

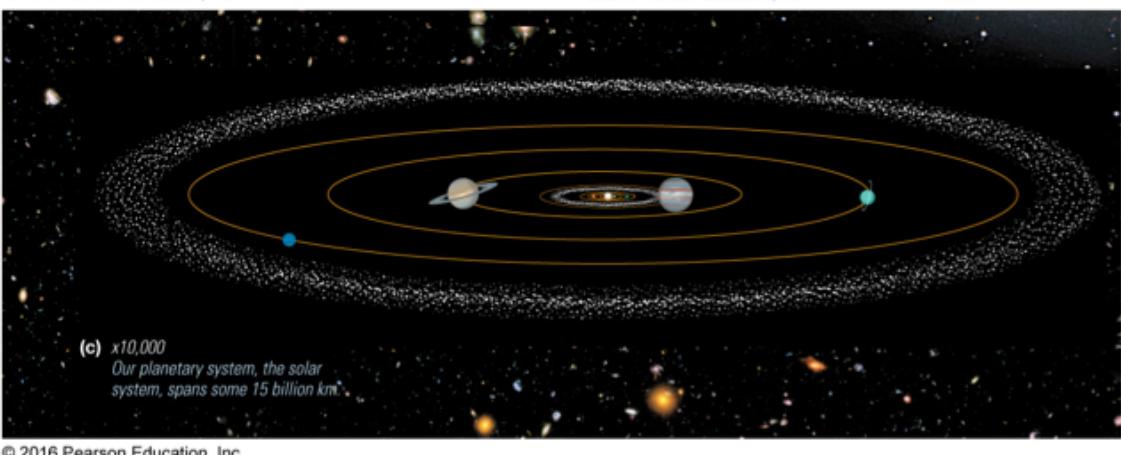
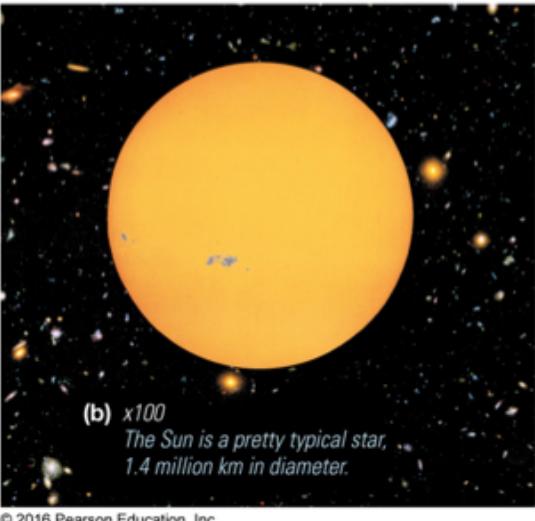
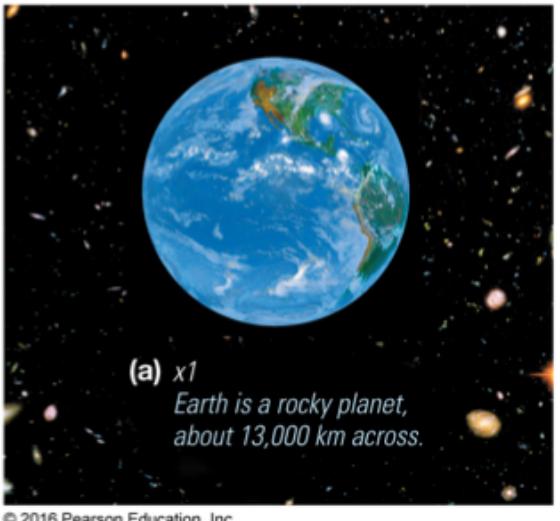
Chapter 1: The Night Sky

