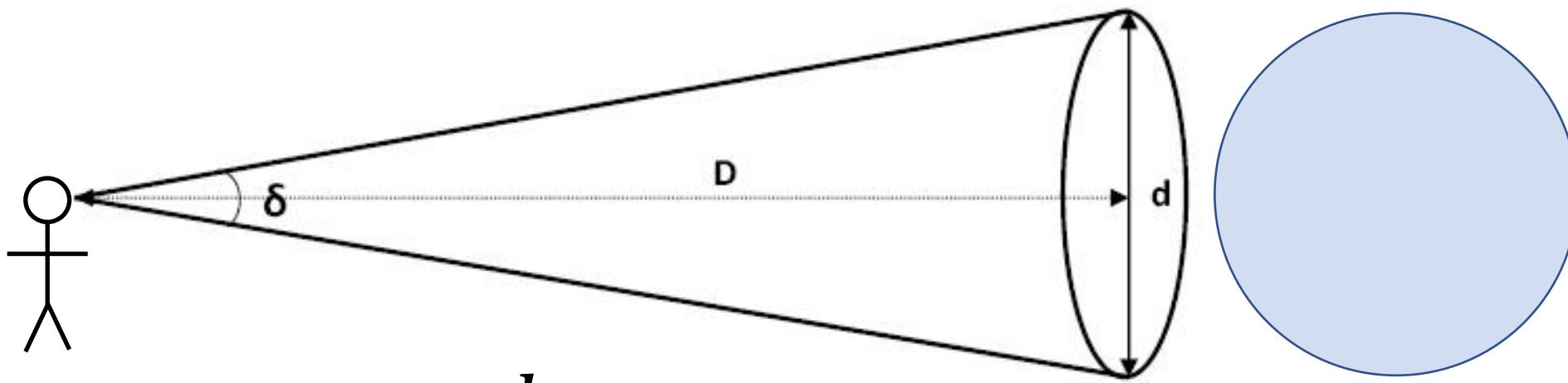
Phases of the Moon (cont'd)



Solar Eclipses

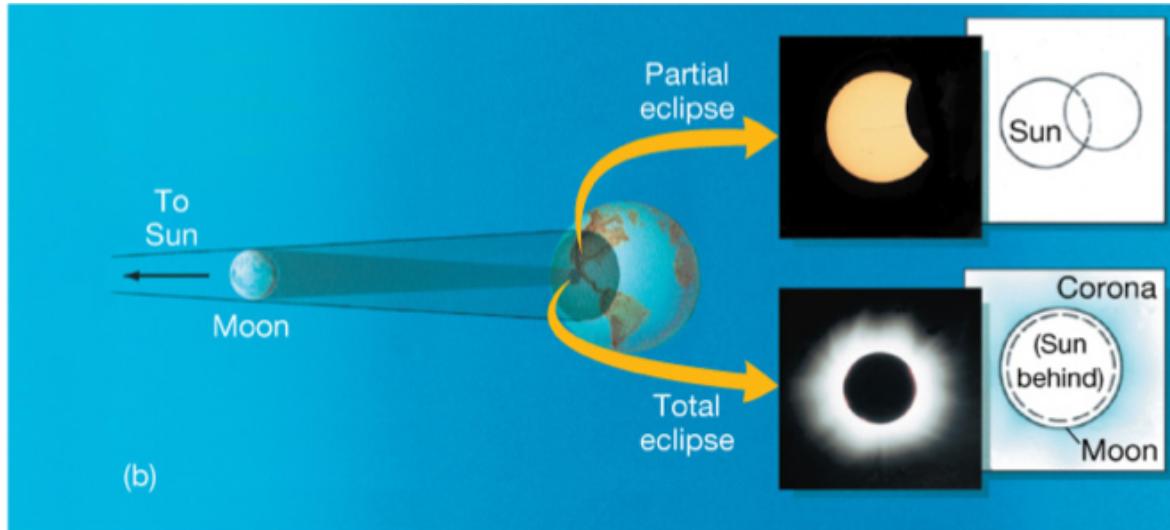


Angular Size



$$\delta \approx \frac{d}{D}$$

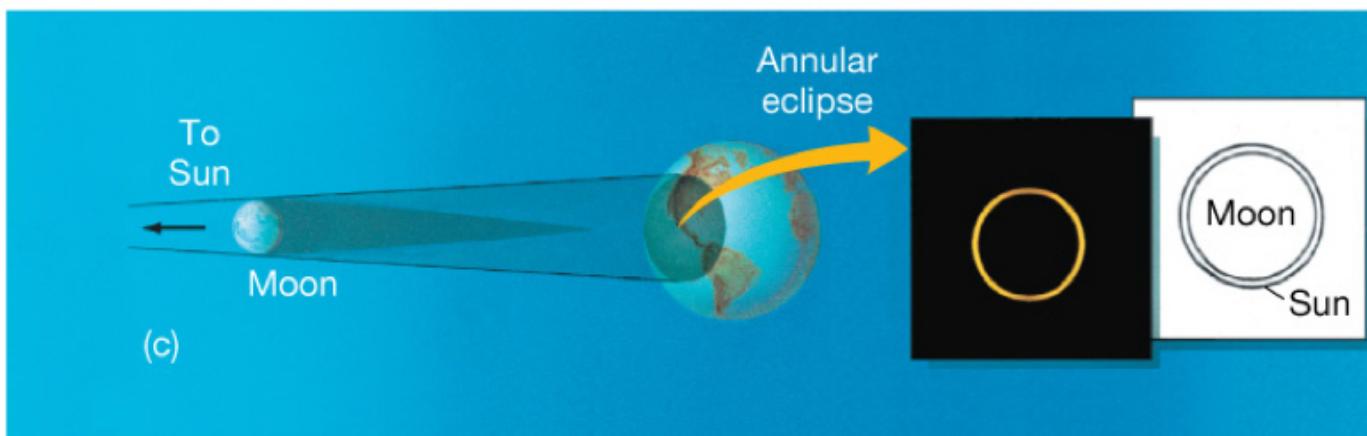
Total vs. Annular Solar Eclipses



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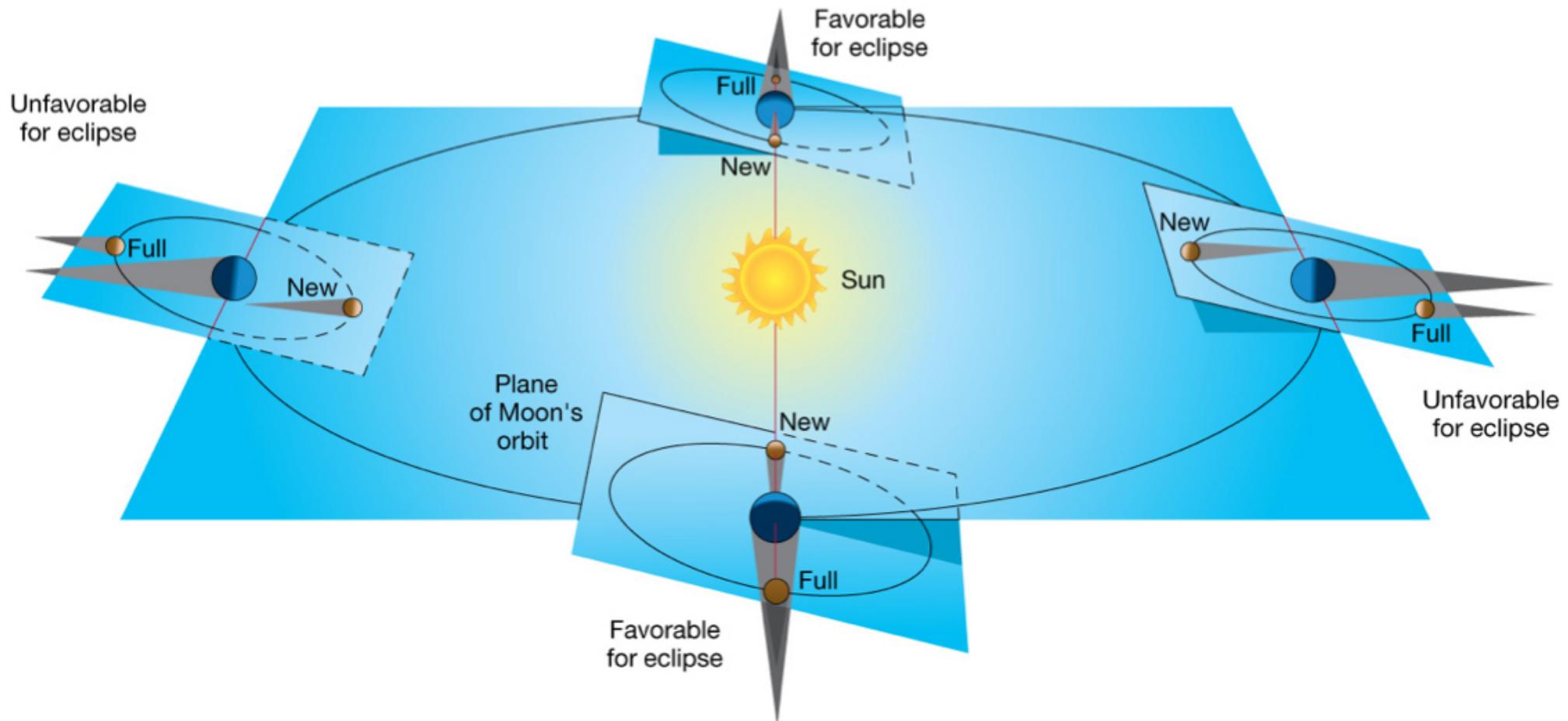
Eclipse Interactive Applet:

https://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::640::480::sites/dl/free/007299181x/220730/eclipse_interactive.swf::Eclipse%20Interactive



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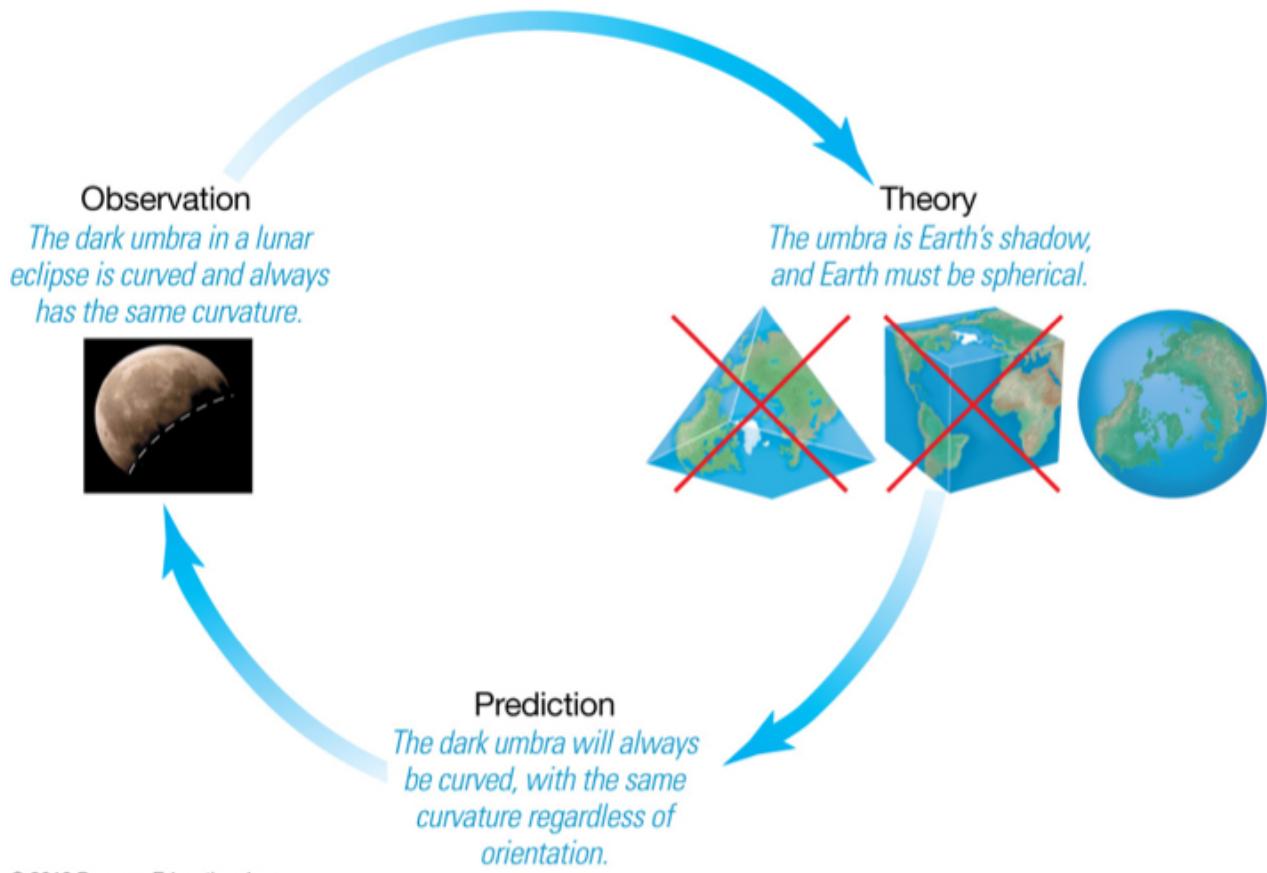
Conditions for Eclipse



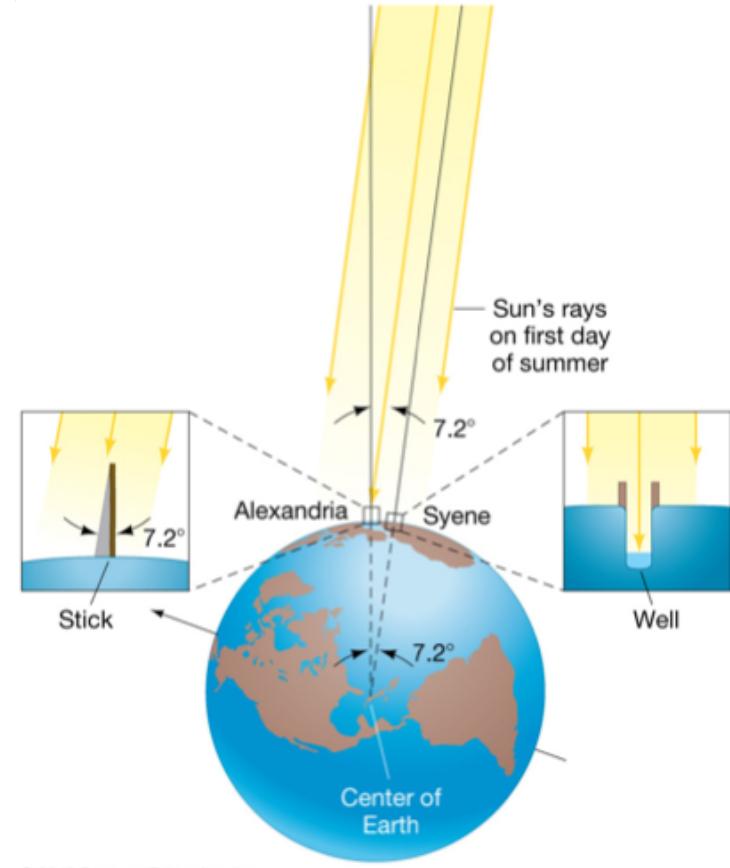
Frequencies of Eclipses

- 2 – 5 solar eclipses occur per year of various types.
 - ~240 per century.
- Total solar eclipses occur somewhere on Earth every ~18mo.
 - But only recur at a given location every ~400yr.
- The moon actually gets further from the Earth each year (3.8 cm/yr) and the sun gets brighter (grows in angular size), so between 650M – 1.4B yr from now, total eclipse will be impossible.

