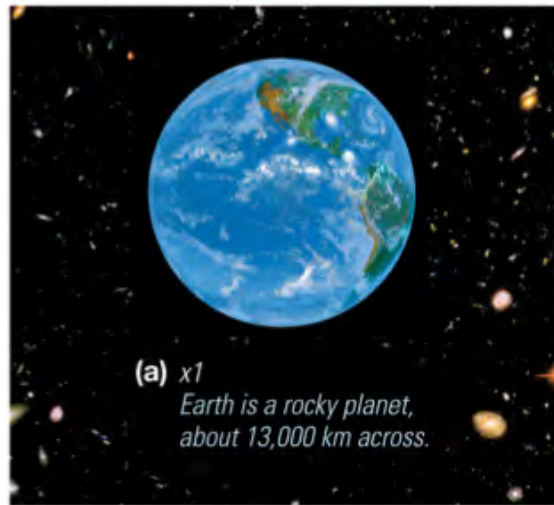


Chapter 1: The Night Sky

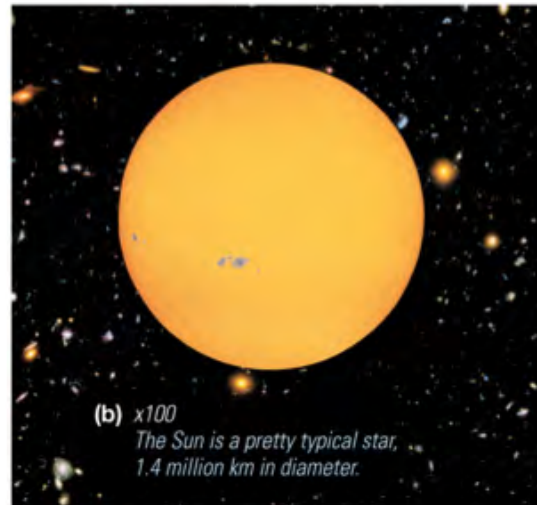
Prof. Douglas Laurence

AST 1002

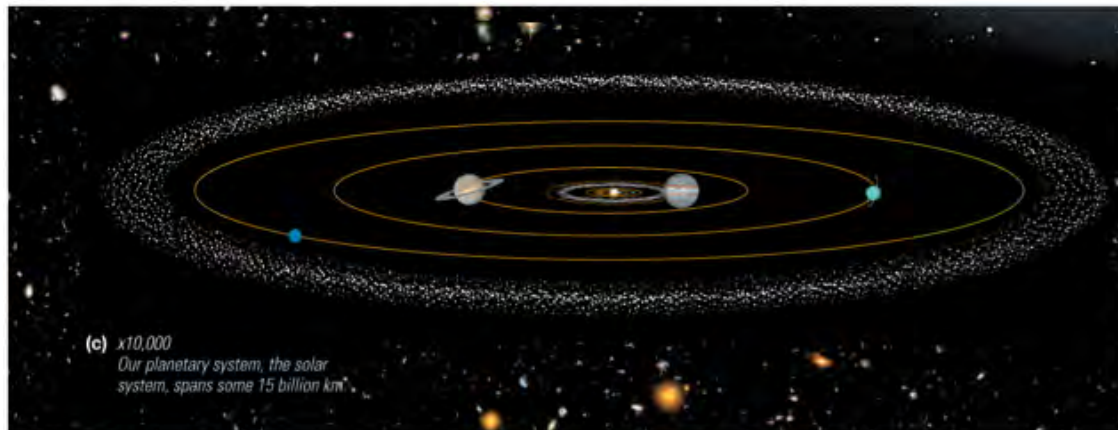
Order of Magnitude



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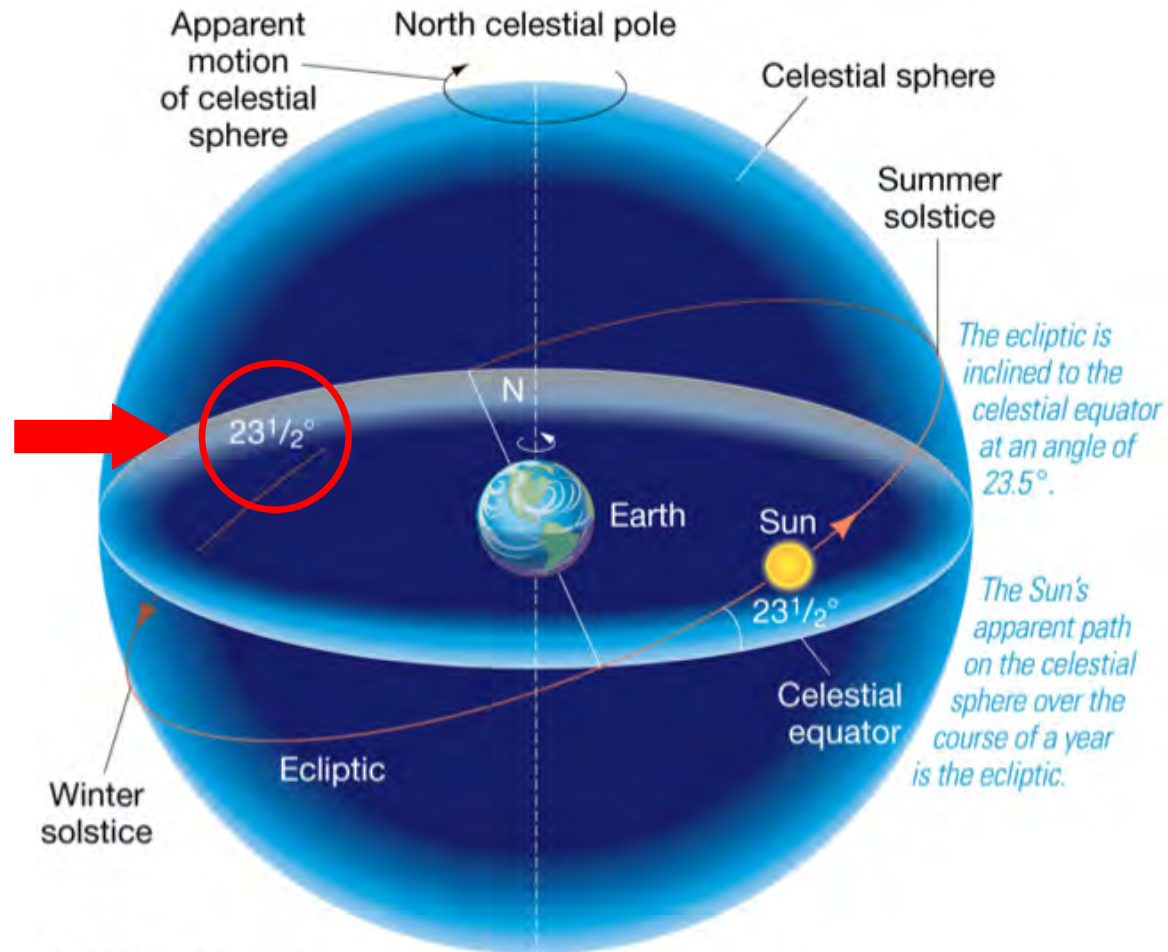
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Geocentric View

Same as orbital tilt
in heliocentric view.



Constellations

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



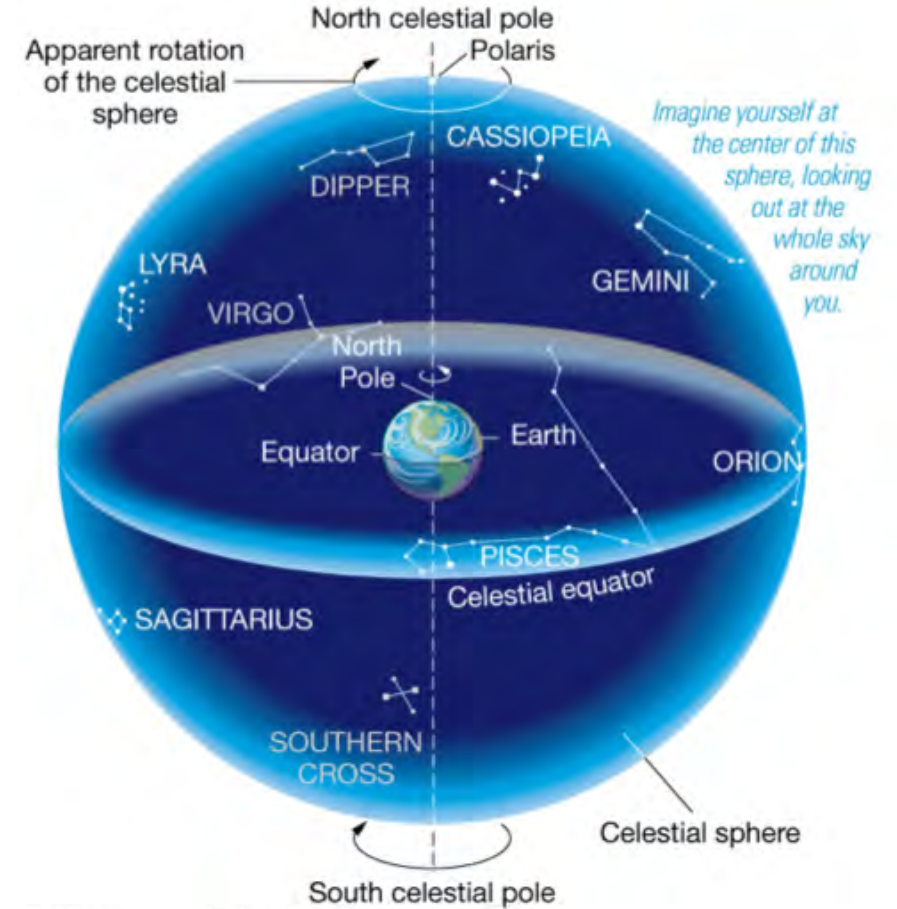
(a)

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

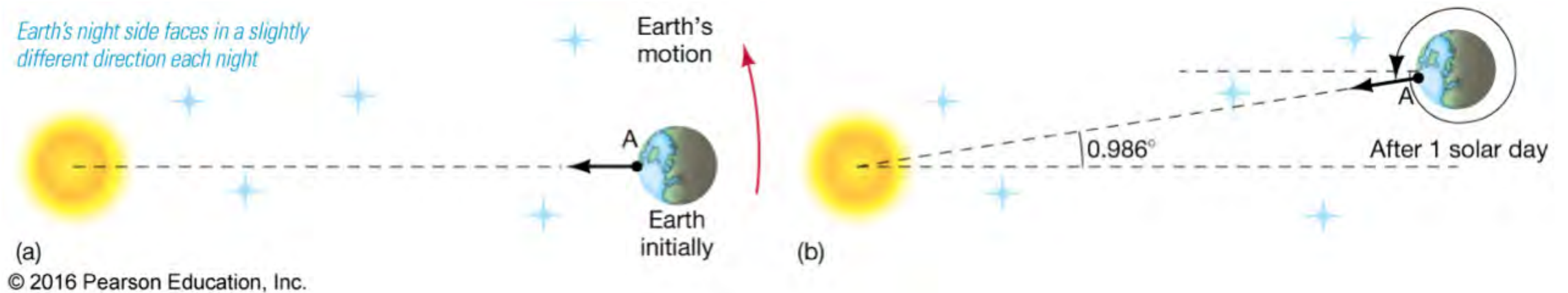


(b)



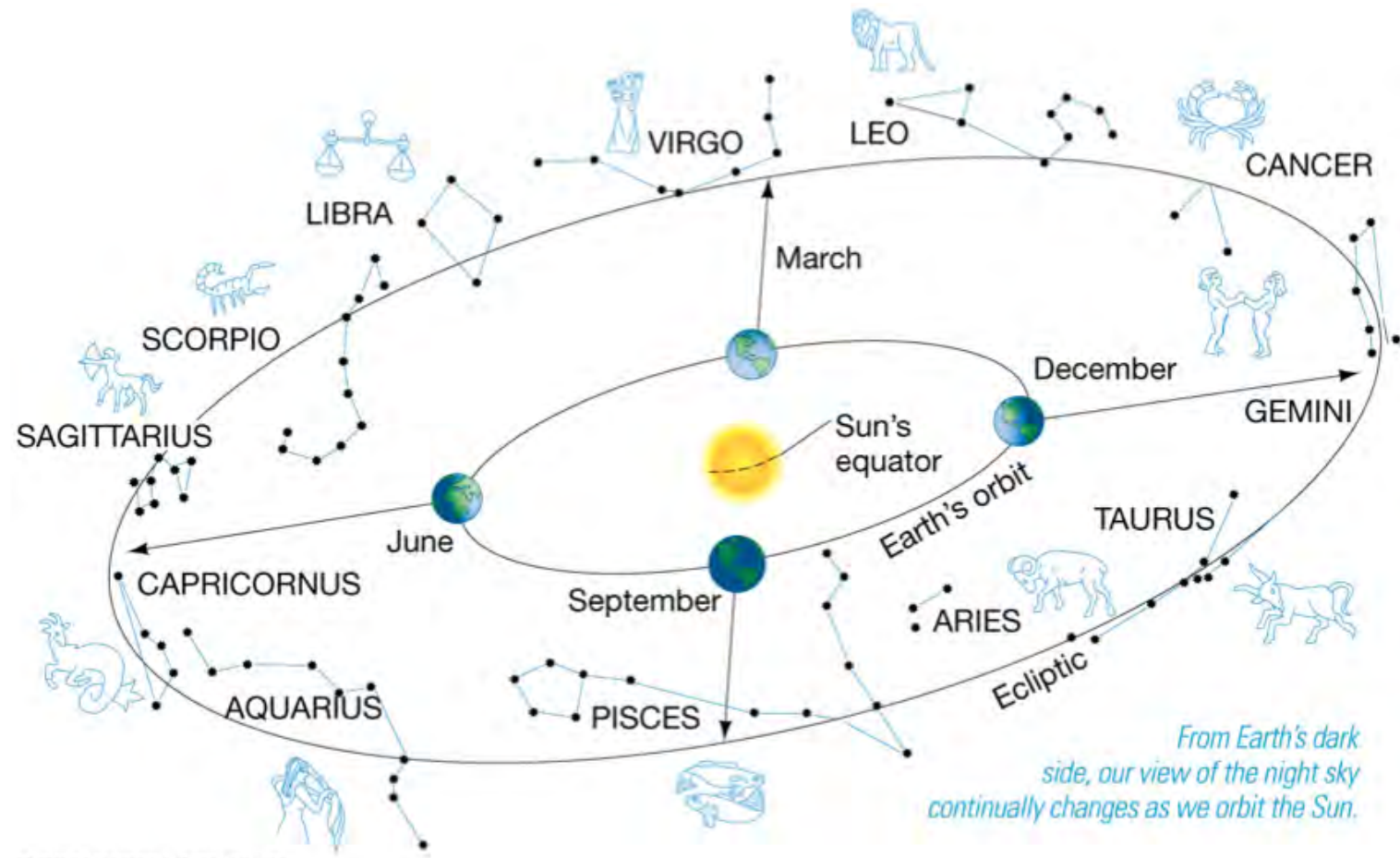
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Sidereal vs. Solar Time



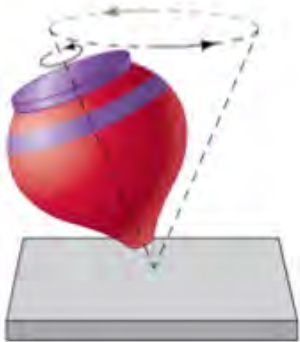
24 solar hours = 23 h 56 min sidereal time