Prof. Douglas Laurence

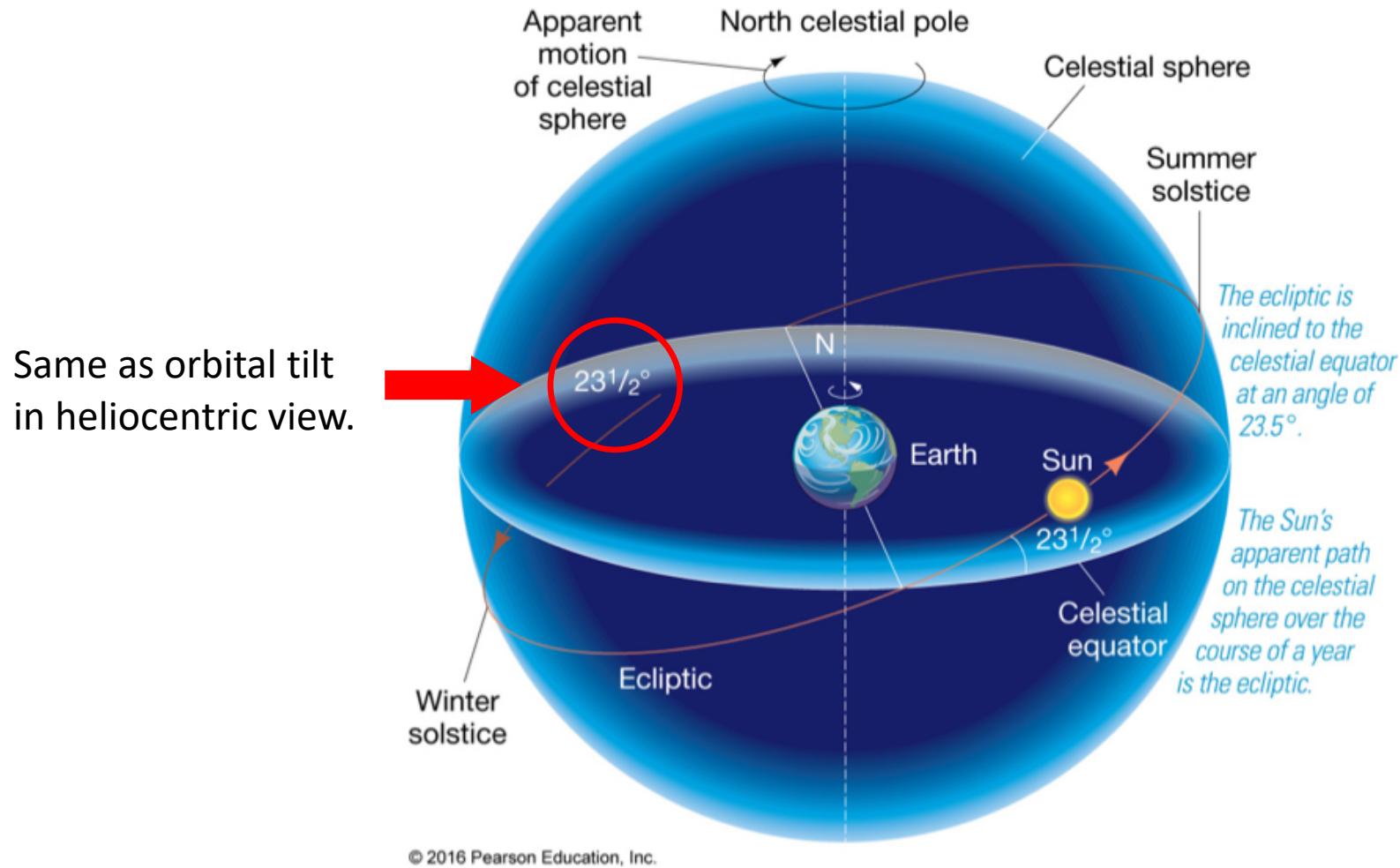
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Spring 2018