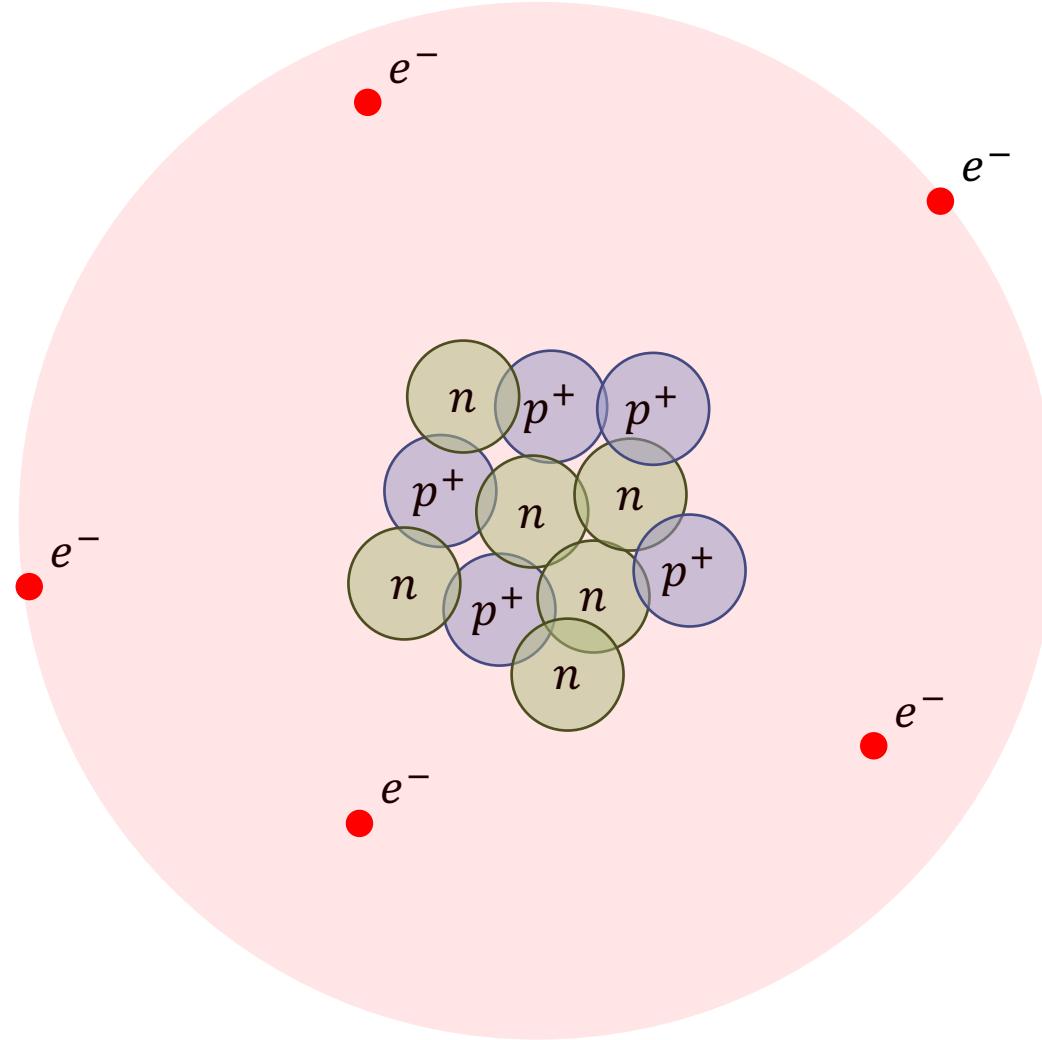
Scientific Method



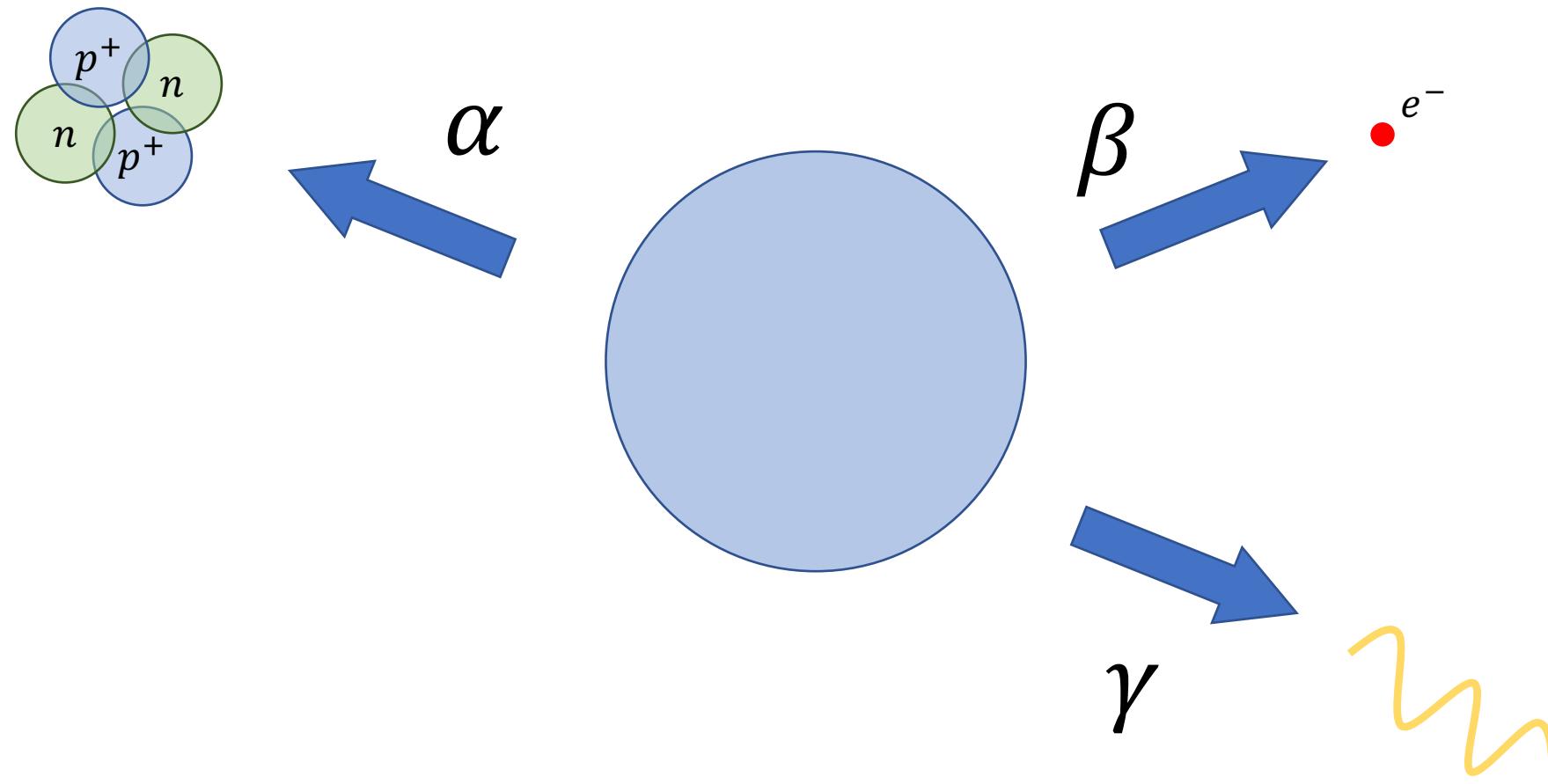
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Atoms