Seasons and the Night Sky

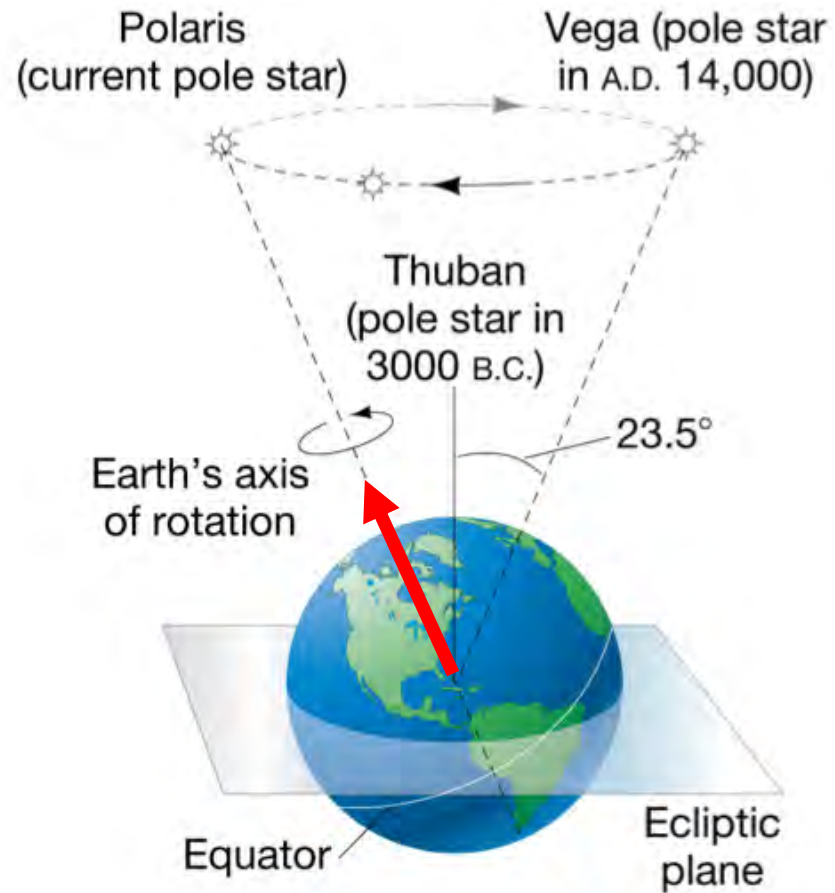


Orbital Precession

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

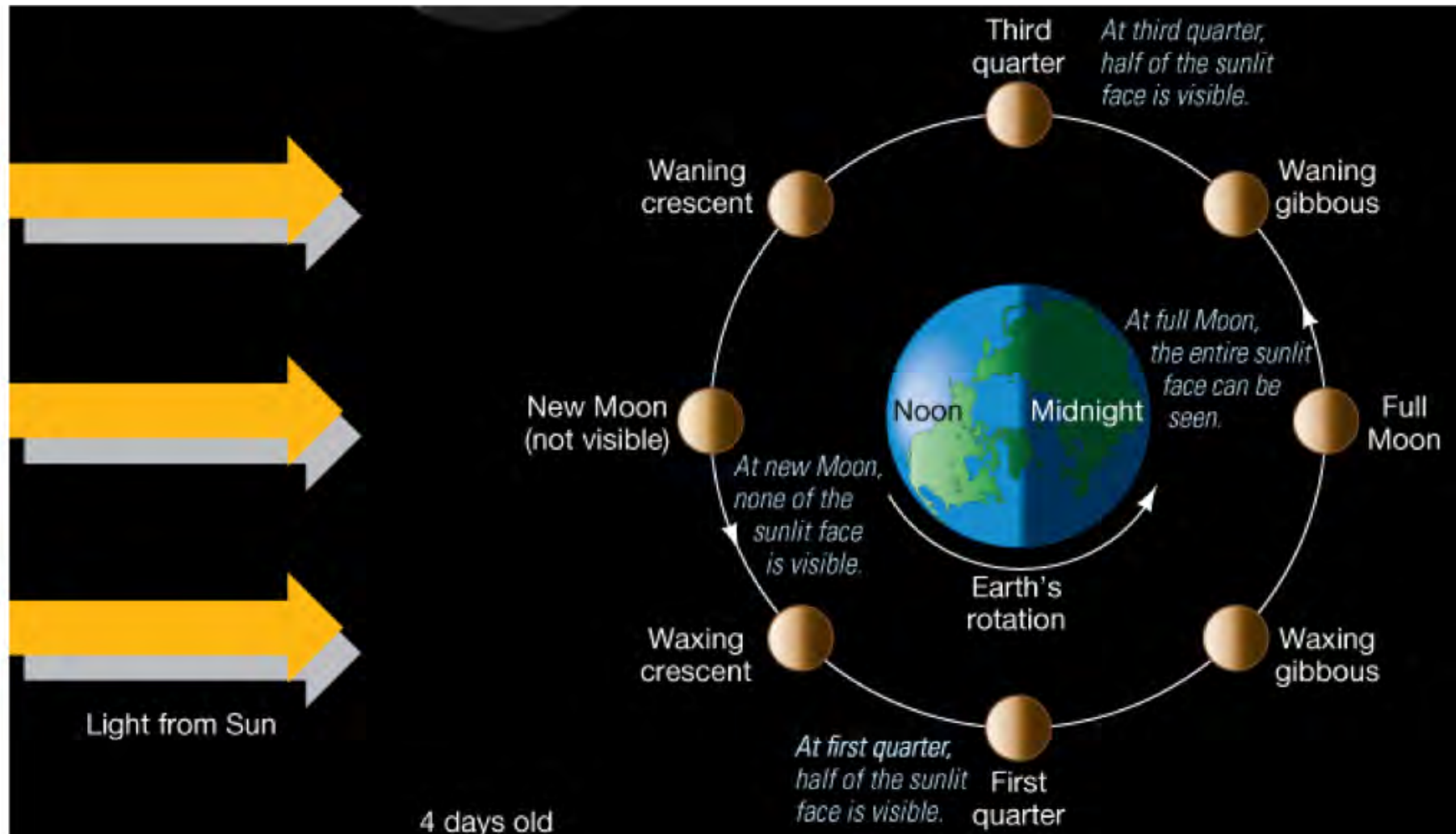


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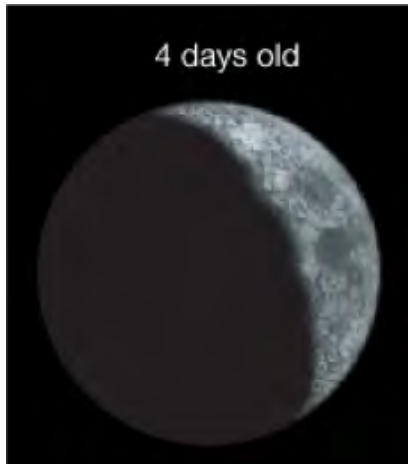
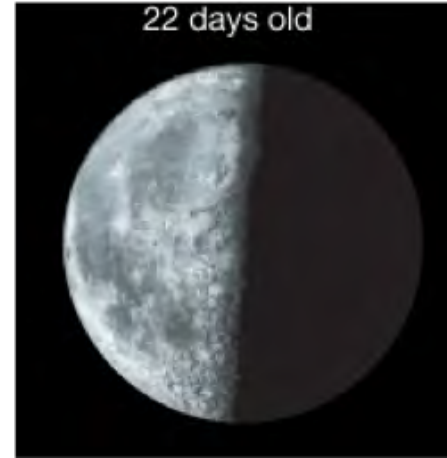


~26,000 years

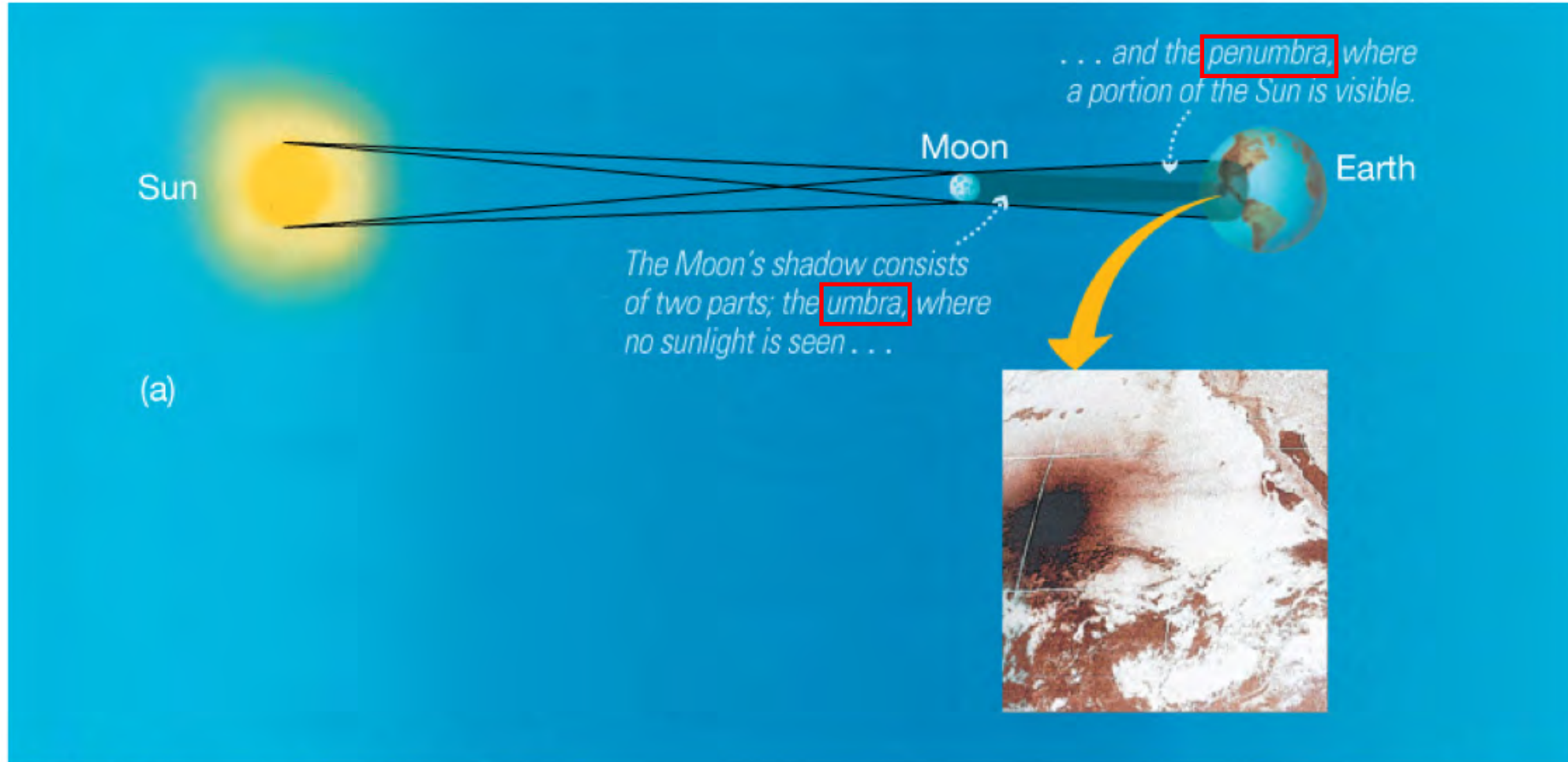
Phases of the Moon



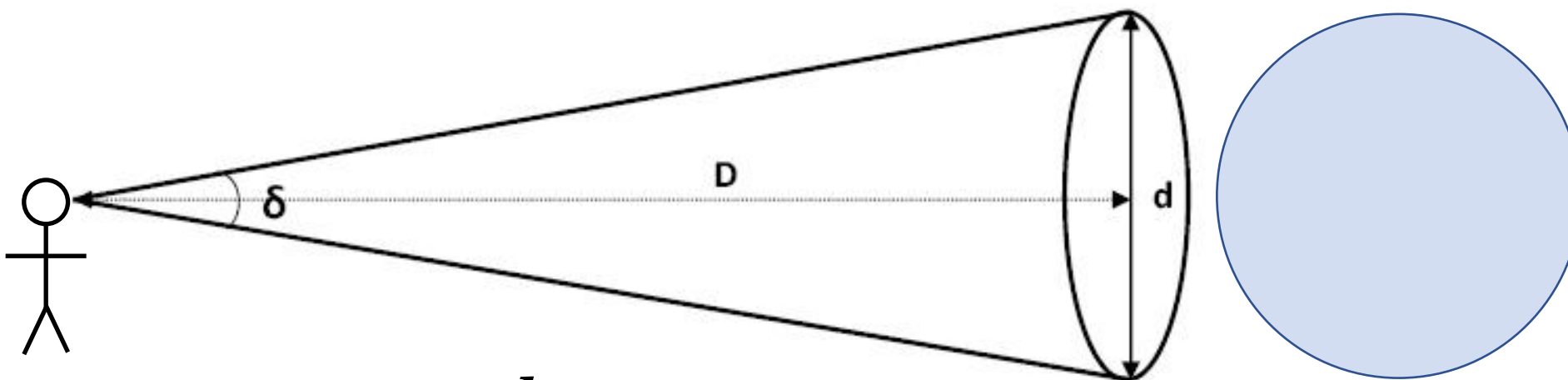
Phases of the Moon (cont'd)



Solar Eclipses

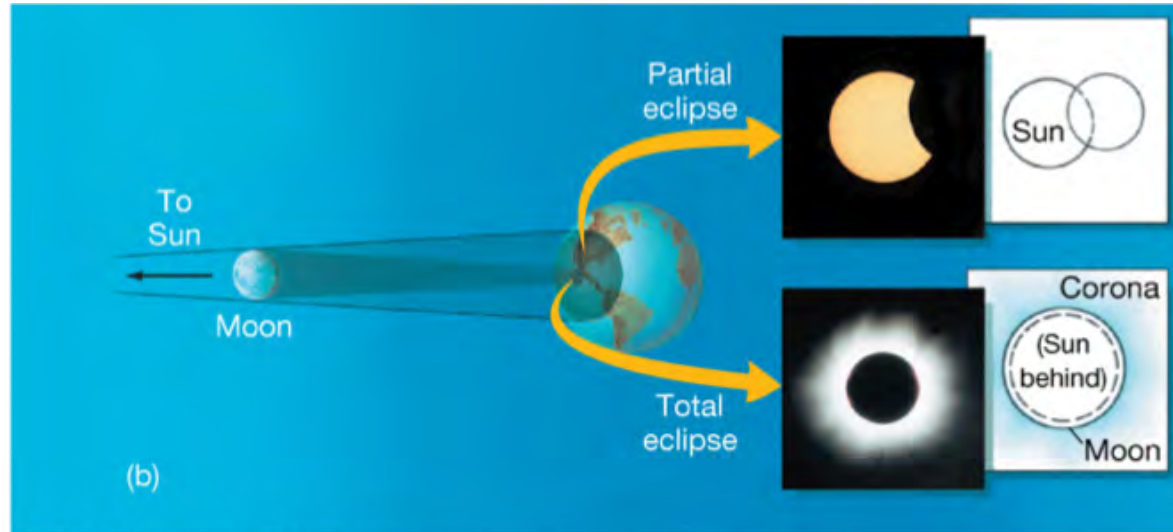


Angular Size



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

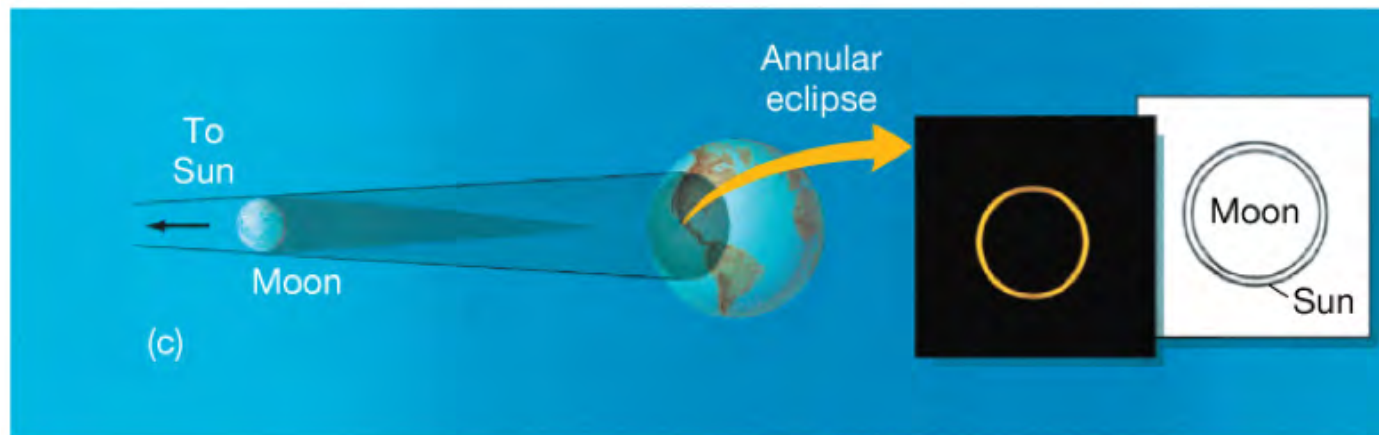
Total vs. Annular Solar Eclipses



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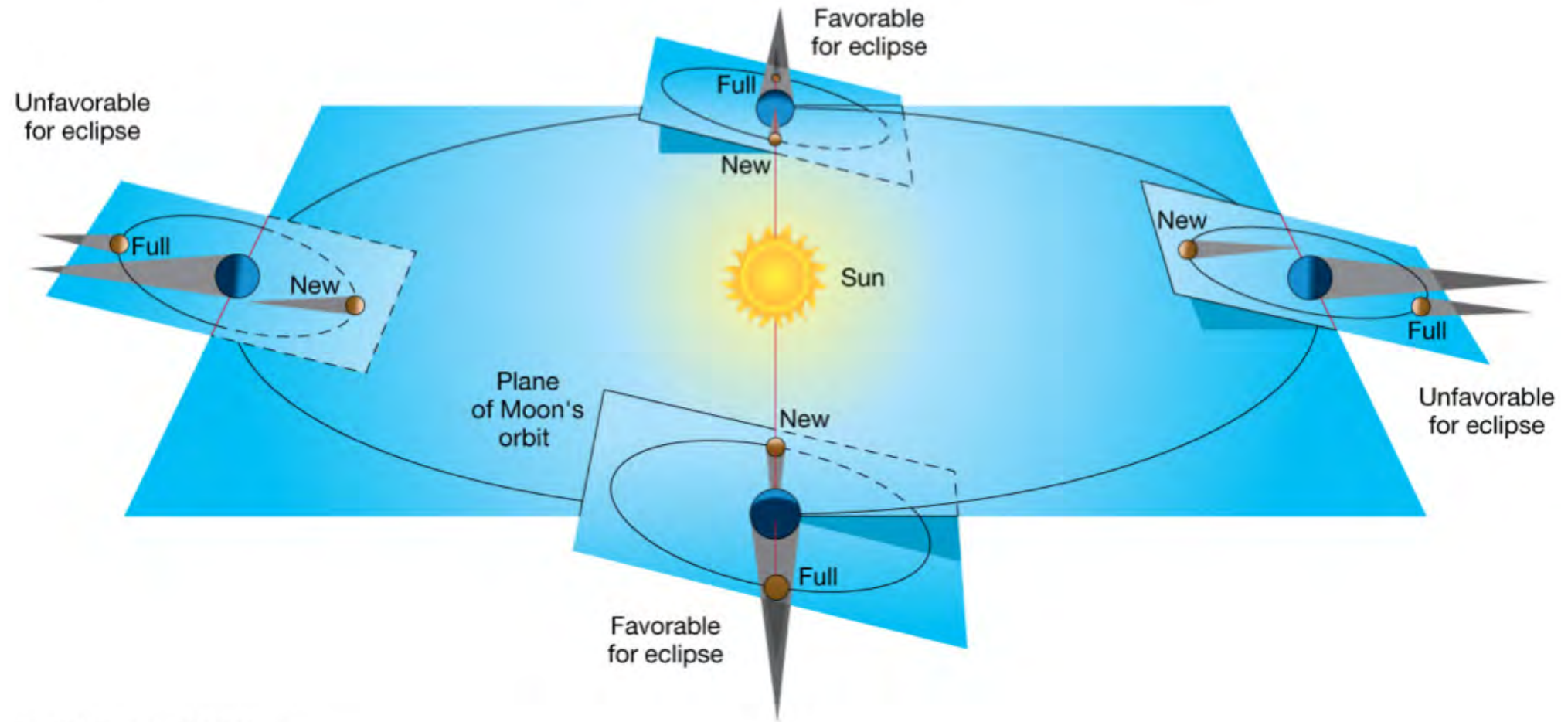
Eclipse Interactive Applet:

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



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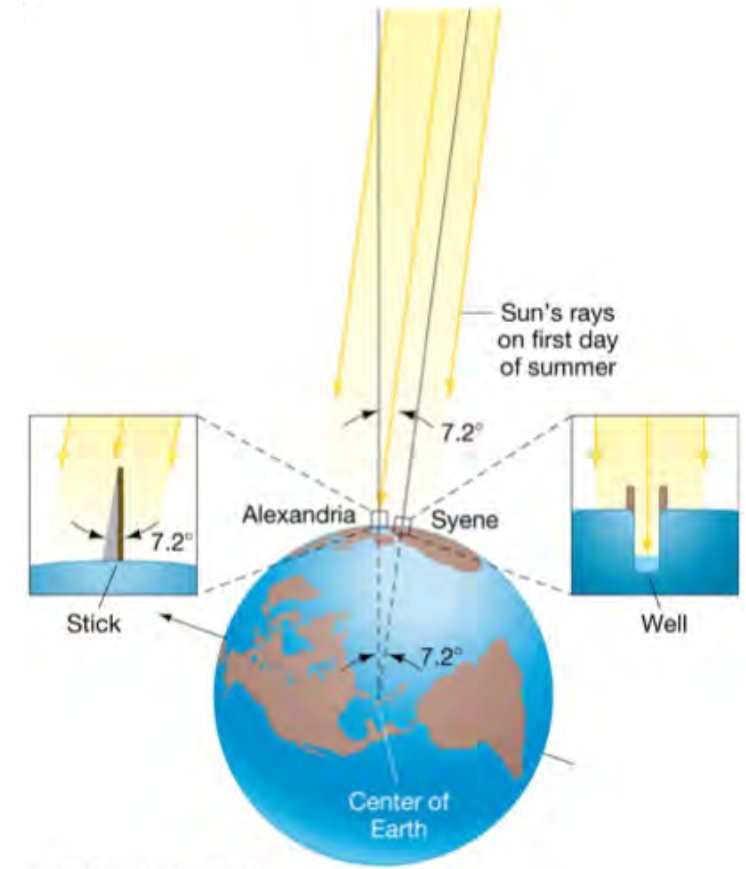
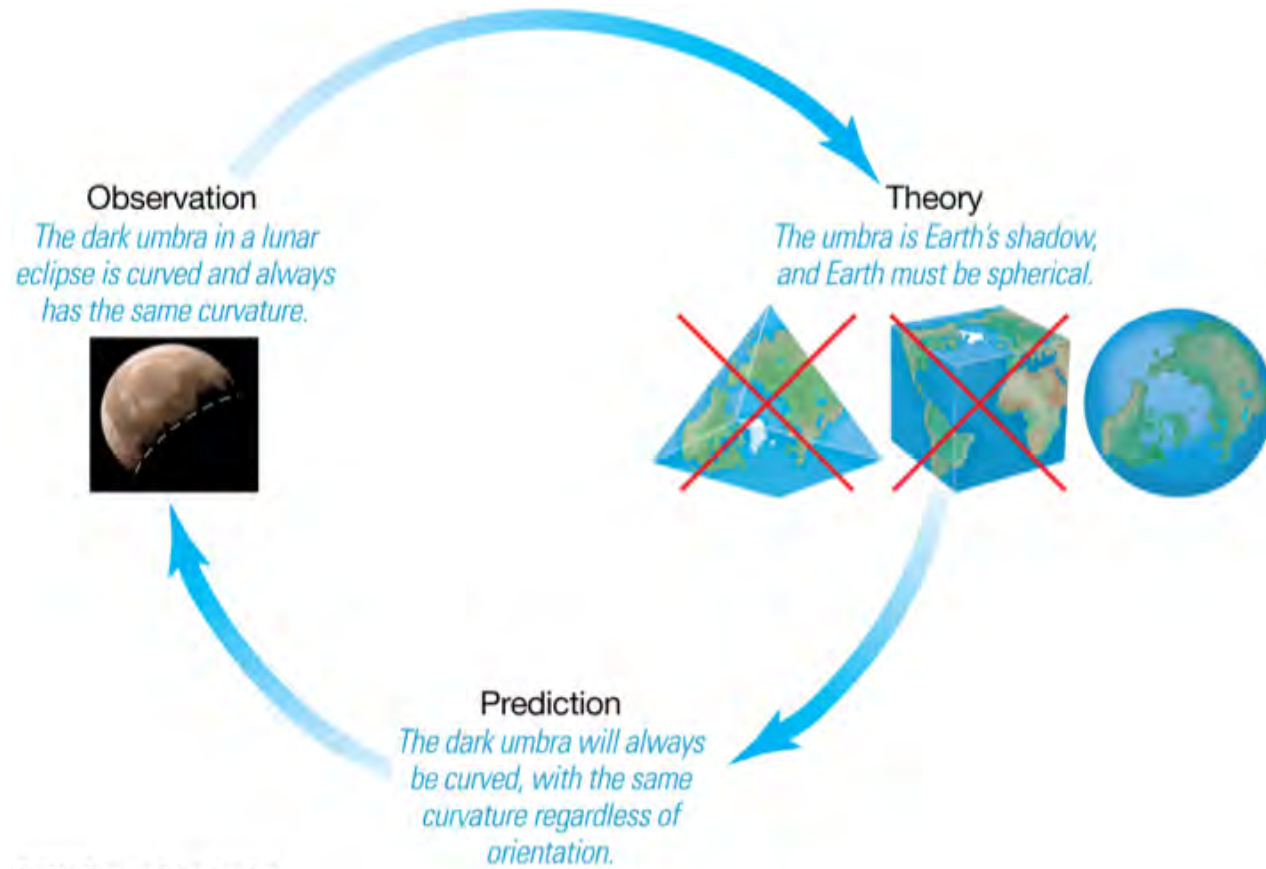
Conditions for Eclipse



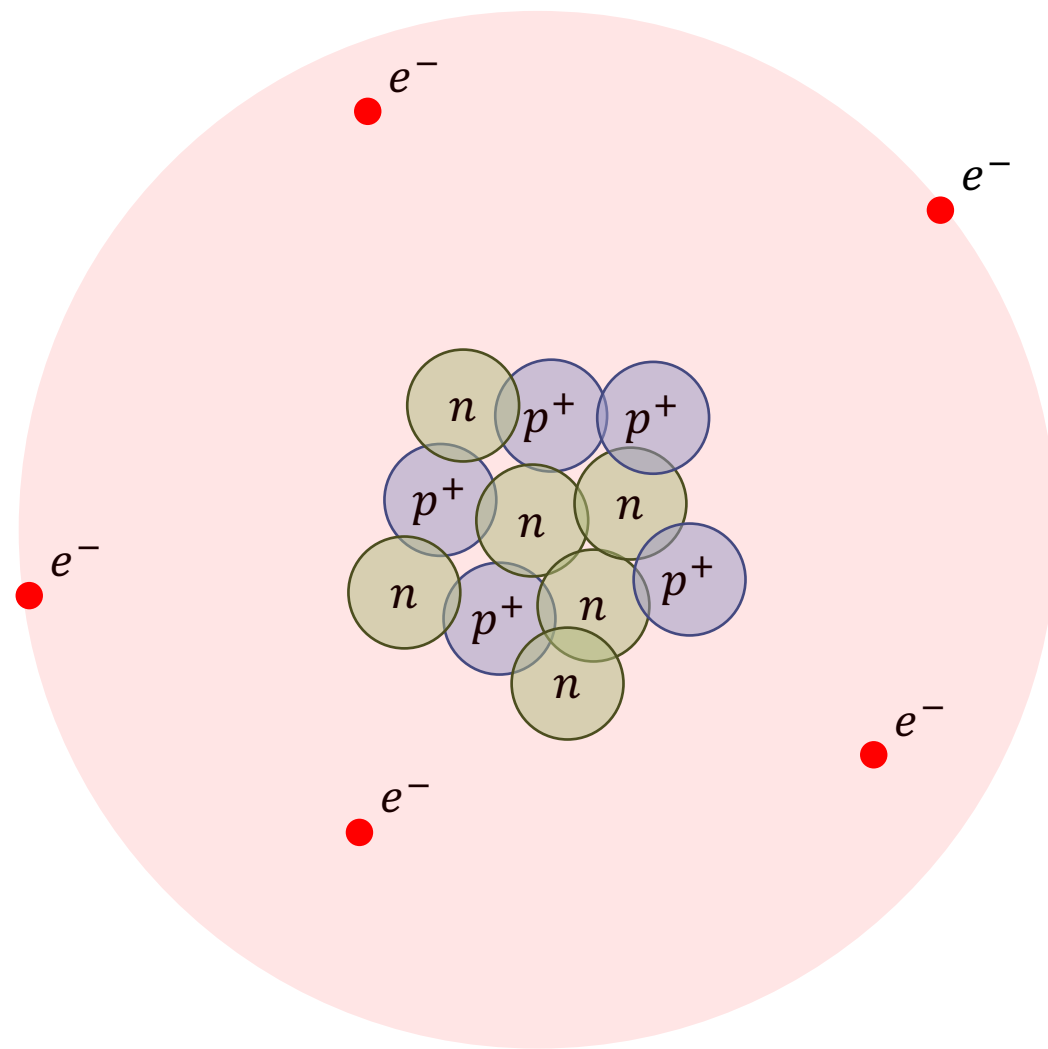
Frequencies of Eclipses

- 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.

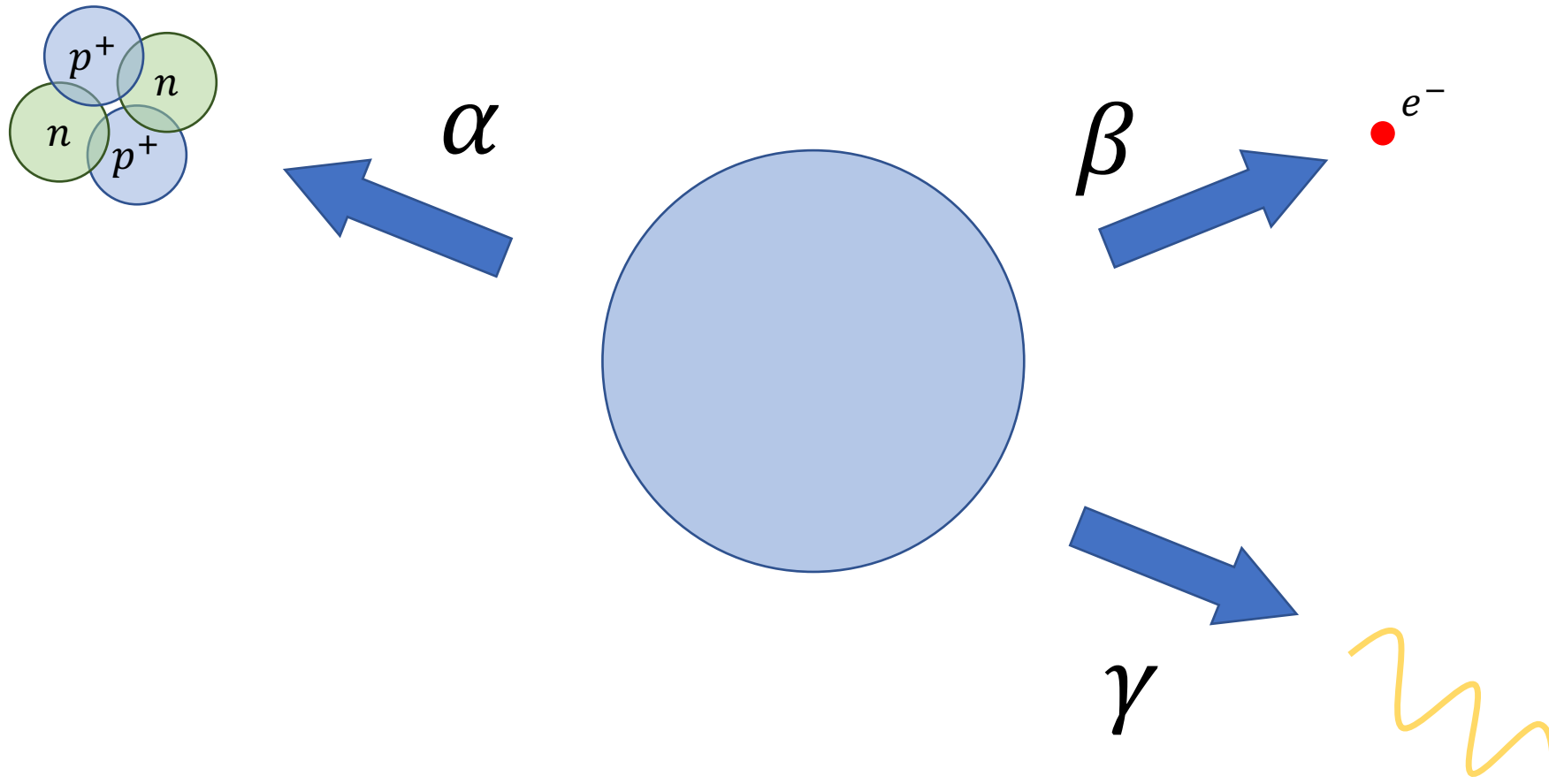
Scientific Method



Atoms



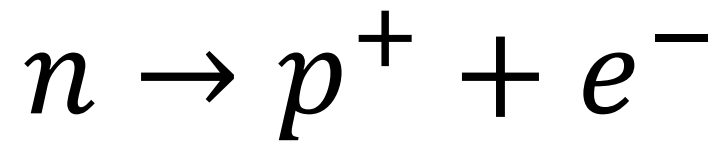
Types of Radiation



Mass-Energy Equivalence

$$E = mc^2$$

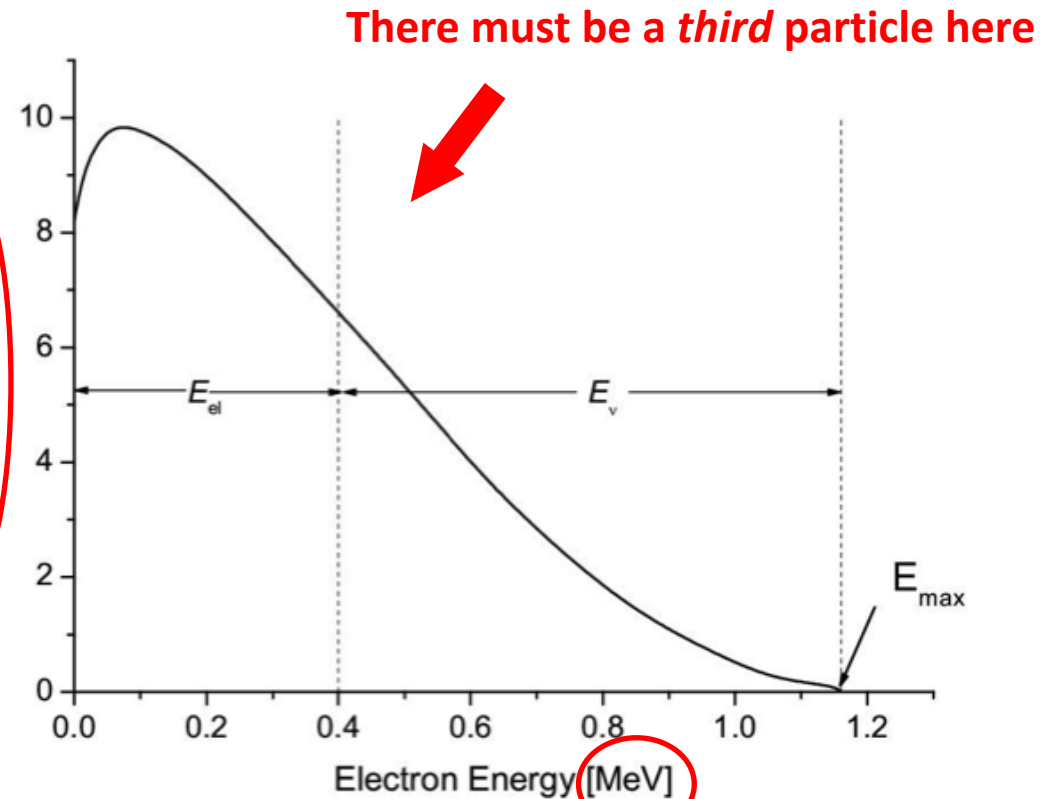
β -Decay



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

Number of electrons

Intensity [arbitrary units]