Order of Magnitude



Geocentric View



Constellations

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



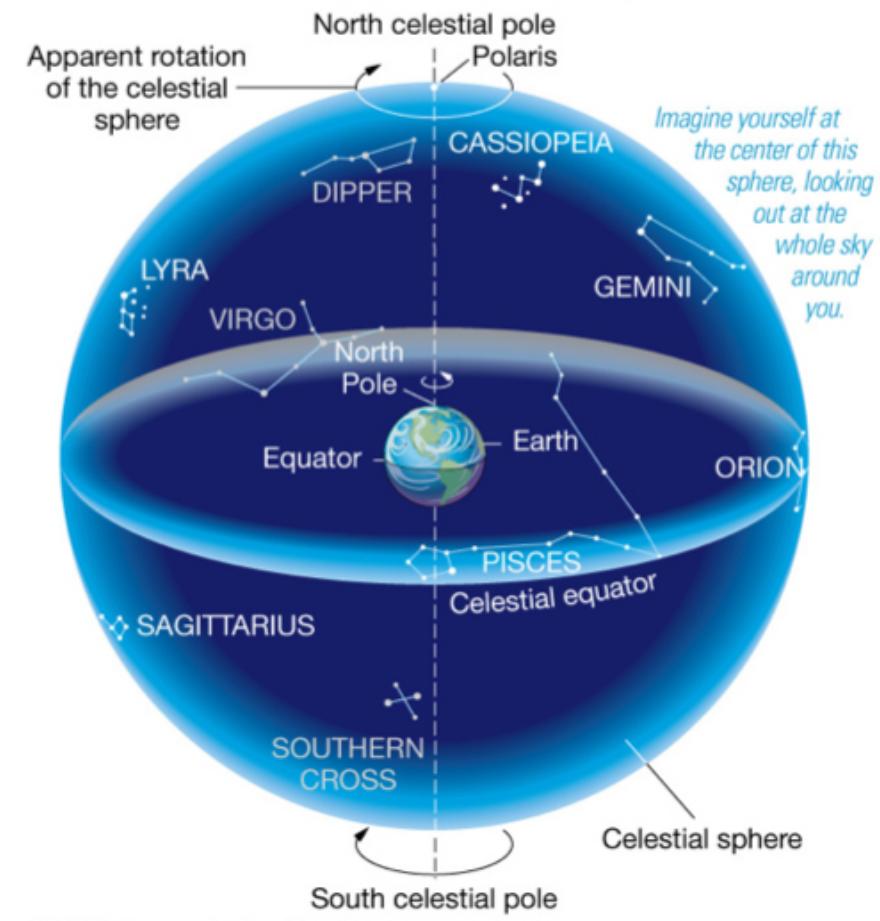
(a)

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

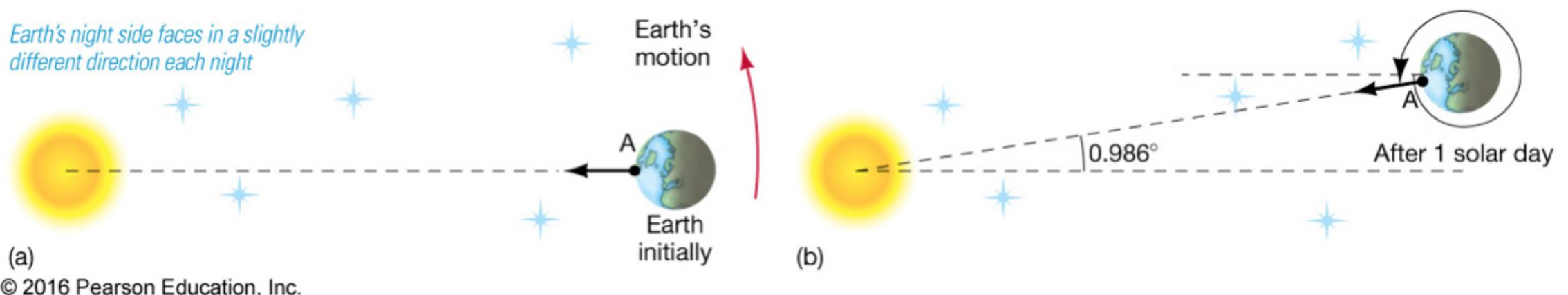


(b)