Types of Radiation



Mass-Energy Equivalence

$$E = mc^2$$

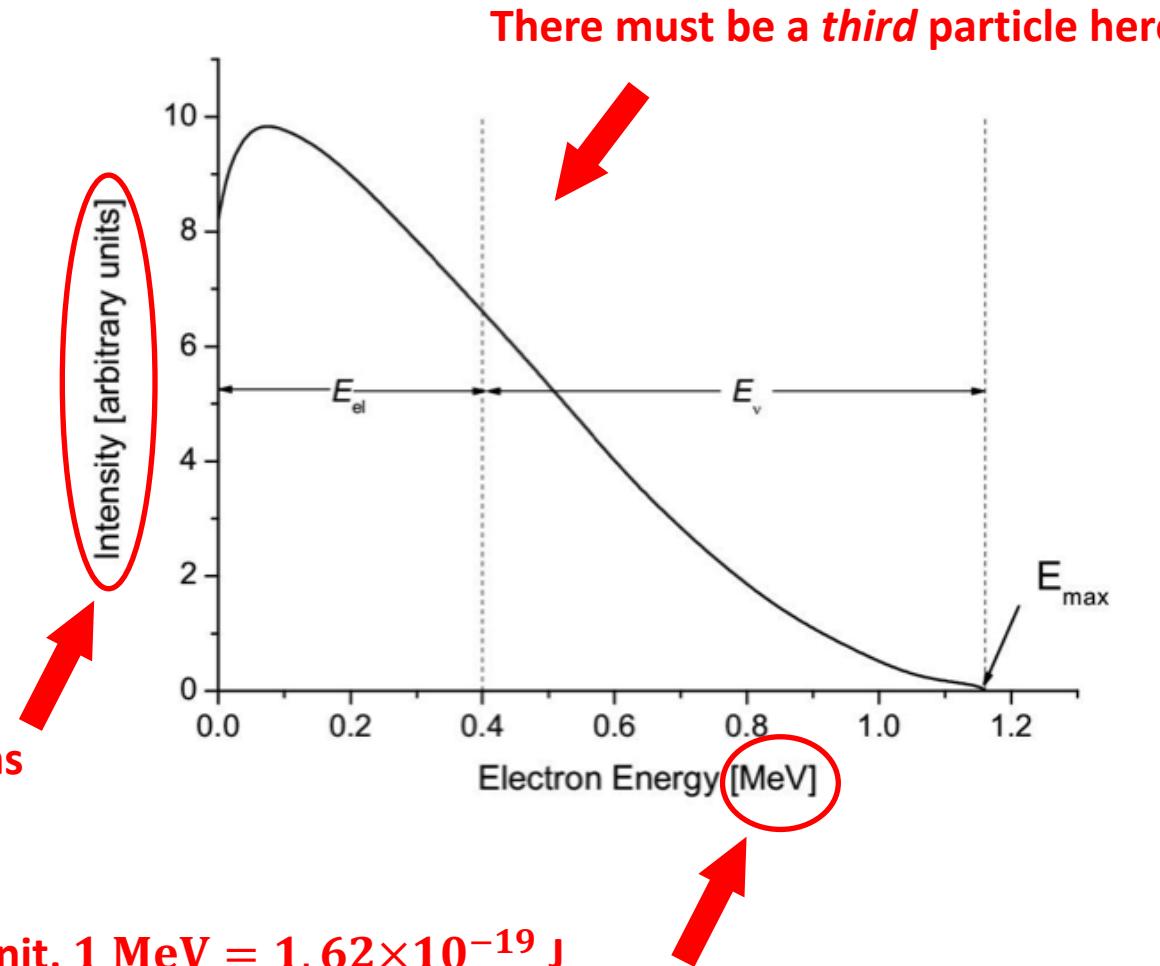
β -Decay



$$\Delta E = 1.252 \times 10^{-13} \text{ J}$$

Number of electrons

Weird energy unit, 1 MeV = $1.62 \times 10^{-19} \text{ J}$



Elementary Particles

2 Types of Matter:

- Quarks
- Leptons

Three Generations of Matter (Fermions)				Bosons (Forces)	
	I	II	III		
mass→	3 MeV	1.24 GeV	172.5 GeV	0	125.7 GeV
charge→	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
s/m →	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
name→	u up	c charm	t top	γ photon	Higgs Higgs
Quarks		Bosons (Forces)		Graviton	
d	s	b	g	G	Graviton
down	strange	bottom	gluon		
$<2 \text{ eV}$	$<0.19 \text{ MeV}$	$<18.2 \text{ MeV}$	Z^0		
0	0	0	0		
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$		
ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	Z^0 weak force		
Leptons		Matter		Forces	
e	μ	τ	W ⁺		
electron	muon	tau	weak force		
0.511 MeV	106 MeV	1.78 GeV	80.4 GeV		
-1	-1	-1	± 1		
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1		

4 Fundamental Forces:

- Strong Force
- Weak Force
- Electromagnetic Force
- Gravity

Quarks

Quarks	3 MeV $\frac{2}{3}$ $\frac{1}{2}$ up	1.24 GeV $\frac{2}{3}$ $\frac{1}{2}$ charm	172.5 GeV $\frac{2}{3}$ $\frac{1}{2}$ top	Bosons (Forces)	0 0 1 photon	125.7 GeV 0 0 Higgs
	6 MeV $-\frac{1}{3}$ $\frac{1}{2}$ down	95 MeV $-\frac{1}{3}$ $\frac{1}{2}$ strange	4.2 GeV $-\frac{1}{3}$ $\frac{1}{2}$ bottom		0 0 1 gluon	0 0 2 Graviton
					90.2 GeV 0 1 Z ⁰ weak force	
					80.4 GeV ± 1 1 W ⁺ weak force	

$$u + u + d + (\text{gluons}) \rightarrow p^+$$

$$u + d + d + (\text{gluons}) \rightarrow n$$

Leptons

No electric charge
= no electric force!

Leptons			Bosons (Forces)		
ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	γ photon	H Higgs	
0.511 MeV -1 $\frac{1}{2}$ electron	106 MeV -1 $\frac{1}{2}$ muon	1.78 GeV -1 $\frac{1}{2}$ tau	g gluon	G Graviton	
			Z^0 weak force	$e^- + p^+ + (\text{photon}) \rightarrow H$	
			W^\pm weak force	$n \rightarrow p^+ + e^- + \bar{\nu}_e$	

$$e^- + p^+ + (\text{photon}) \rightarrow H$$

$$n \rightarrow p^+ + e^- + \bar{\nu}_e$$

No strong force!