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)					
	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
spin→	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
name→	u up	c charm	t top	γ photon	H Higgs
Quarks	6 MeV $-\frac{1}{3}$ $\frac{1}{2}$ d down	95 MeV $-\frac{1}{3}$ $\frac{1}{2}$ s strange	4.2 GeV $-\frac{1}{3}$ $\frac{1}{2}$ b bottom	0 0 1 g gluon	0 0 2 G Graviton
	<2 eV 0 $\frac{1}{2}$ ν_e electron neutrino	<0.19 MeV 0 $\frac{1}{2}$ ν_μ muon neutrino	<18.2 MeV 0 $\frac{1}{2}$ ν_τ tau neutrino	90.2 GeV 0 1 Z^0 weak force	
	0.511 MeV -1 $\frac{1}{2}$ e electron	106 MeV -1 $\frac{1}{2}$ μ muon	1.78 GeV -1 $\frac{1}{2}$ τ tau	80.4 GeV ± 1 1 W^\pm weak force	
Leptons					
Matter			Forces		

4 Fundamental Forces:

- Strong Force
- Weak Force
- Electromagnetic Force
- Gravity

Quarks

			0 0 1 Y photon		125.7 GeV 0 0 H Higgs
Quarks	3 MeV 2/3 1/2 u up	1.24 GeV 2/3 1/2 c charm	172.5 GeV 2/3 1/2 t top	0 0 0 1 g gluon	0 0 0 2 G Graviton
	6 MeV -1/3 1/2 d down	95 MeV -1/3 1/2 s strange	4.2 GeV -1/3 1/2 b bottom	90.2 GeV 0 1 Z ⁰ weak force	
			80.4 GeV ±1 1 W [±] weak force	Bosons (Forces)	

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

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

Leptons

No electric charge
= no electric force!



Leptons

<2 eV 0 ν_e 1/2 electron neutrino	<0.19 MeV 0 ν_μ 1/2 muon neutrino	<18.2 MeV 0 ν_τ 1/2 tau neutrino
0.511 MeV -1 e 1/2 electron	106 MeV -1 μ 1/2 muon	1.78 GeV -1 τ 1/2 tau

0 0 1 γ photon

0 0 1 g gluon

125.7 GeV 0 0 H Higgs

0 0 2 G Graviton

90.2 GeV 0 1 Z weak force

80.4 GeV ± 1 1 W ⁺ weak force
--

Bosons (Forces)



No strong force!

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

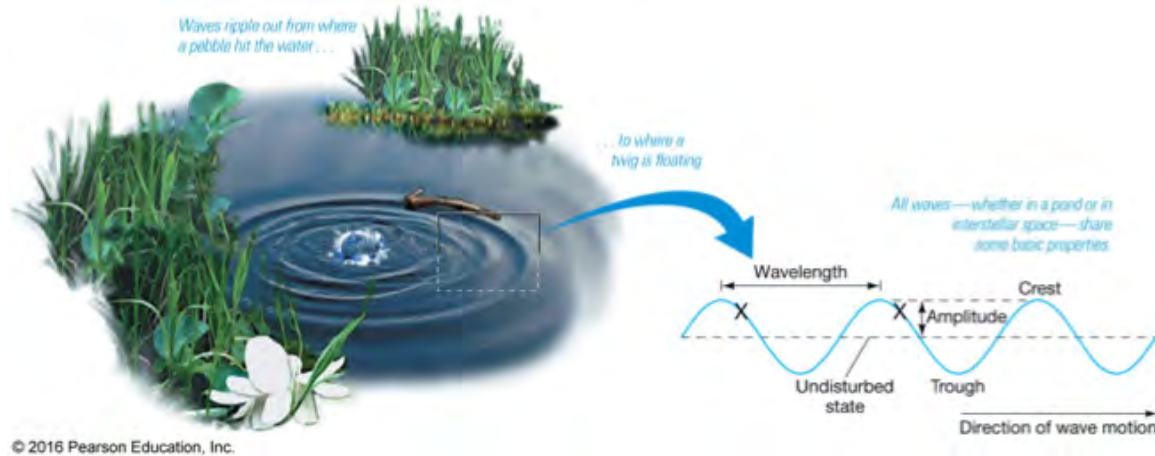
$$n \rightarrow p^+ + e^- + \bar{\nu}_e$$

Chapter 2: Light and Telescopes

Prof. Douglas Laurence

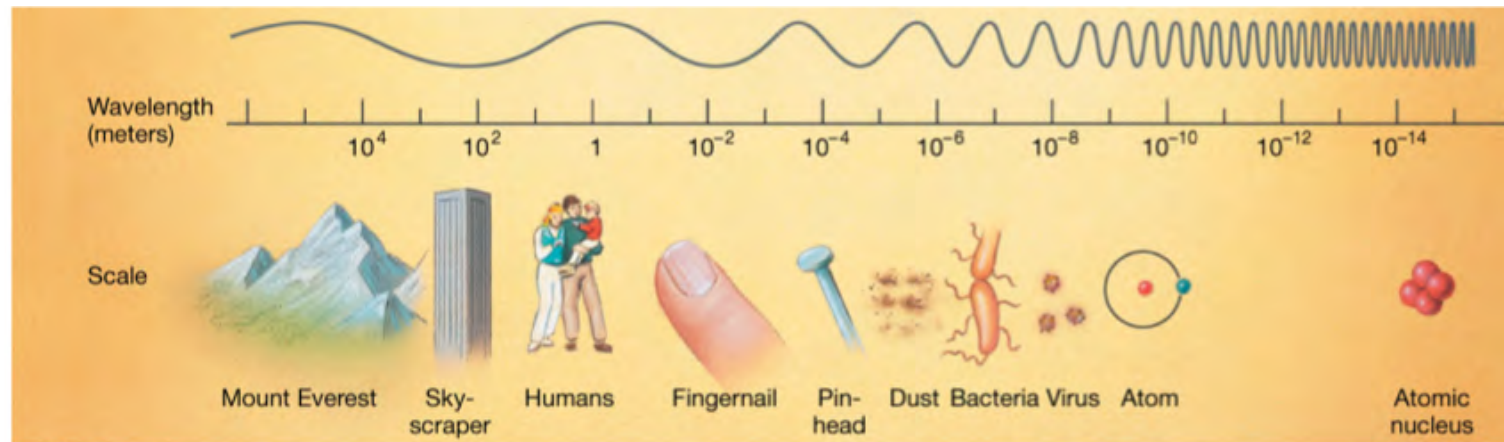
AST 1002

Electromagnetic Radiation

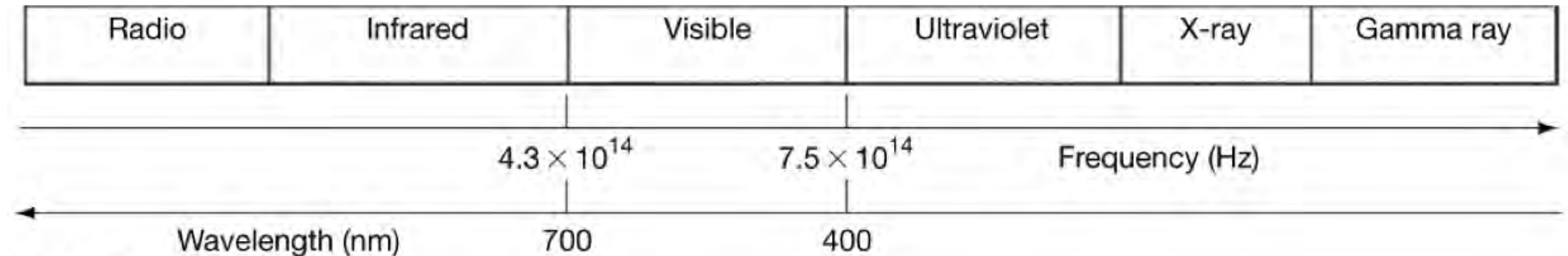
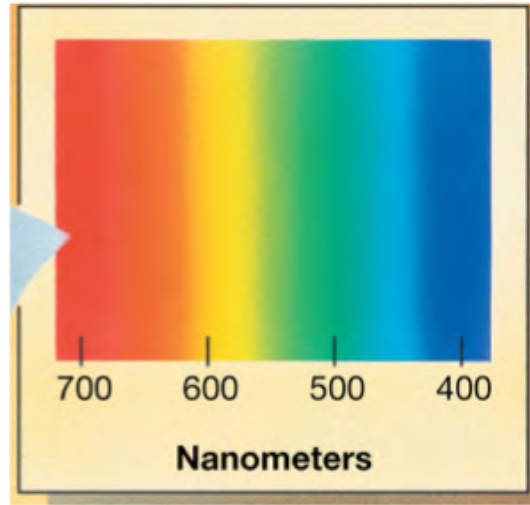


$$v = \lambda f$$

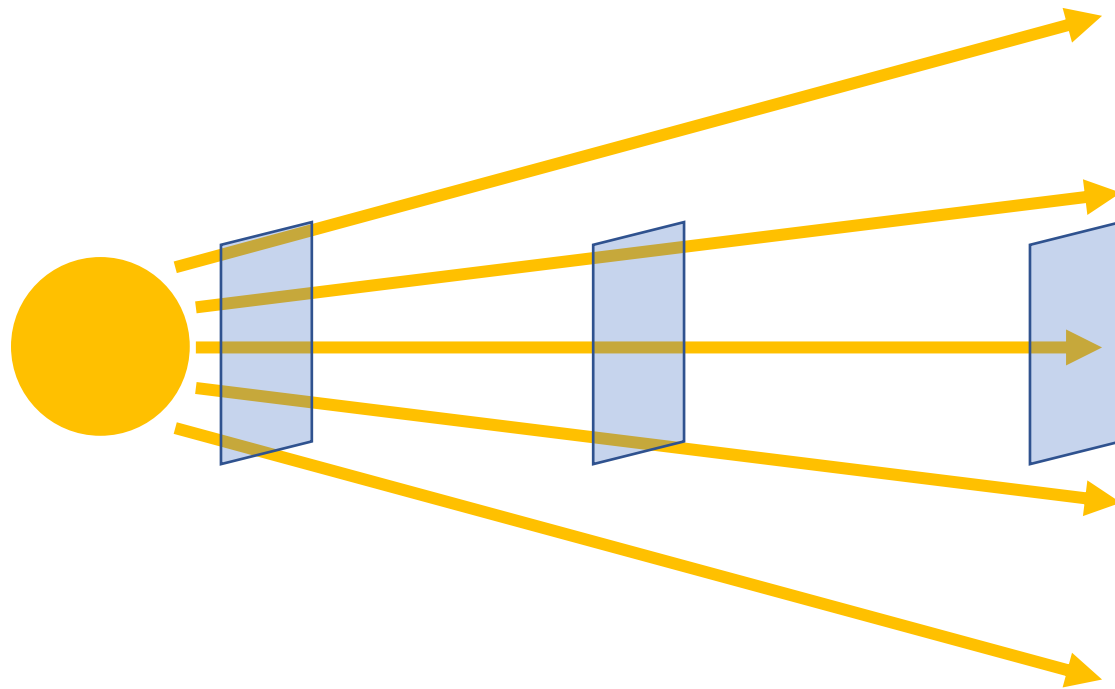
$$E = hf$$



Visible Light Spectrum



Isotropic Emission



Brightness *decreases* with distance (squared)

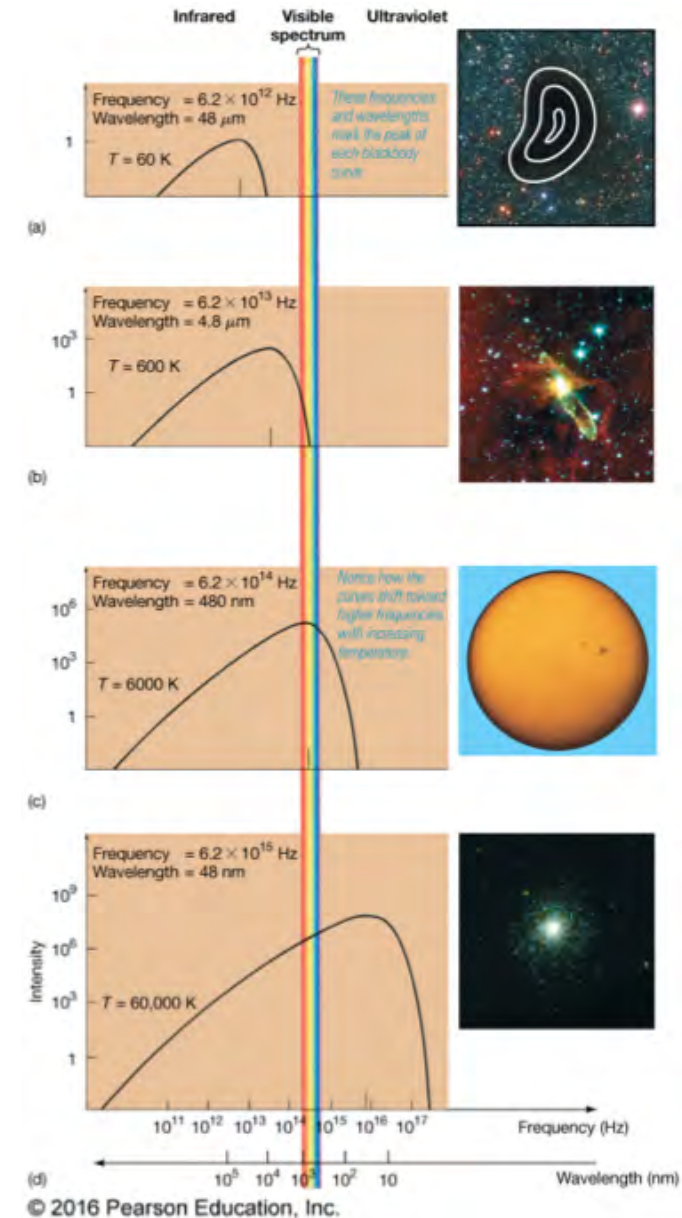
Blackbody Radiation

Stefan-Boltzmann Law:

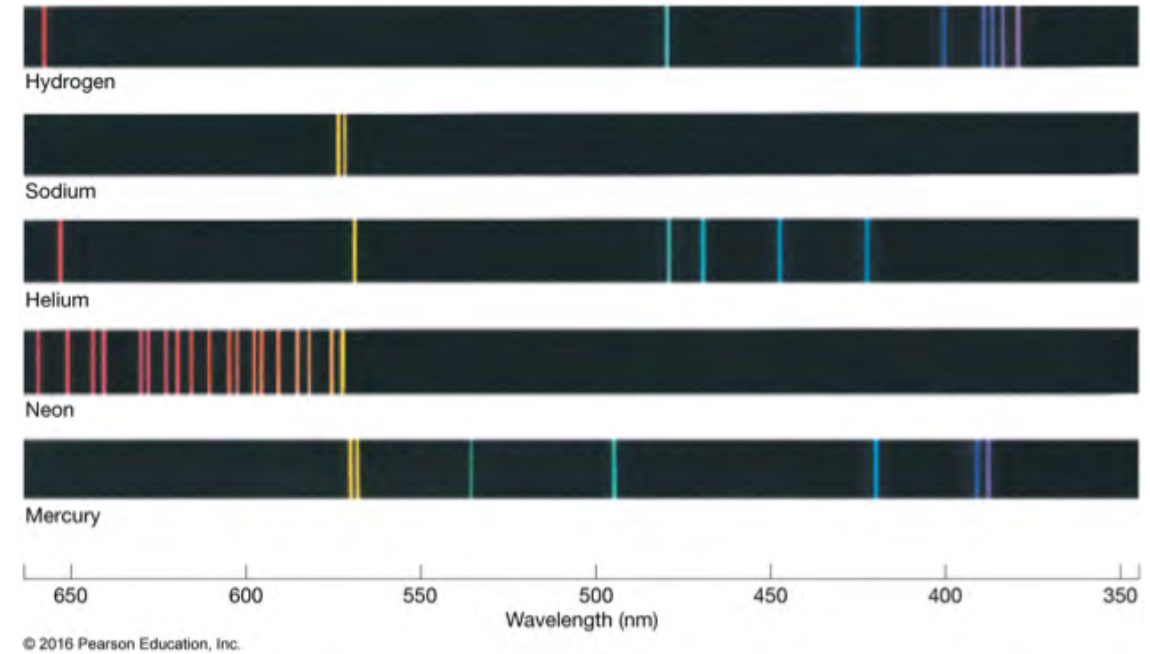
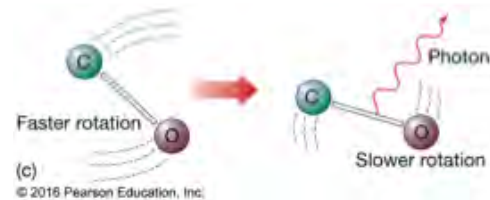
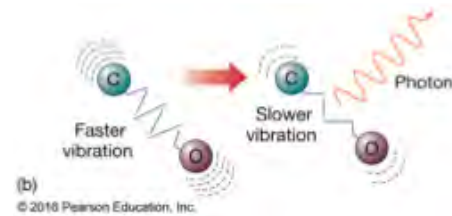
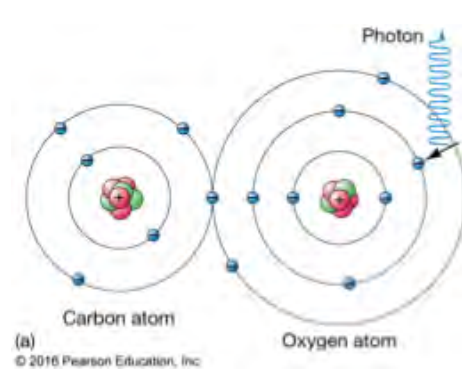
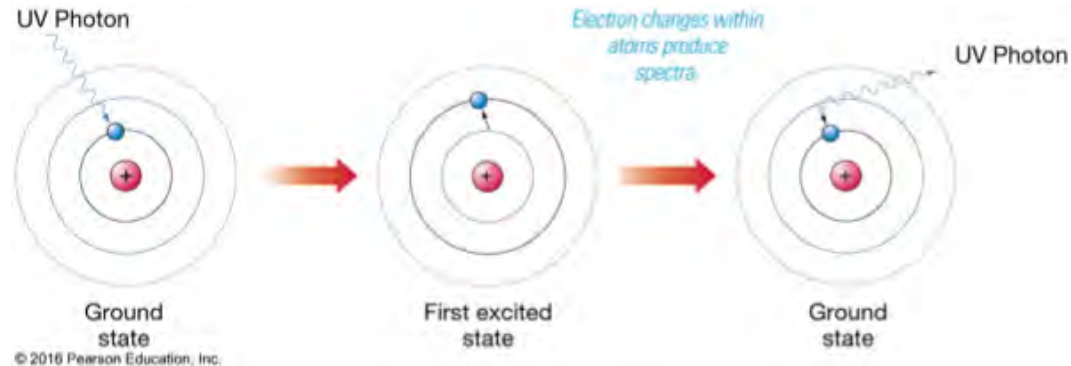
$$I = \sigma T^4$$

Wein's Law:

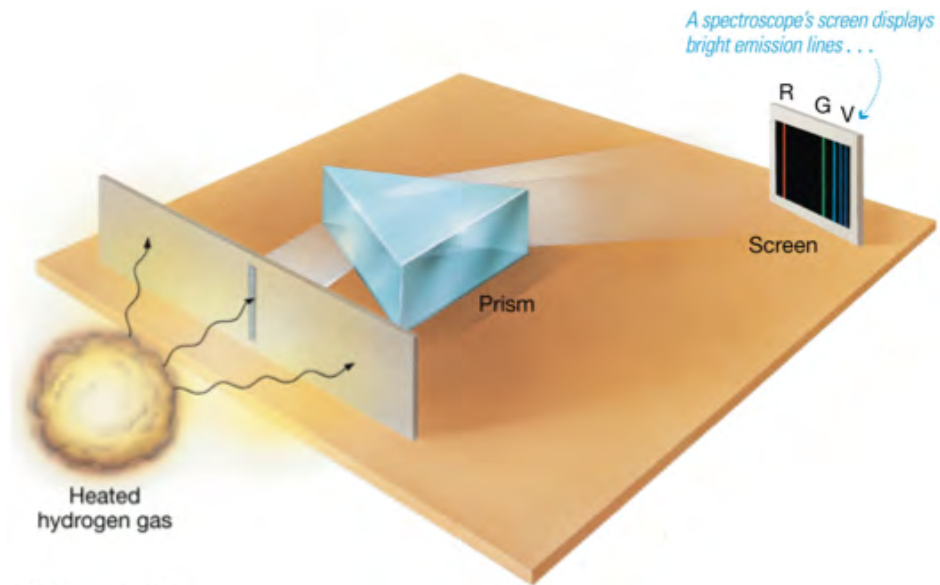
$$\lambda_{max} = \frac{b}{T}$$



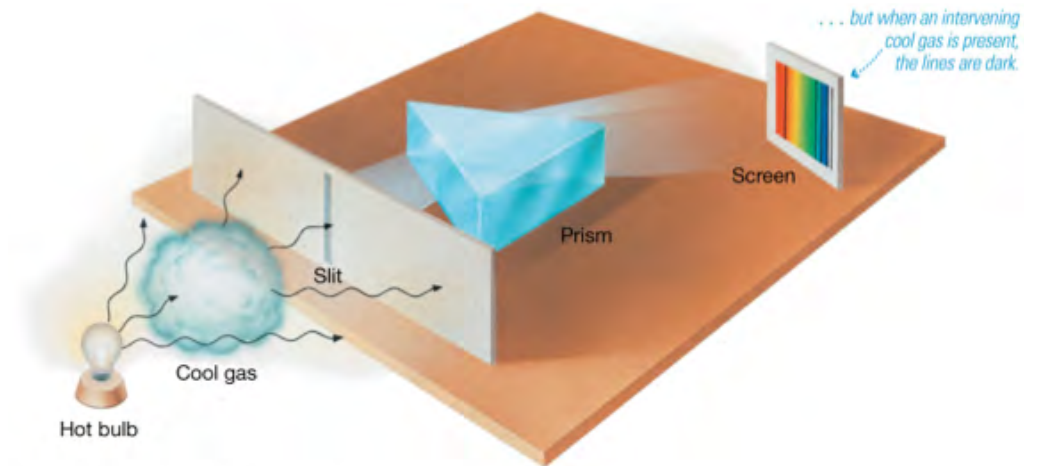
Emission and Absorption of Photons



Spectroscopy



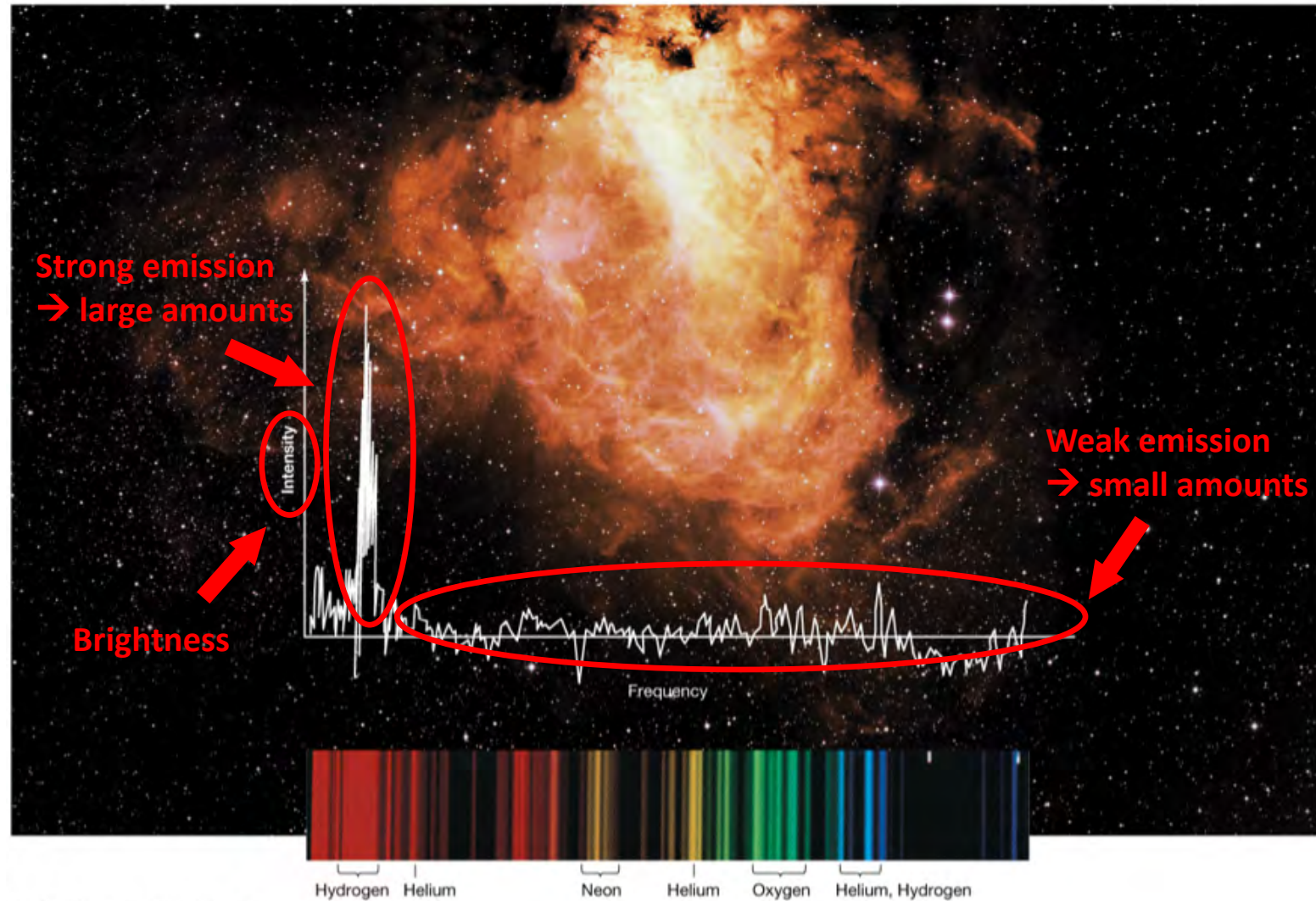
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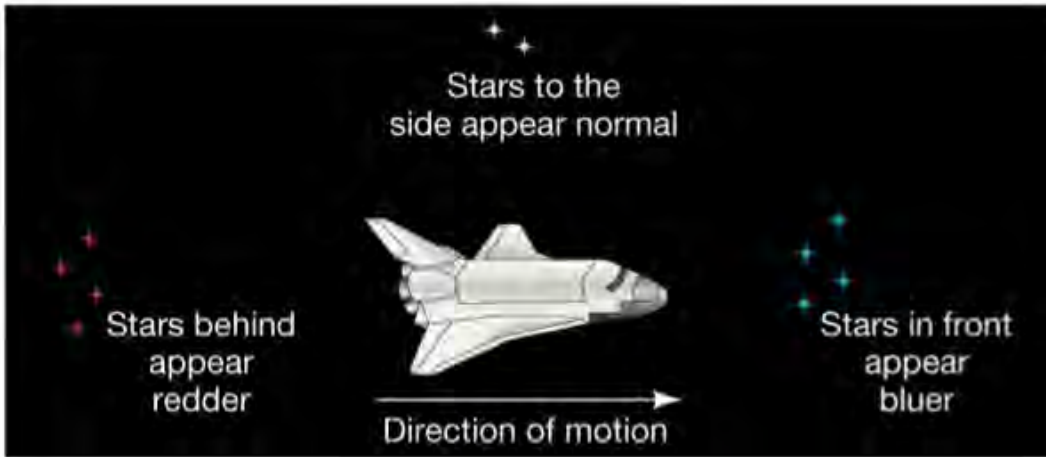
(a)

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Detecting Chemical Elements

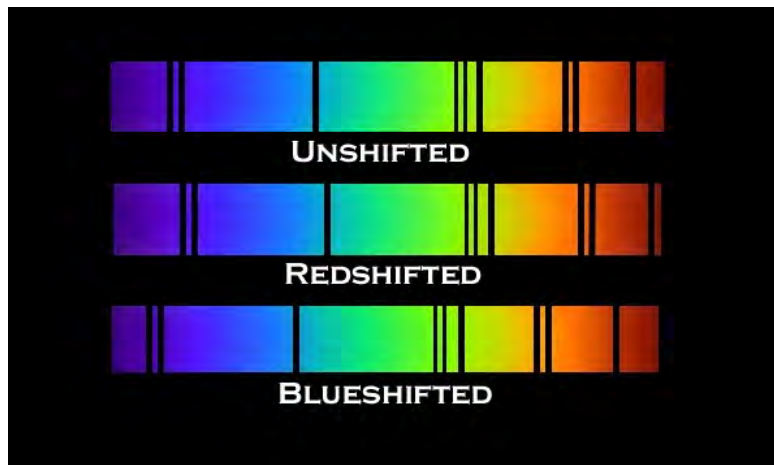


Doppler Effect



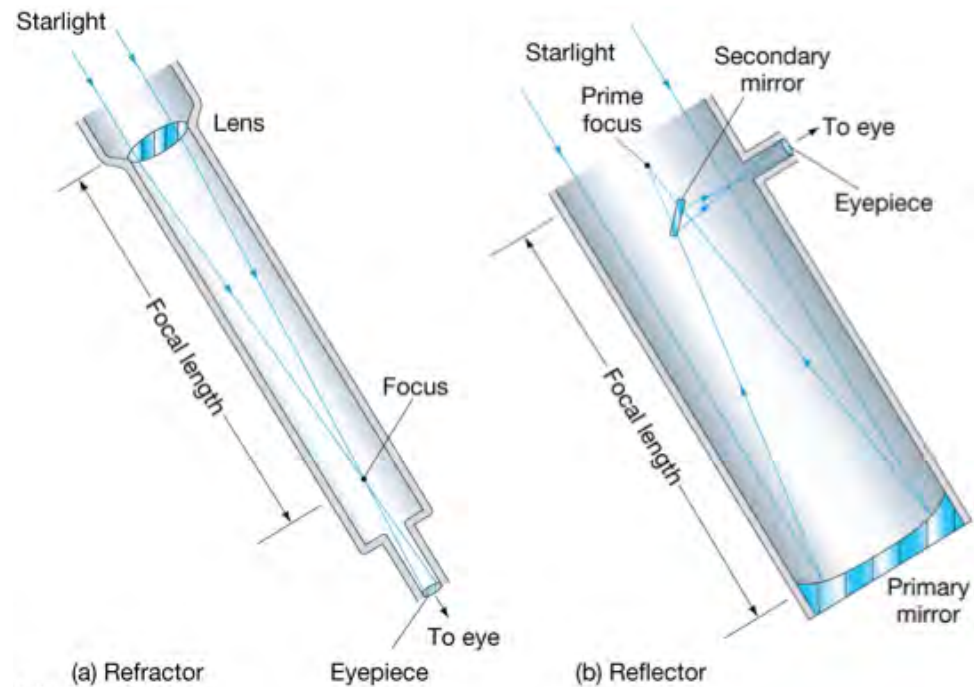
(a)