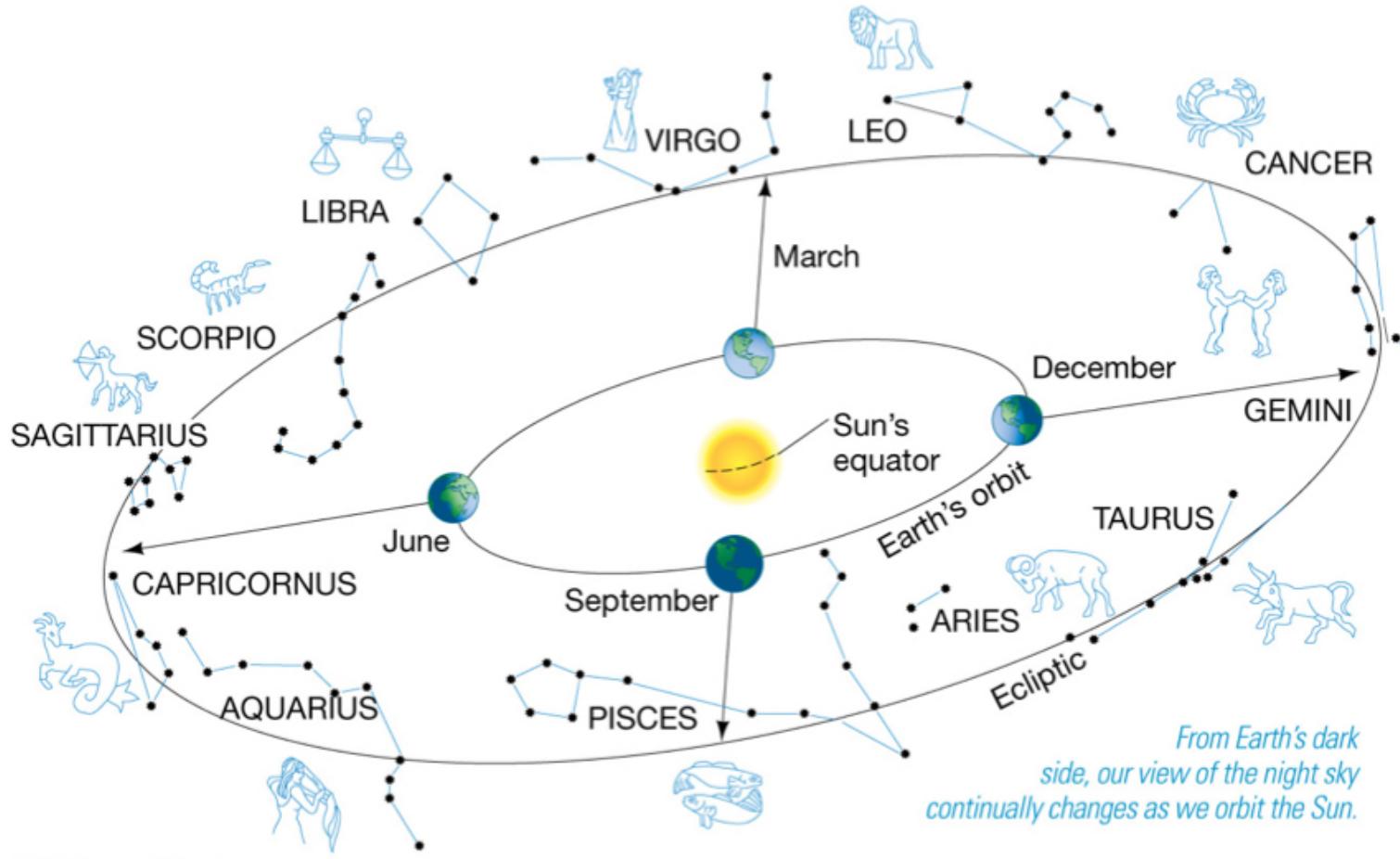
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Sidereal vs. Solar Time