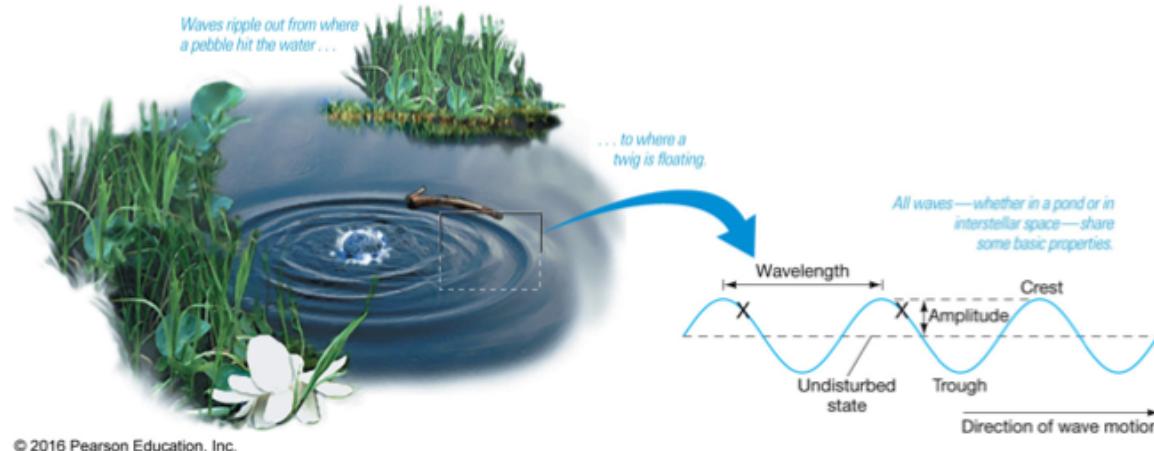
Chapter 2: Light and Telescopes

Prof. Douglas Laurence

AST 1002

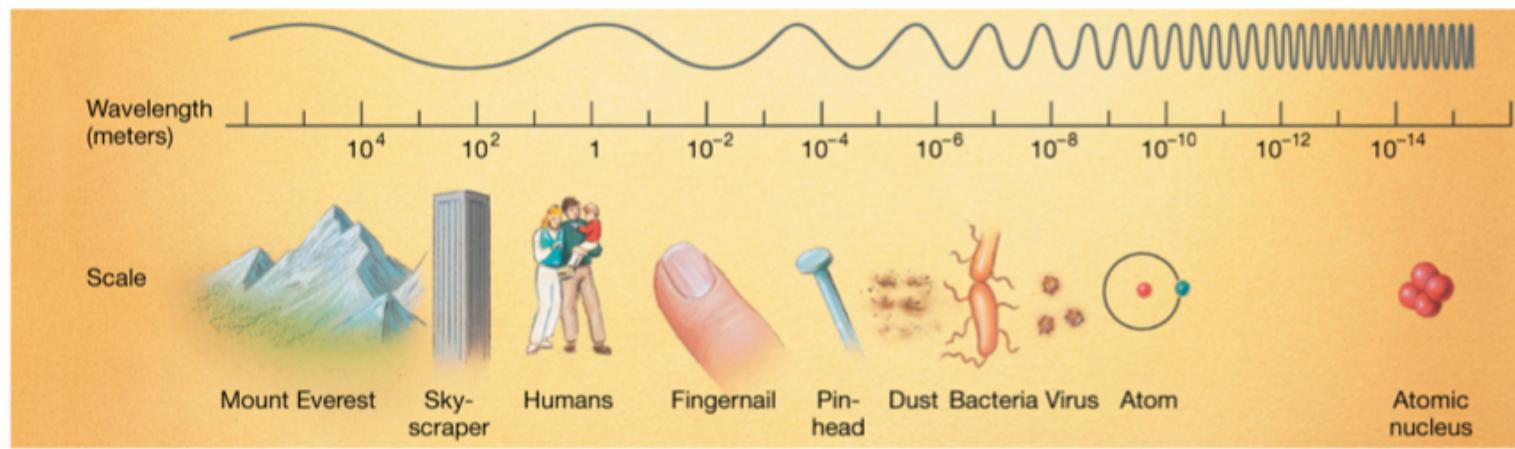
Spring 2018

Electromagnetic Radiation

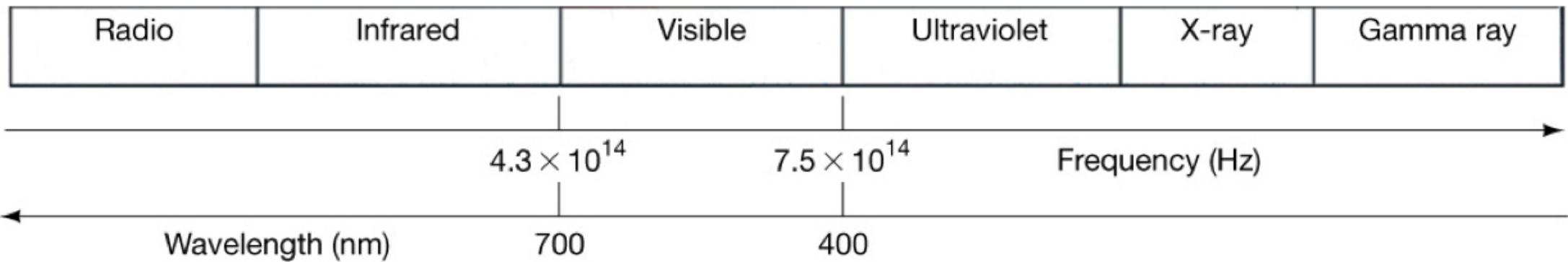
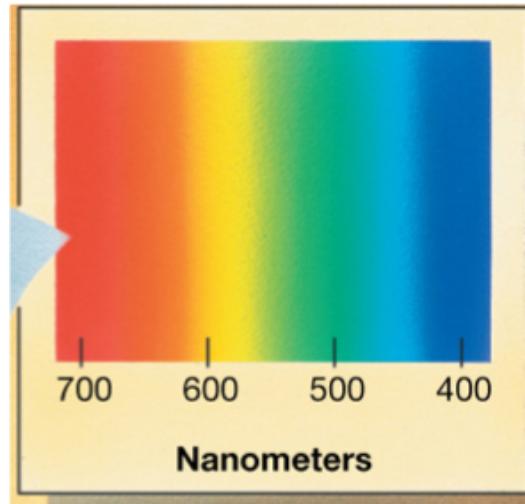


$$v = \lambda f$$

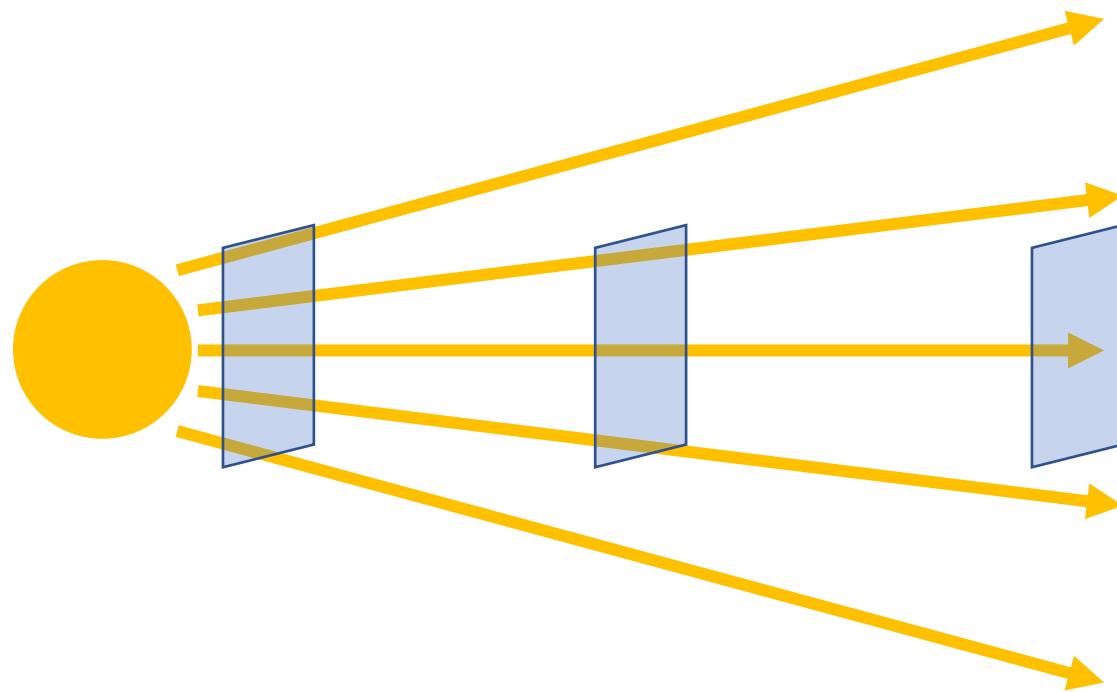
$$E = hf$$



Visible Light Spectrum



Isotropic Emission



Brightness *decreases* with distance (squared)