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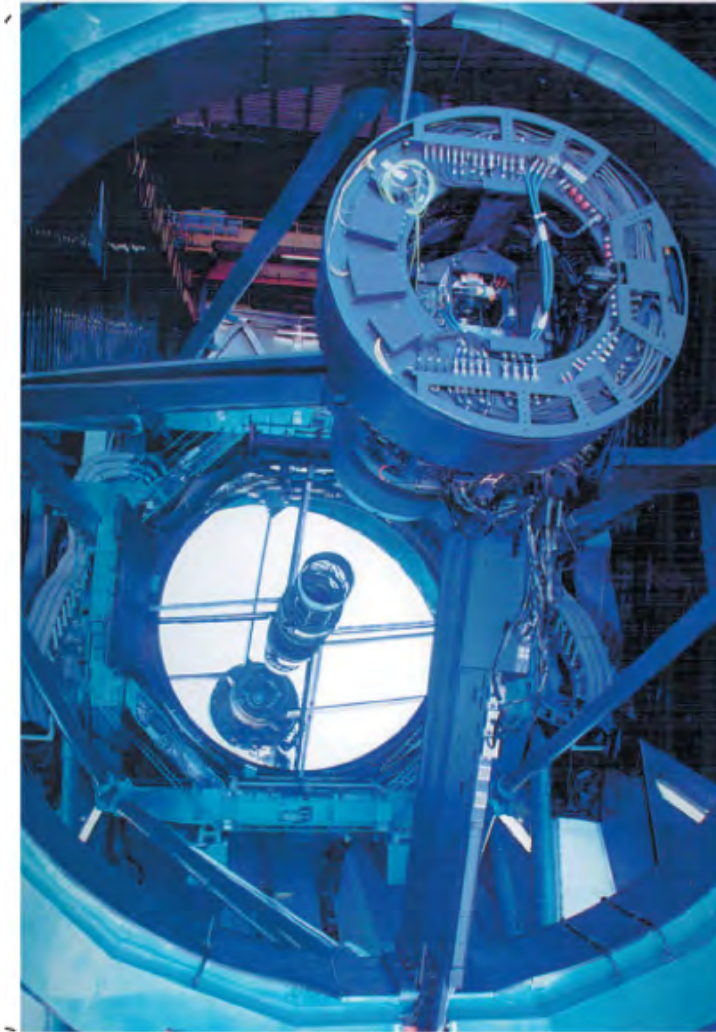
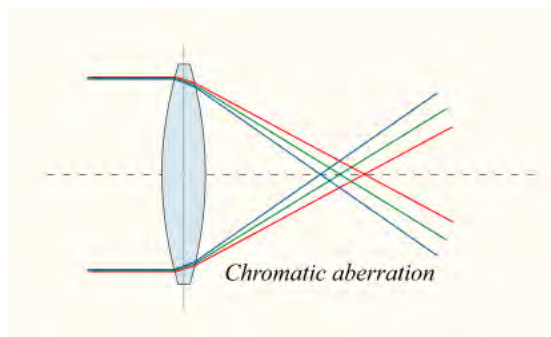


$$\Delta f = \frac{v}{c} f_0$$

Optical Astronomy

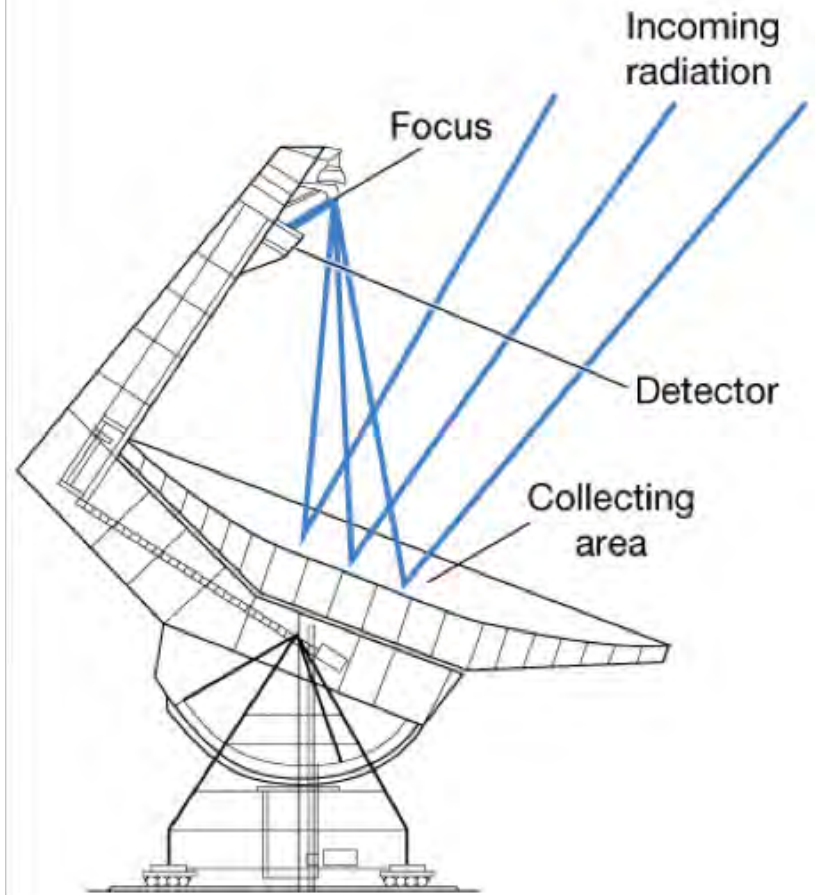


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*An inside look
at the Subaru
telescope*

Radio Astronomy



IR and UV Astronomy



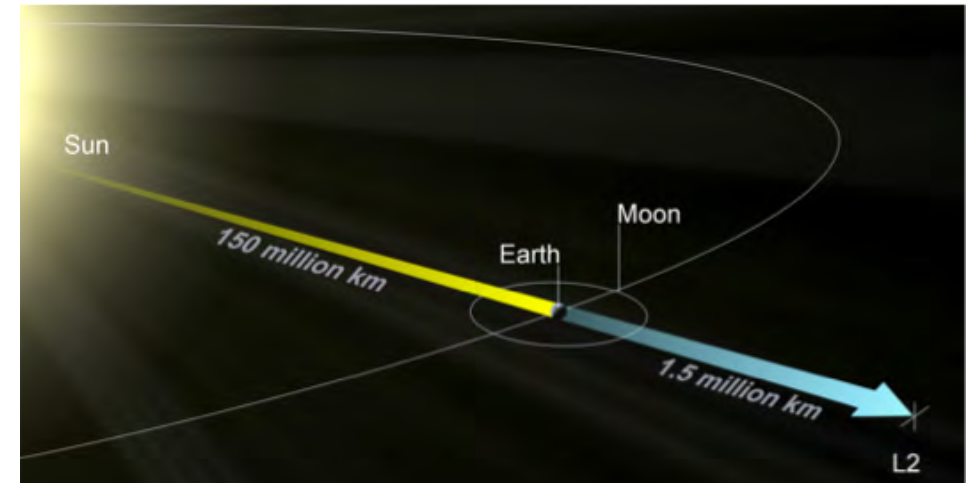
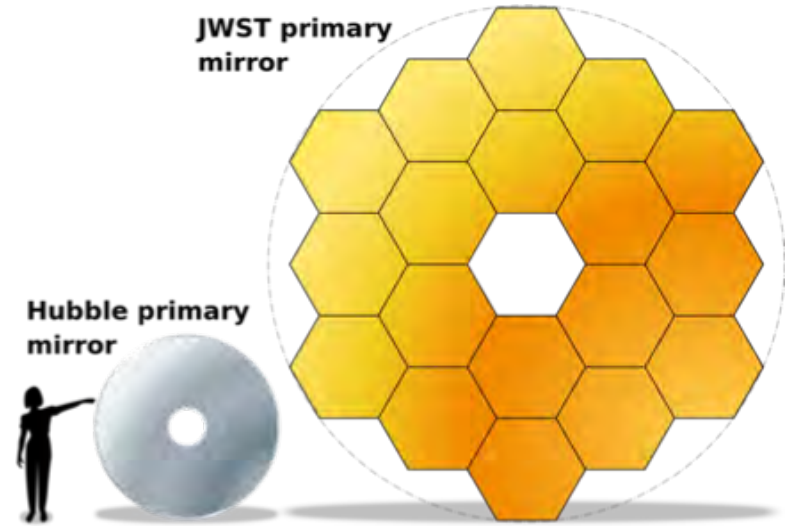
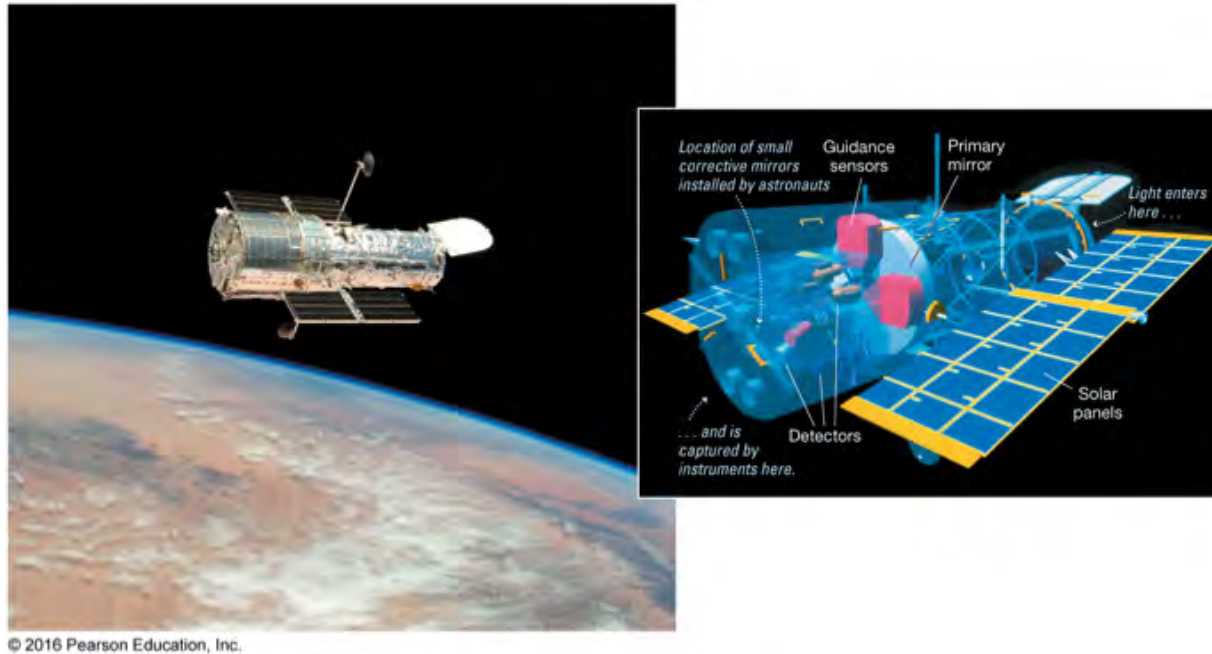
(a)

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(b)

Space-Based Telescopes

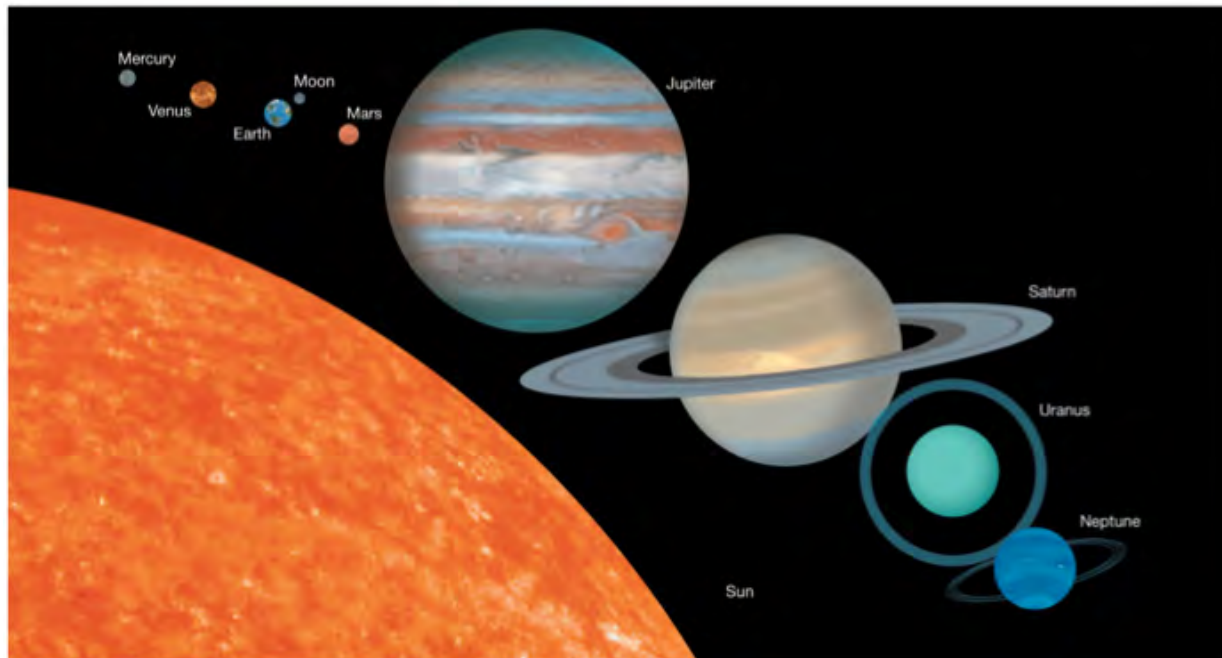


Chapter 3: The Solar System

Prof. Douglas Laurence

AST 1002

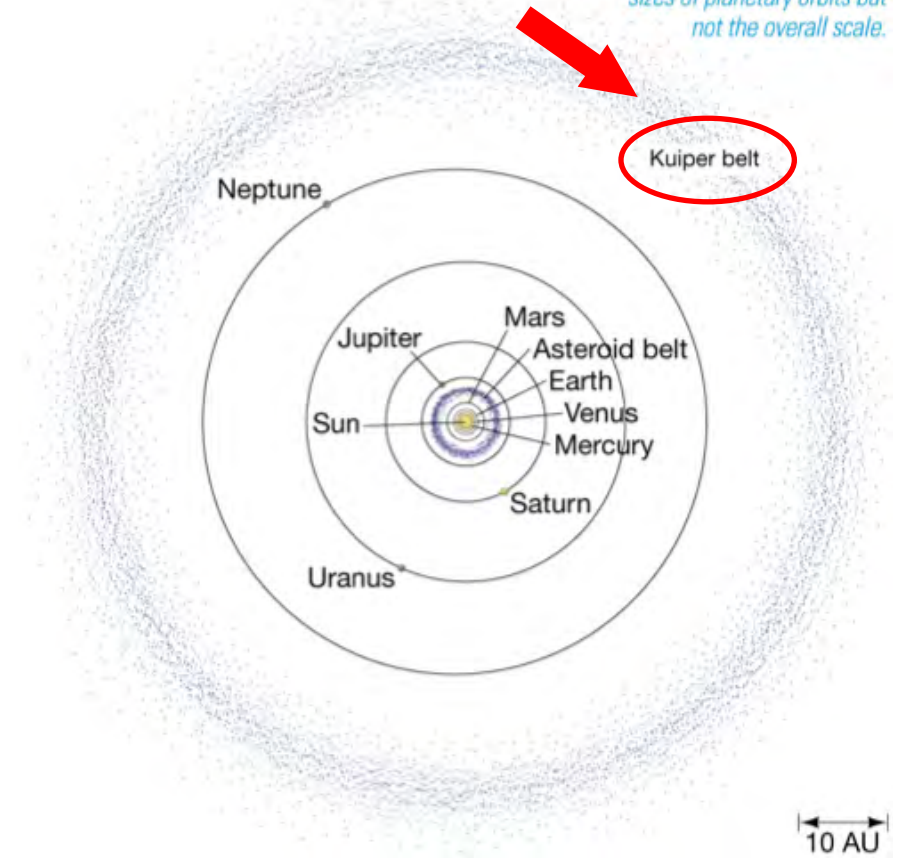
The Planets



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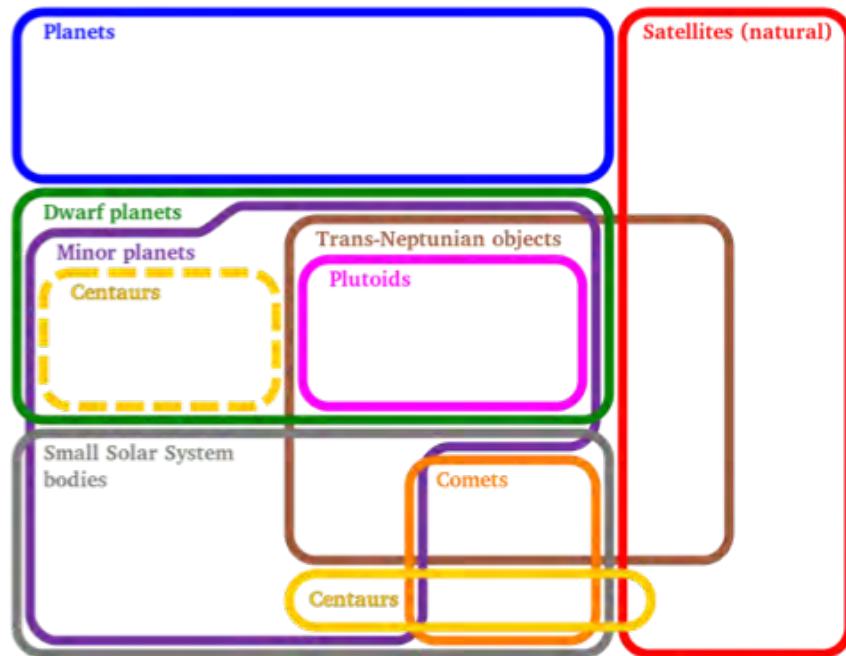
Pluto = Kuiper belt object

Kepler's laws tell us the relative sizes of planetary orbits but not the overall scale.