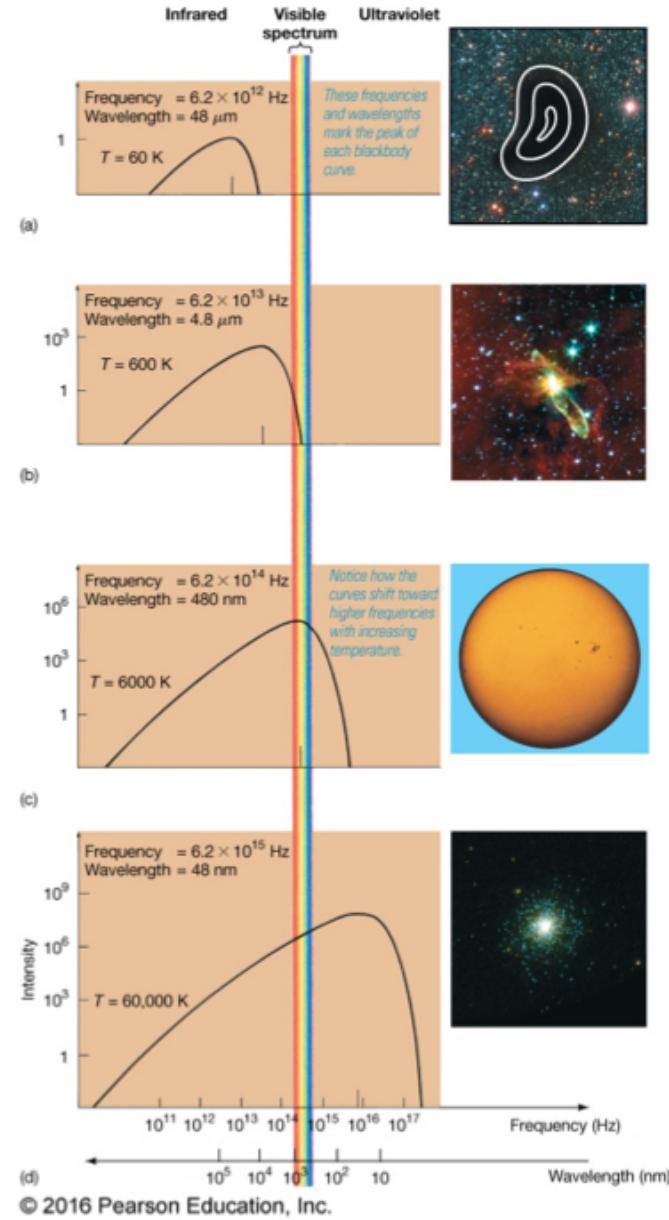
Blackbody Radiation

Stefan-Boltzmann Law:

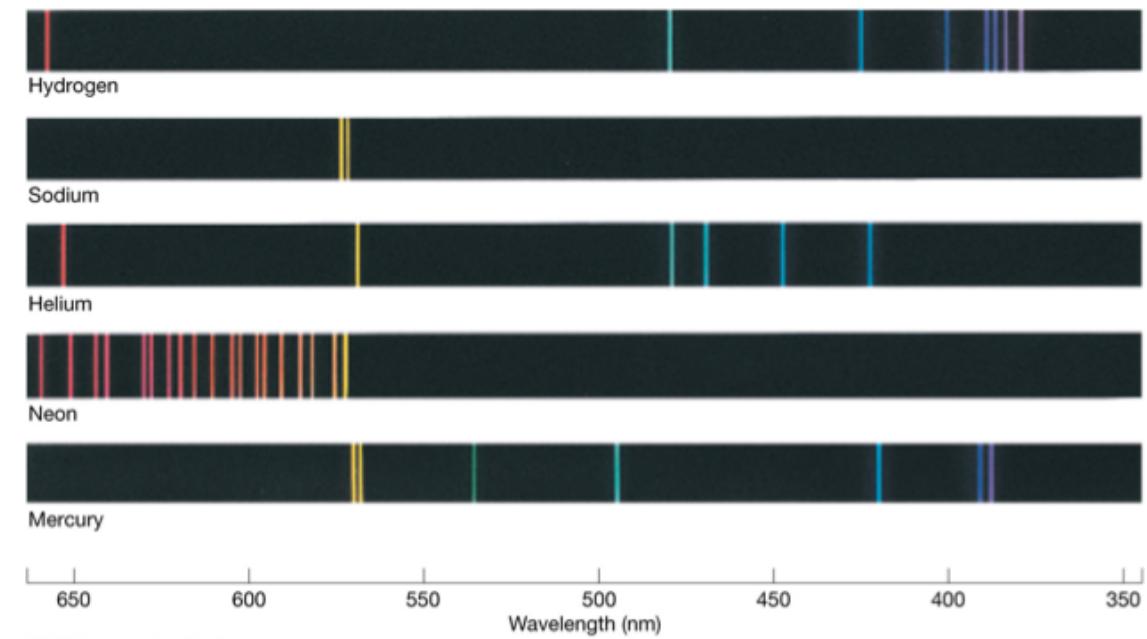
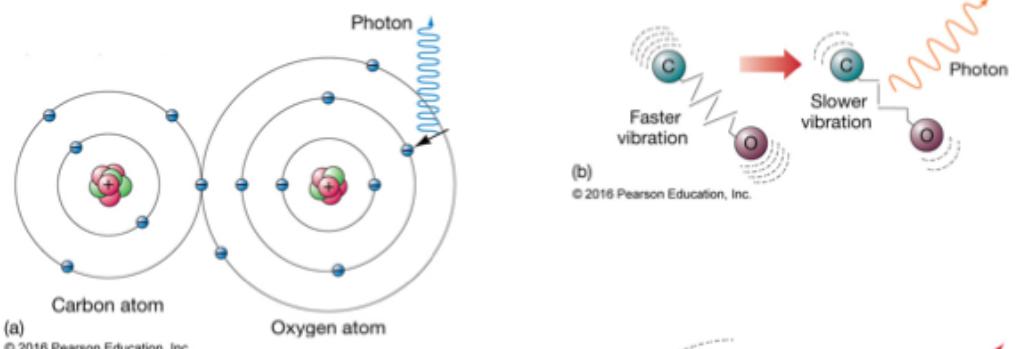
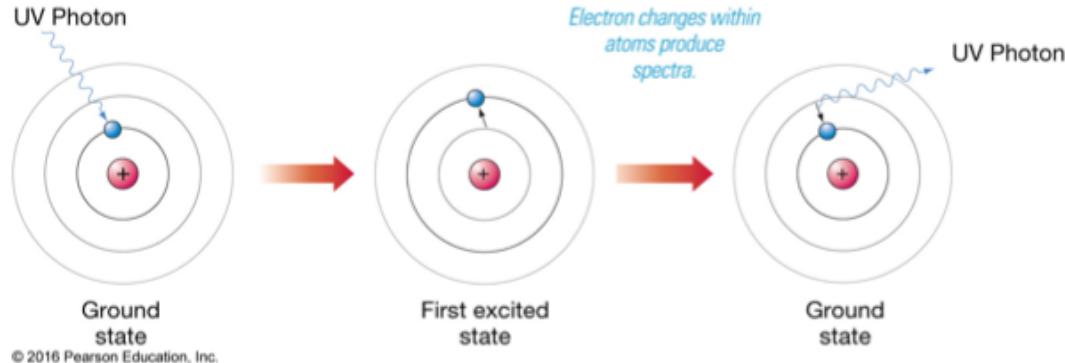
$$I = \sigma T^4$$

Wein's Law:

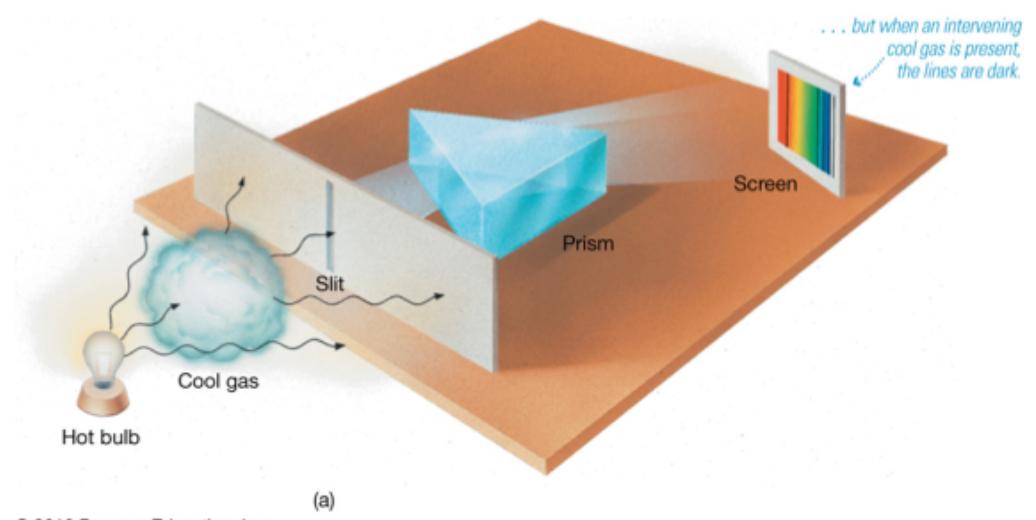
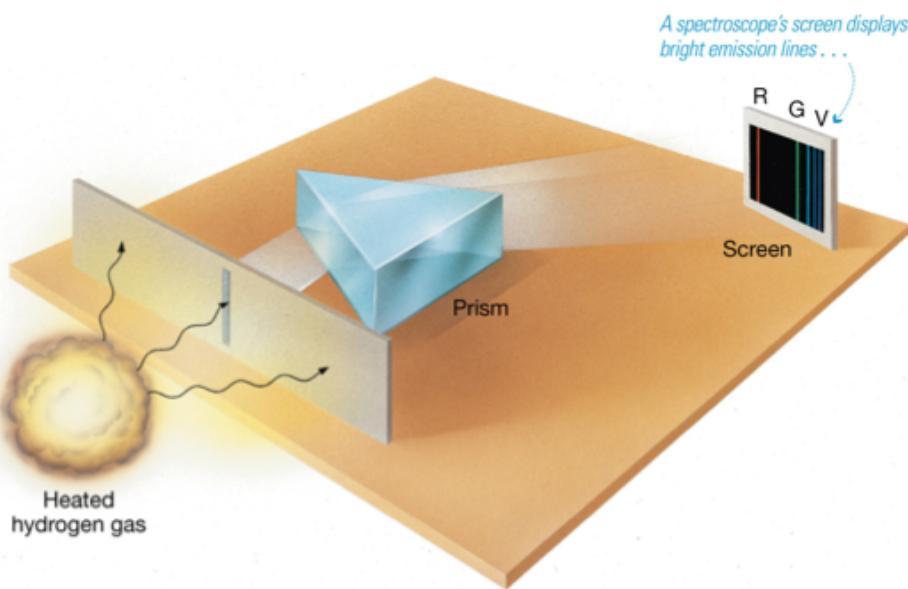
$$\lambda_{max} = \frac{b}{T}$$



Emission and Absorption of Photons



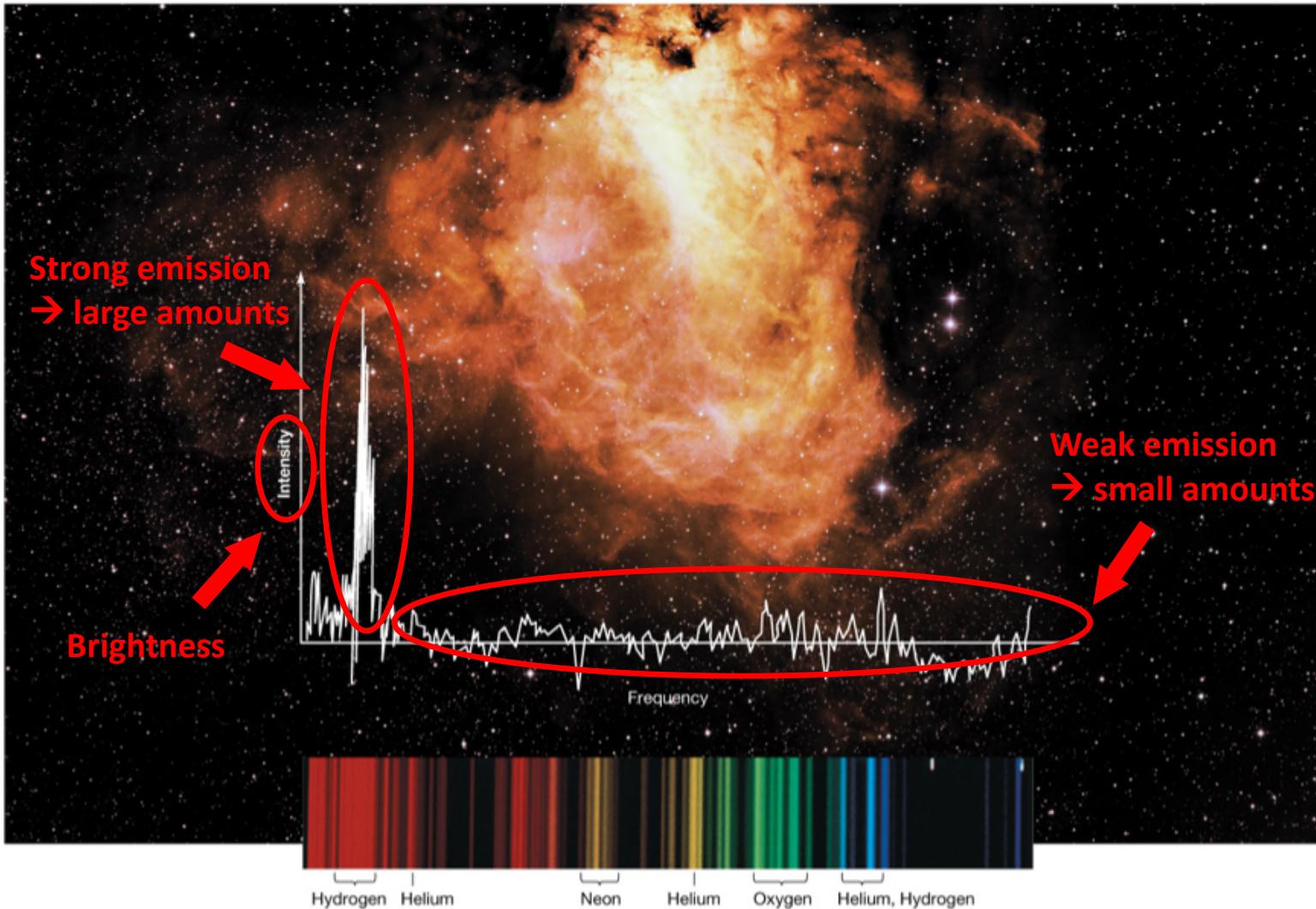
Spectroscopy



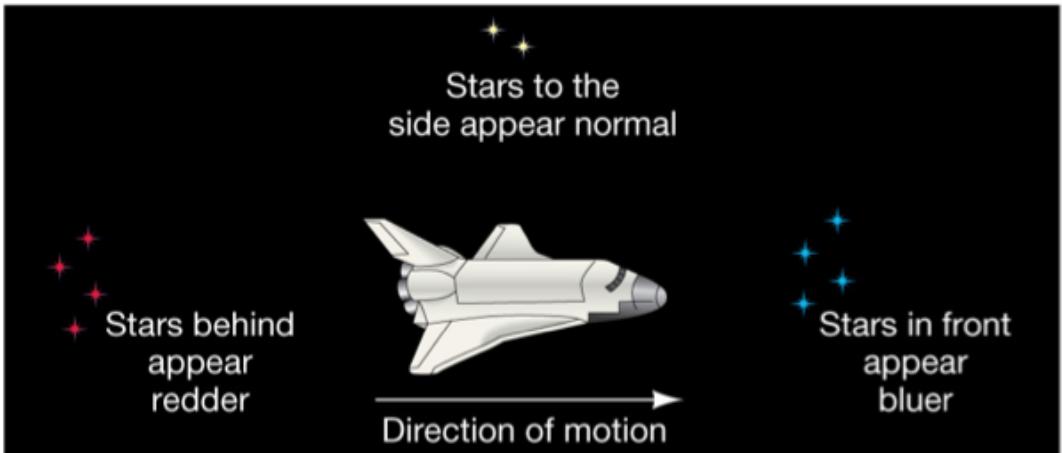
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Detecting Chemical Elements