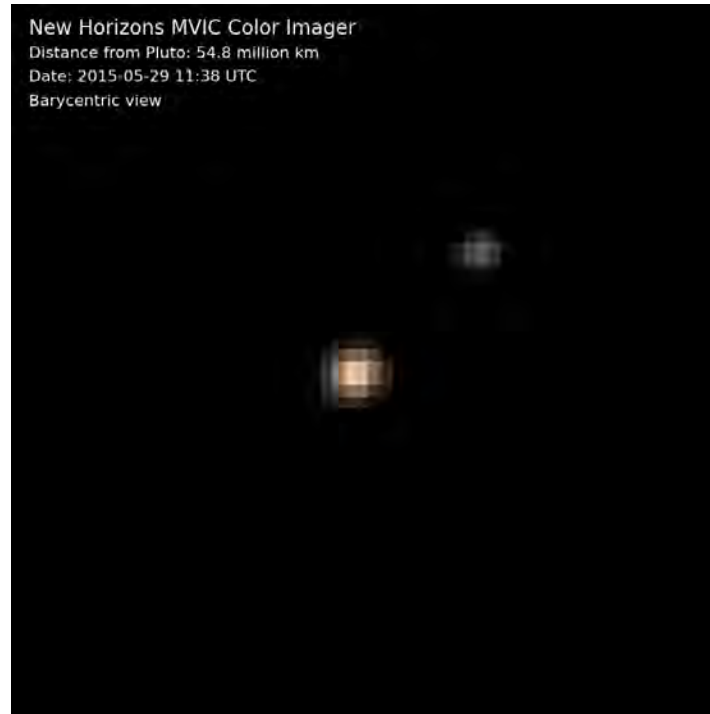


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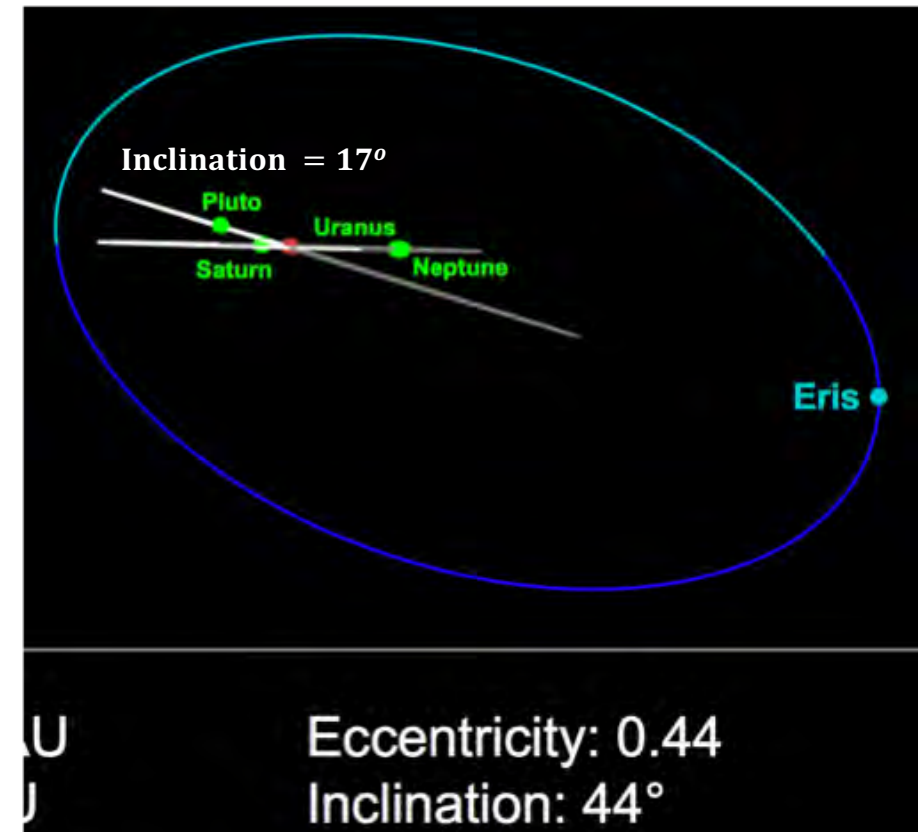
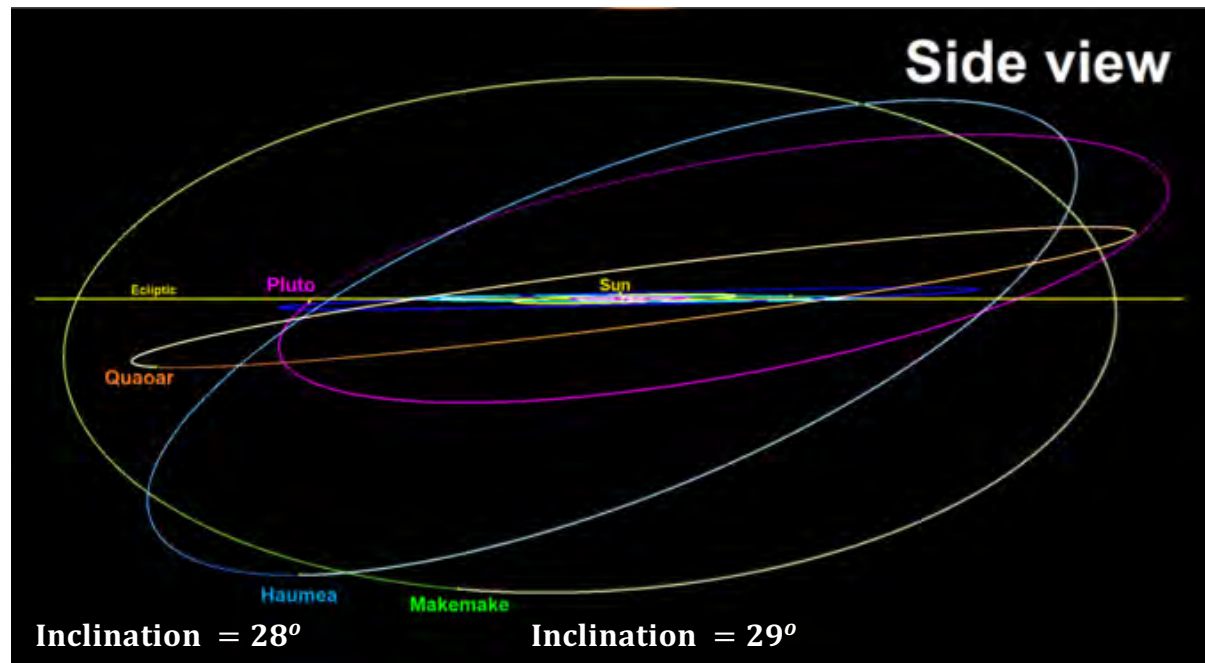
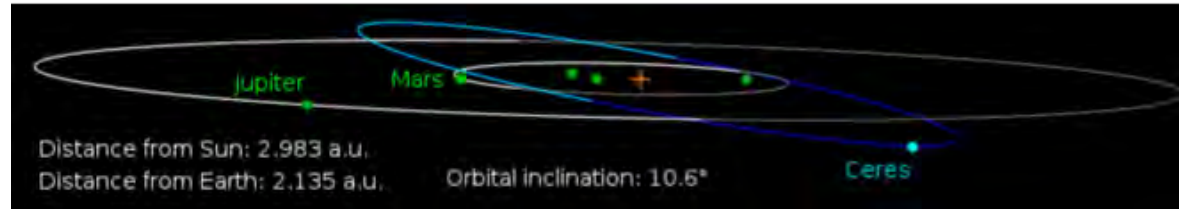
Pluto: Not a Planet (Unfortunately)



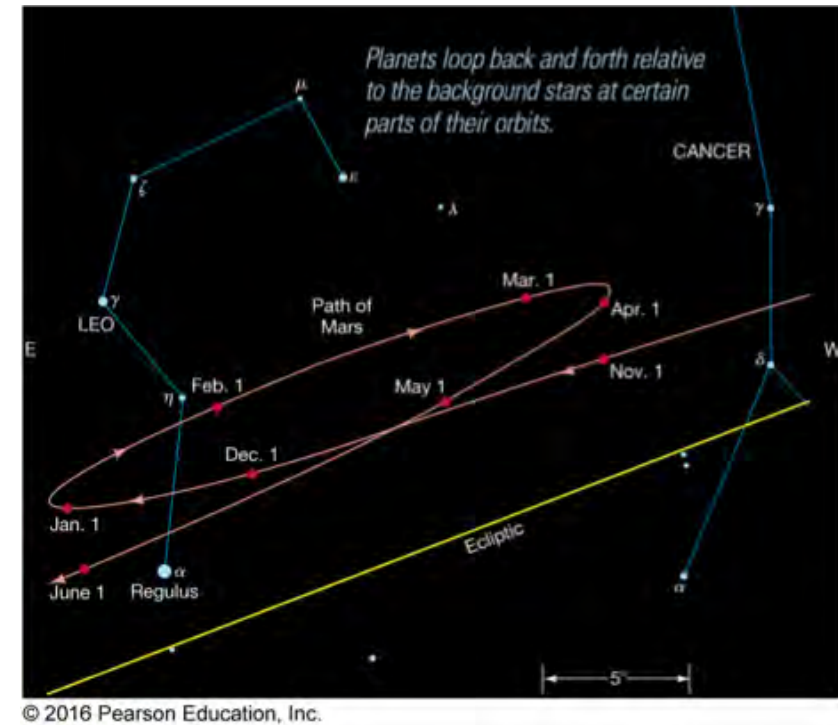
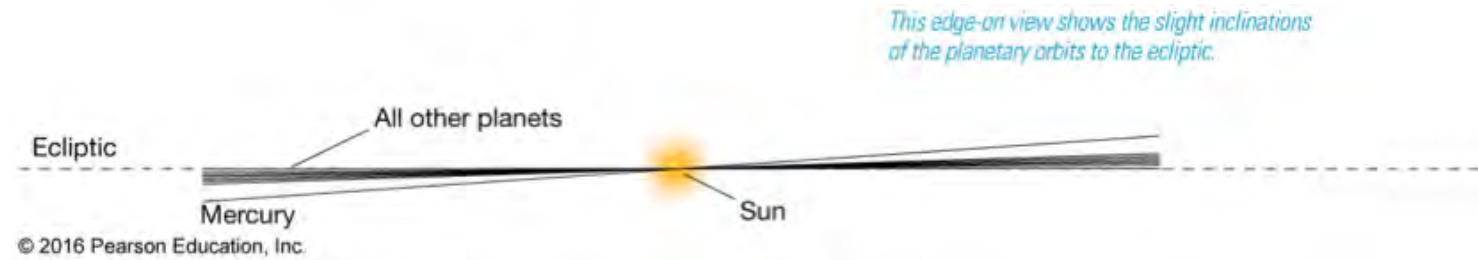
New Horizons MVIC Color Imager
Distance from Pluto: 54.8 million km
Date: 2015-05-29 11:38 UTC
Barycentric view



Dwarf Planet Orbits



Features of Planets



Elliptical Orbits

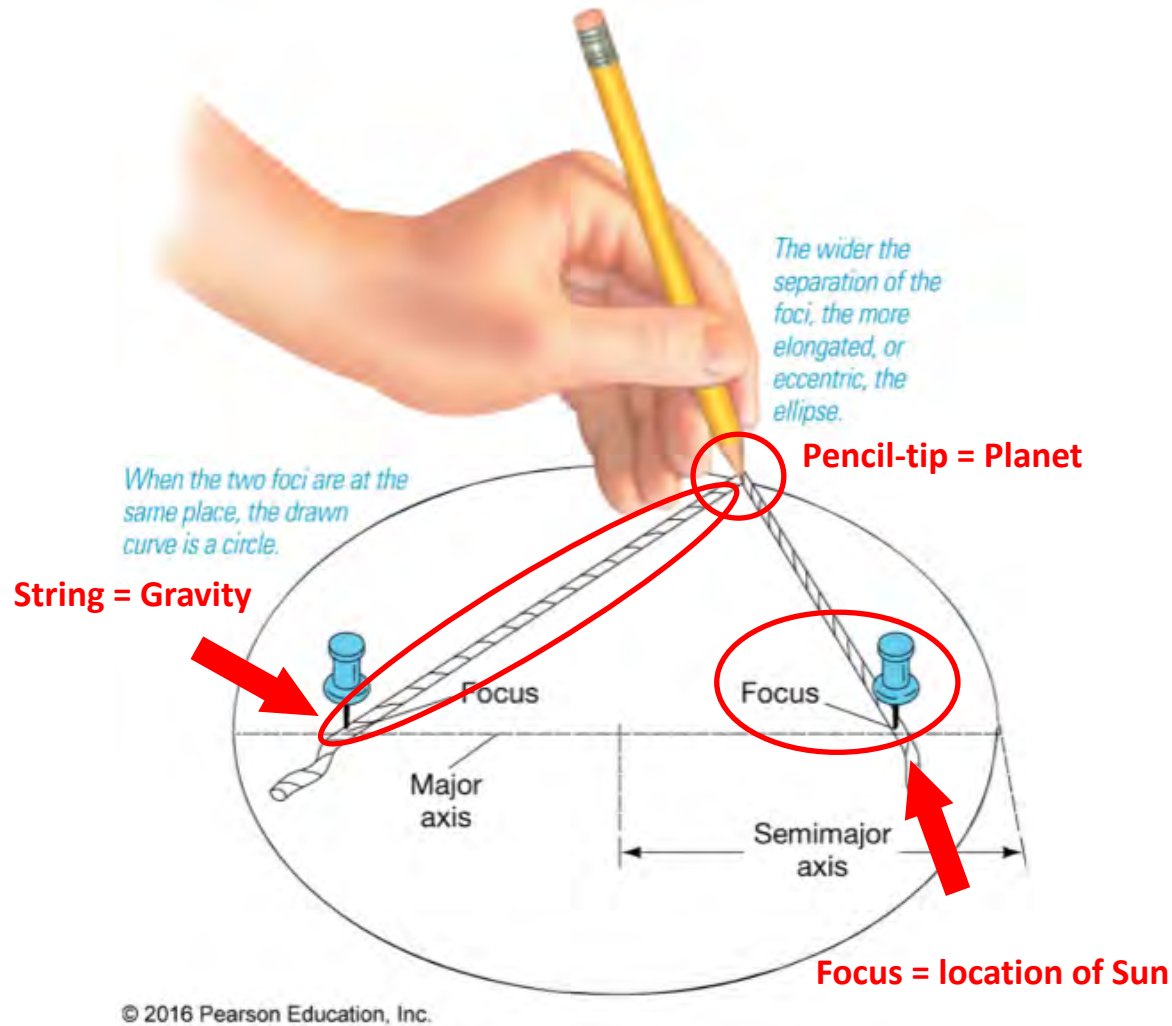


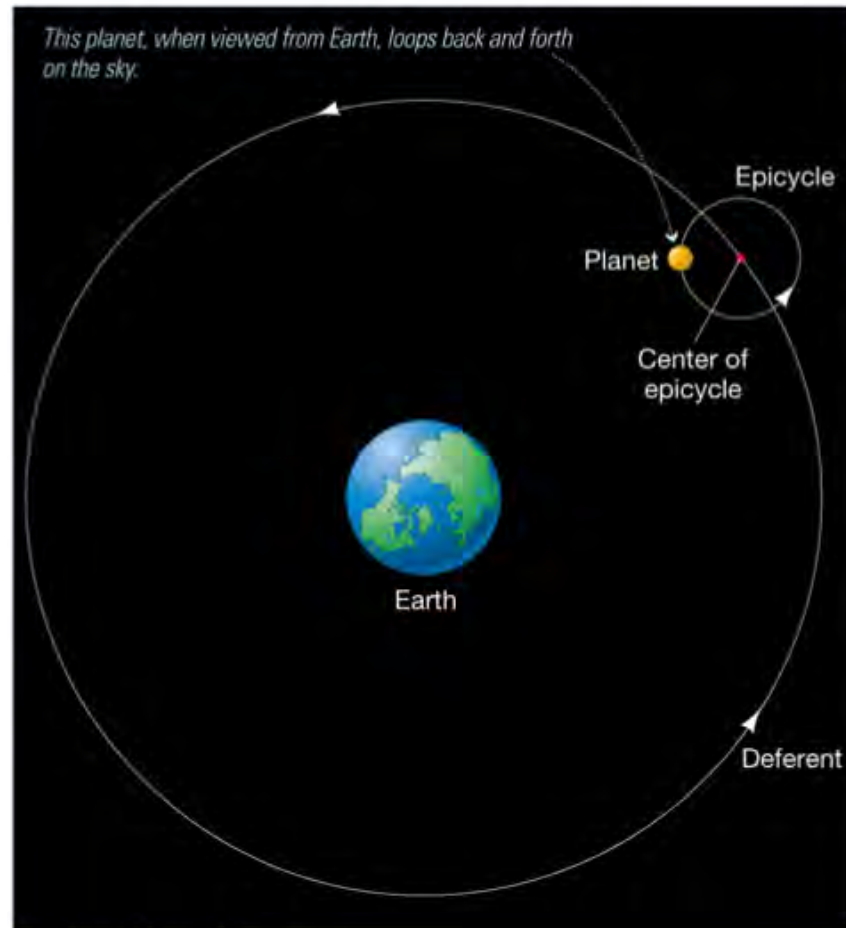
Table 3.1 Properties of Some Solar System Objects

Object	Orbital semimajor axis (AU)	Orbital period (Earth years)	Orbital eccentricity
Mercury	0.39	0.24	0.206
Venus	0.72	0.62	0.007
Earth	1.00	1.0	0.017
Mars	1.52	1.9	0.093
Jupiter	5.2	11.9	0.048
Saturn	9.5	29.4	0.054
Uranus	19.2	84	0.047
Neptune	30.1	164	0.009
Sun	—	—	—

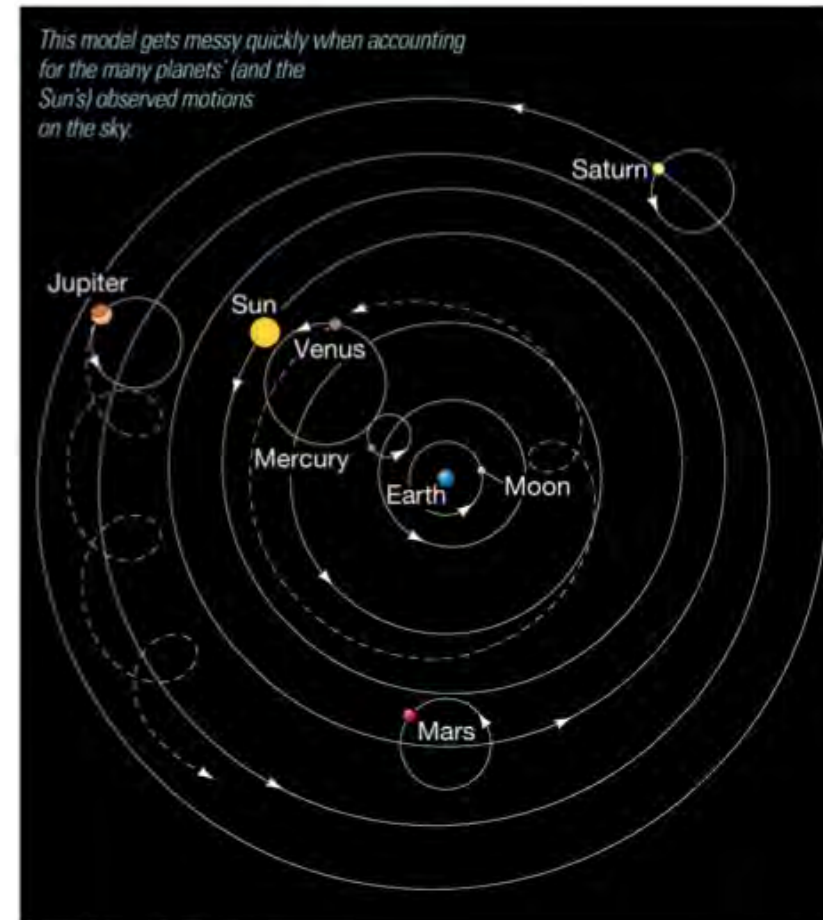
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$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

Ptolemaic Geocentrism

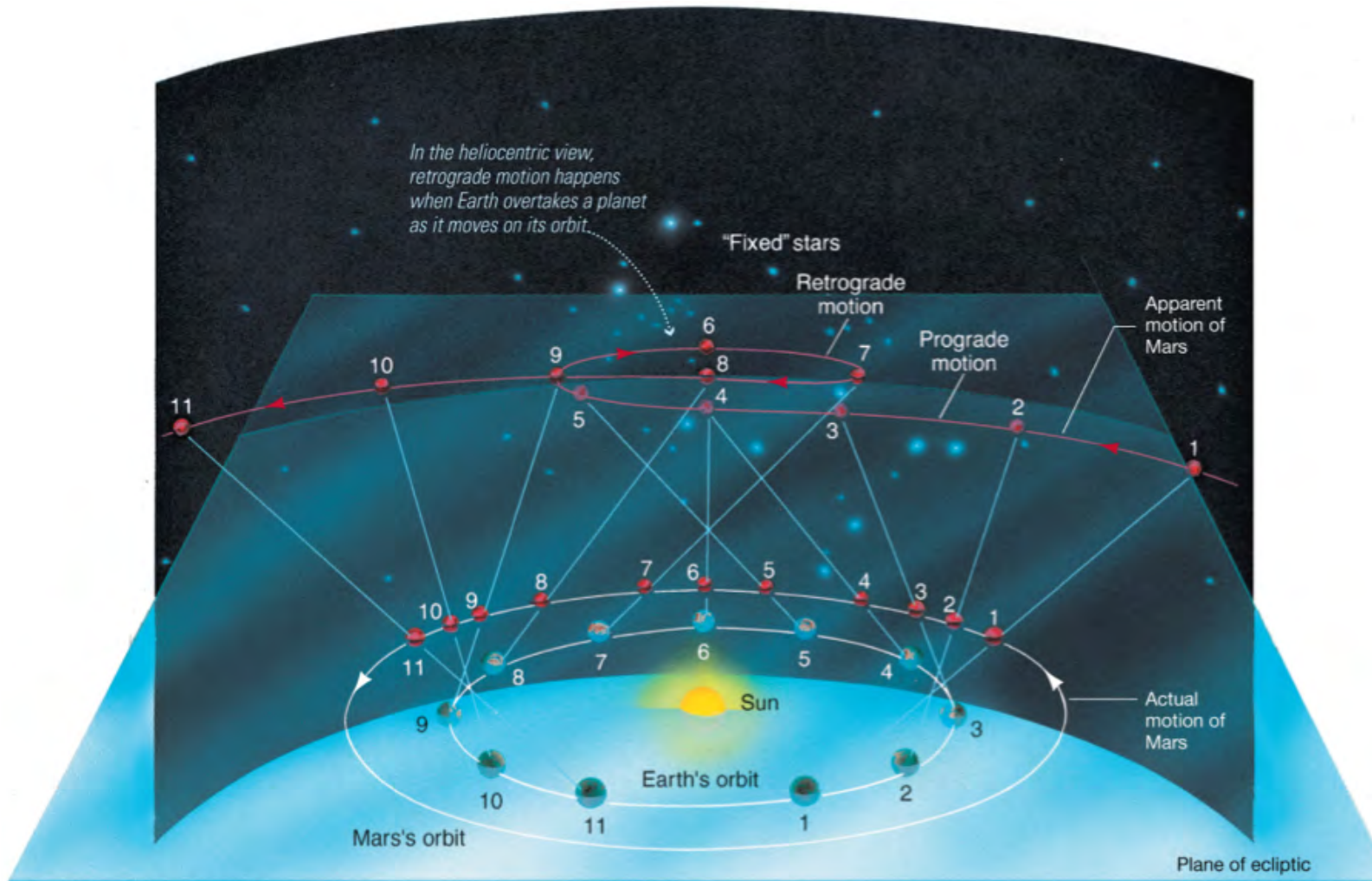


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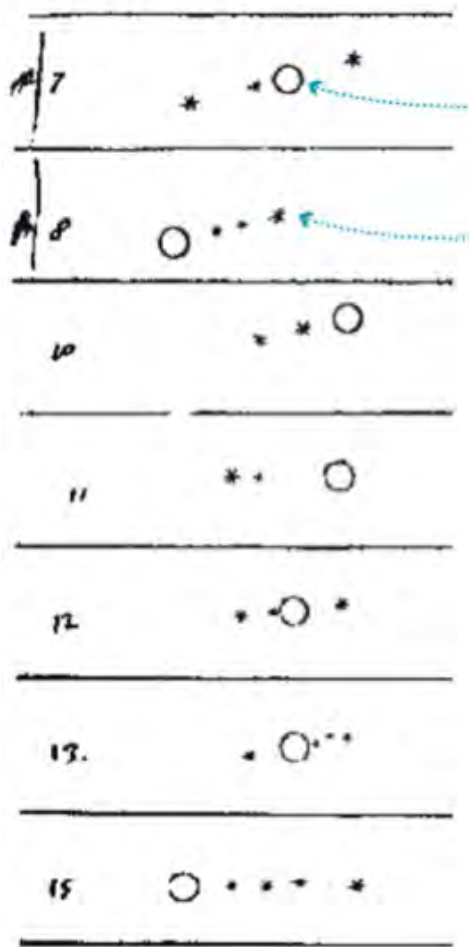
Heliocentrism (Copernicus)



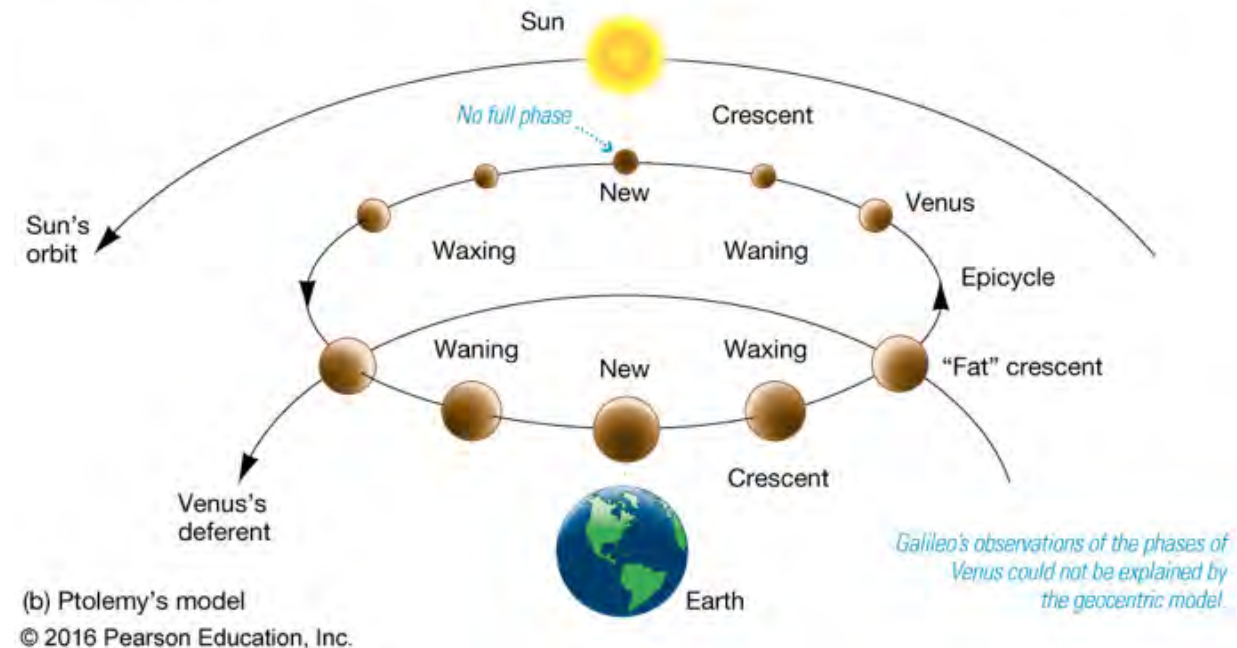
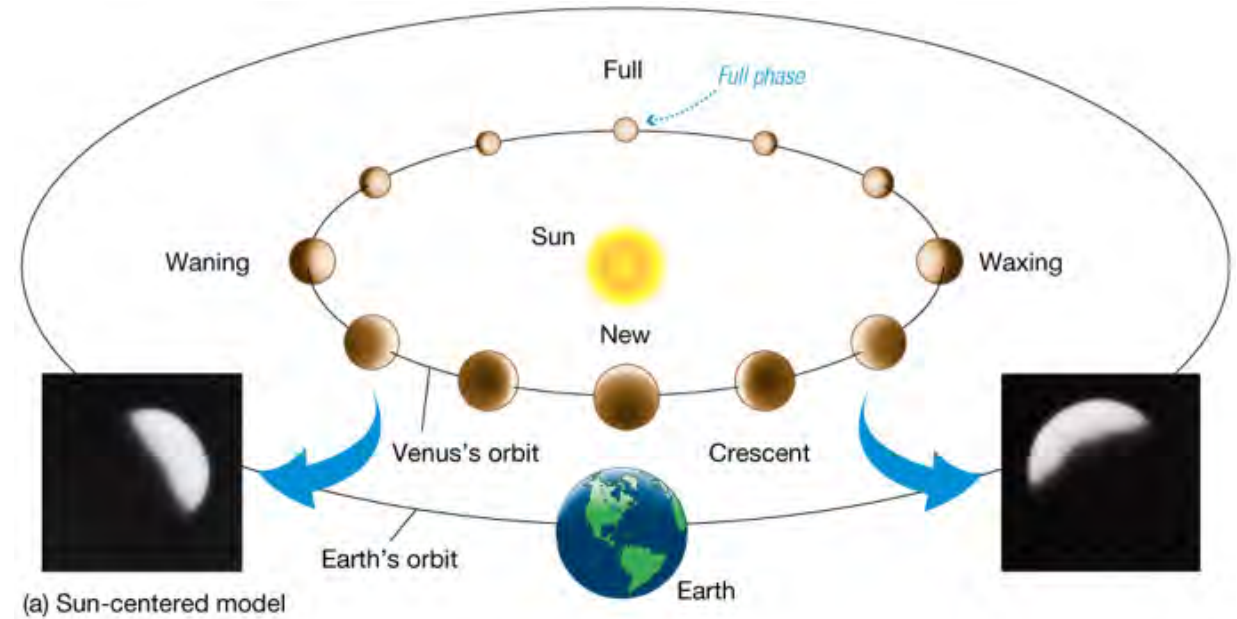
Heliocentrism (Galileo)



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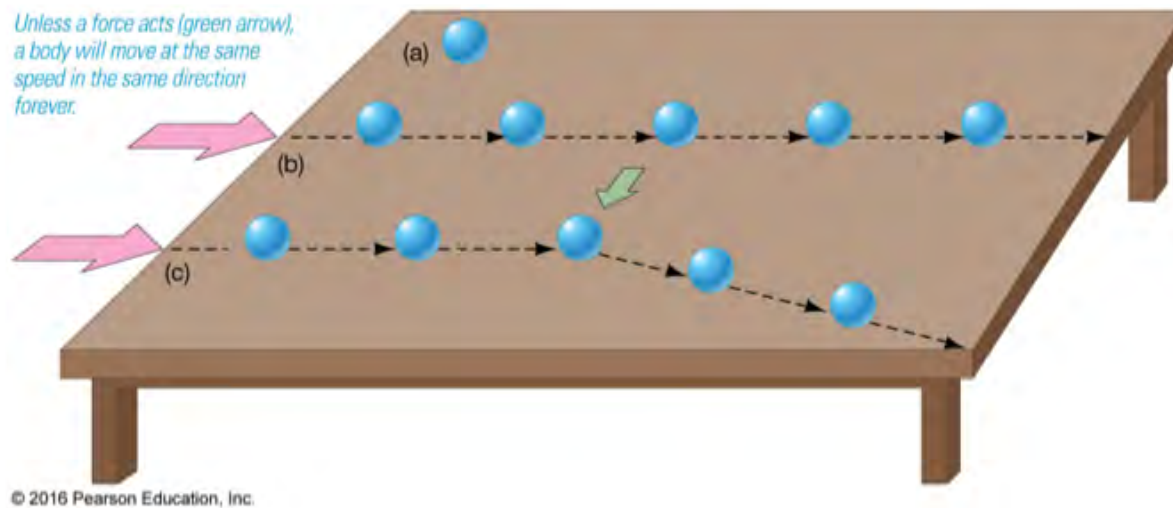


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Newton's Laws of Motion

- I. An object at rest will remain at rest, and an object in motion will remain in motion, unless acted upon by a force.
- II. $F = ma$
- III. For every action, there is an equal and opposite reaction.

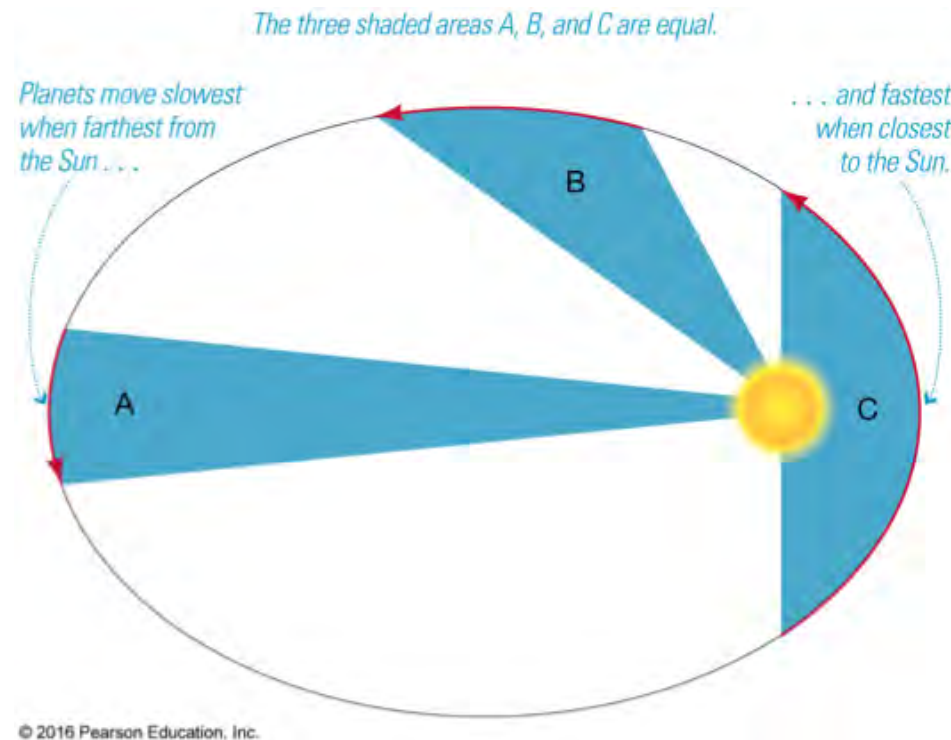


Kepler's Laws of Planetary Motion



- I. Planetary orbits are ellipses
- II. A planet covers equal areas in equal times around the ellipse

III. $P^2 \text{ (years)} = \frac{a^3 \text{ (AU)}}{M \text{ (solar masses)}}$



Using Kepler's Third Law