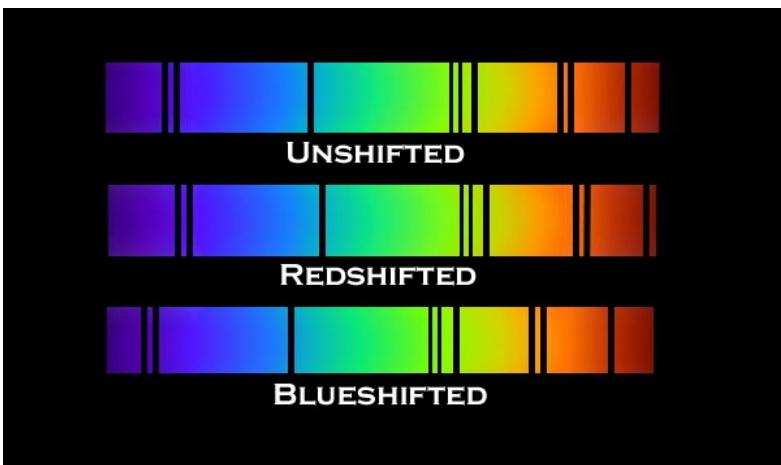
Doppler Effect



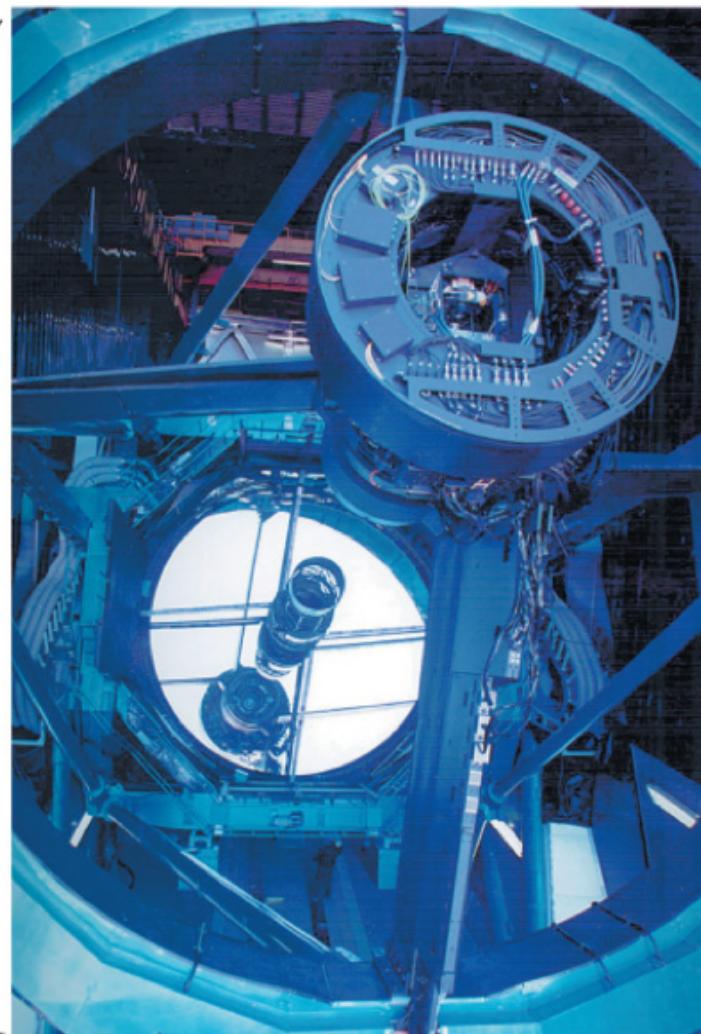
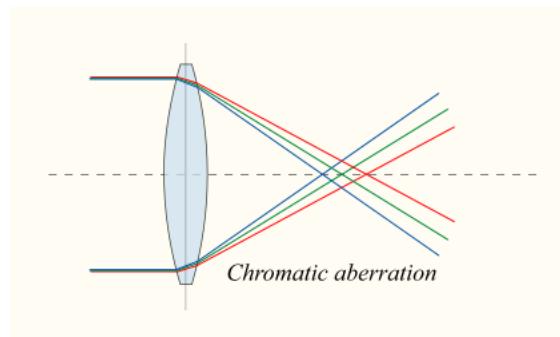
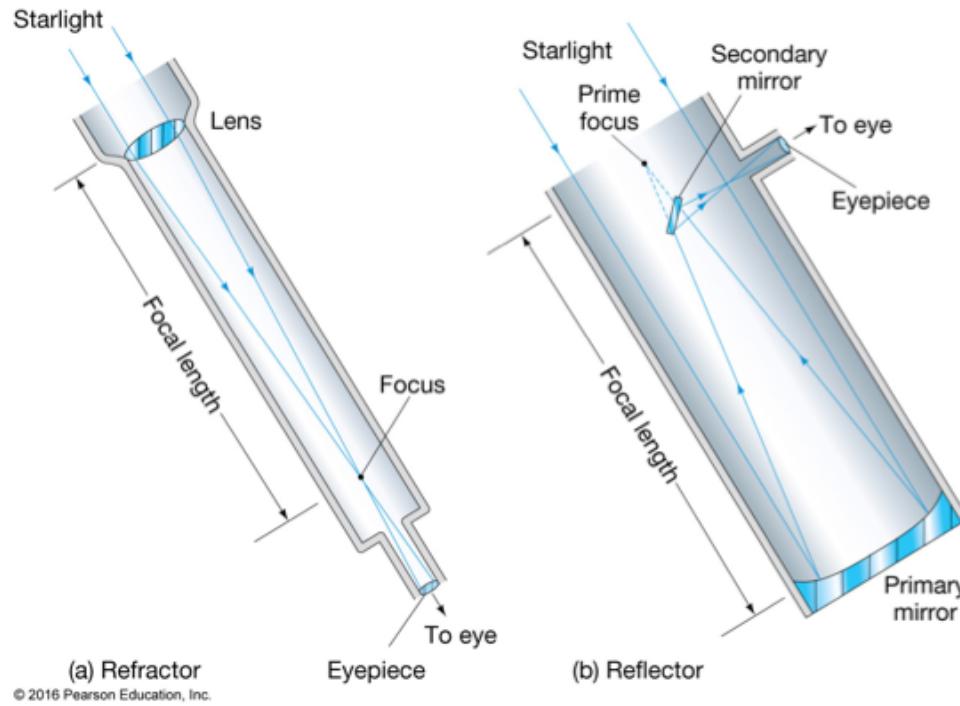
(a)

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$$\Delta f = \frac{v}{c} f_0$$

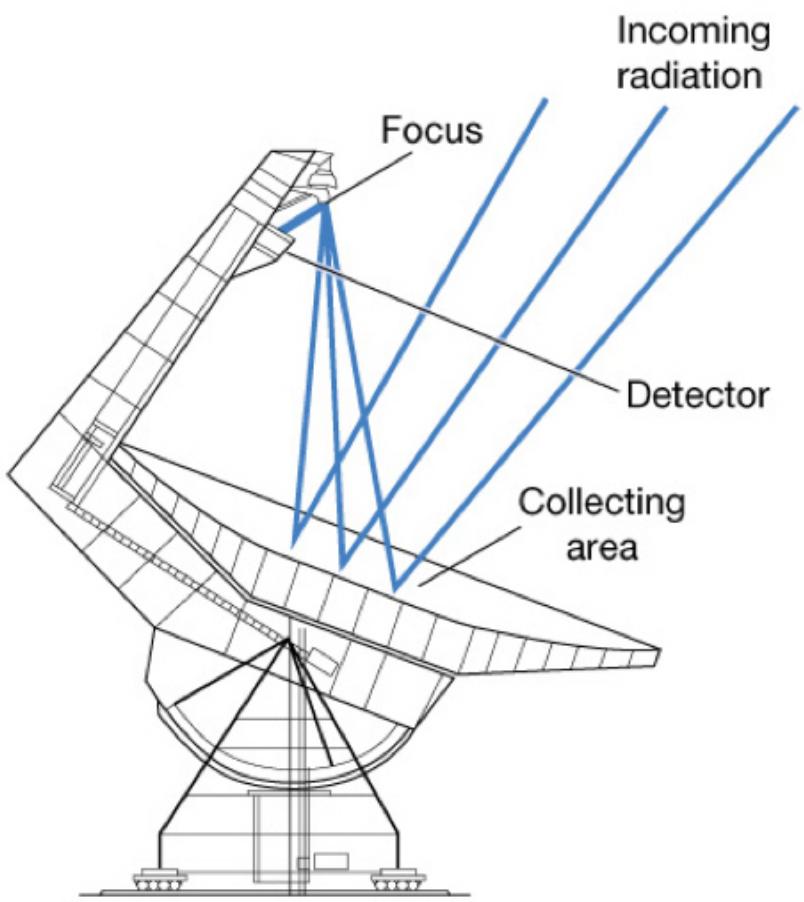


Optical Astronomy



An inside look
at the Subaru
telescope

Radio Astronomy



IR and UV Astronomy



(a)

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(b)

Space-Based Telescopes



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