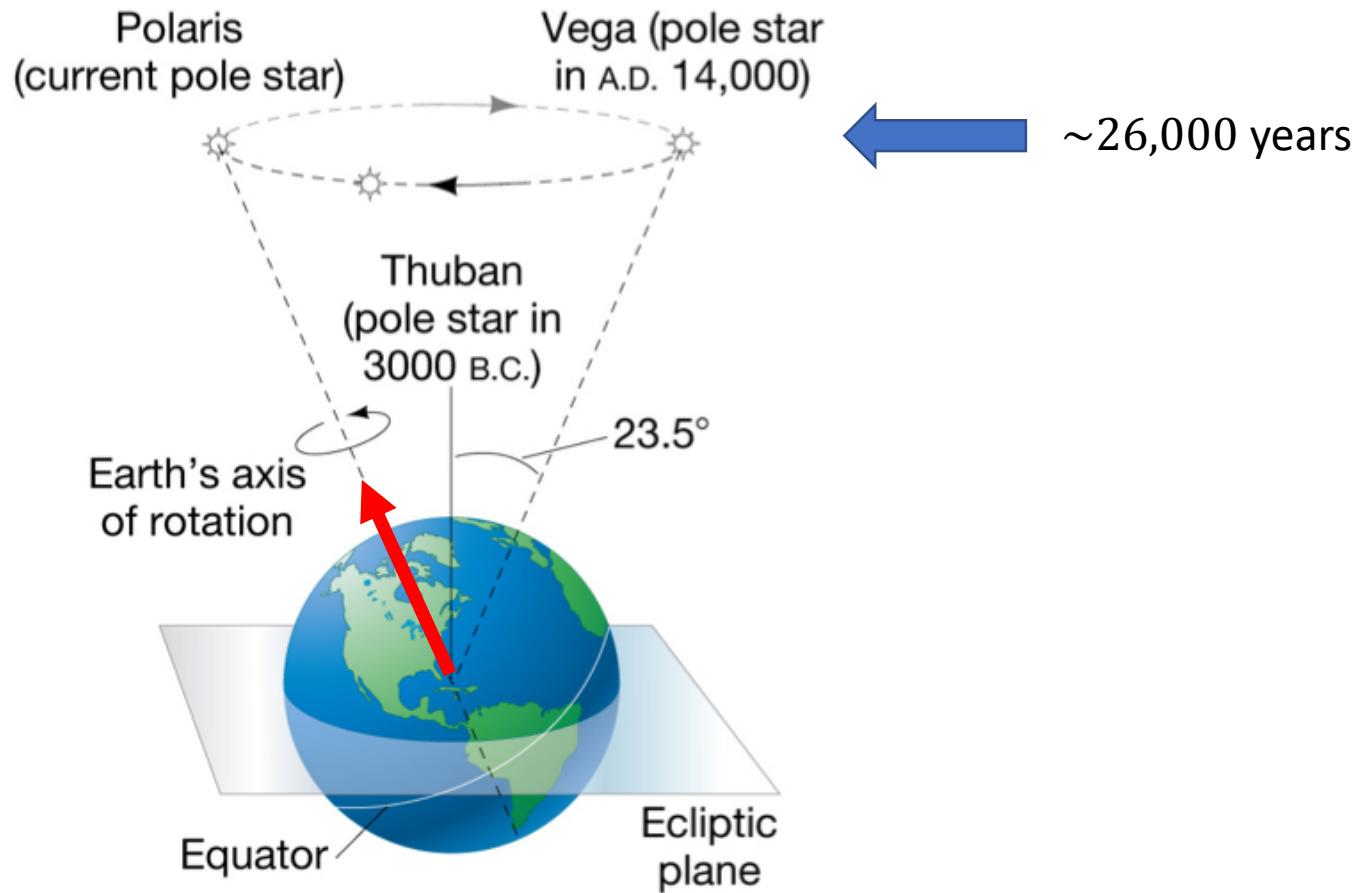
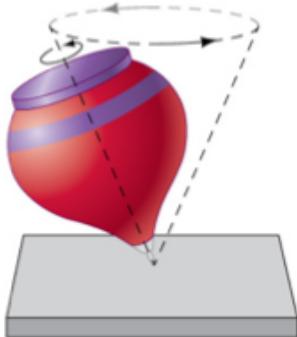
$$24 \text{ solar hours} = 23 \text{ h } 56 \text{ min sidereal time}$$

Seasons and the Night Sky

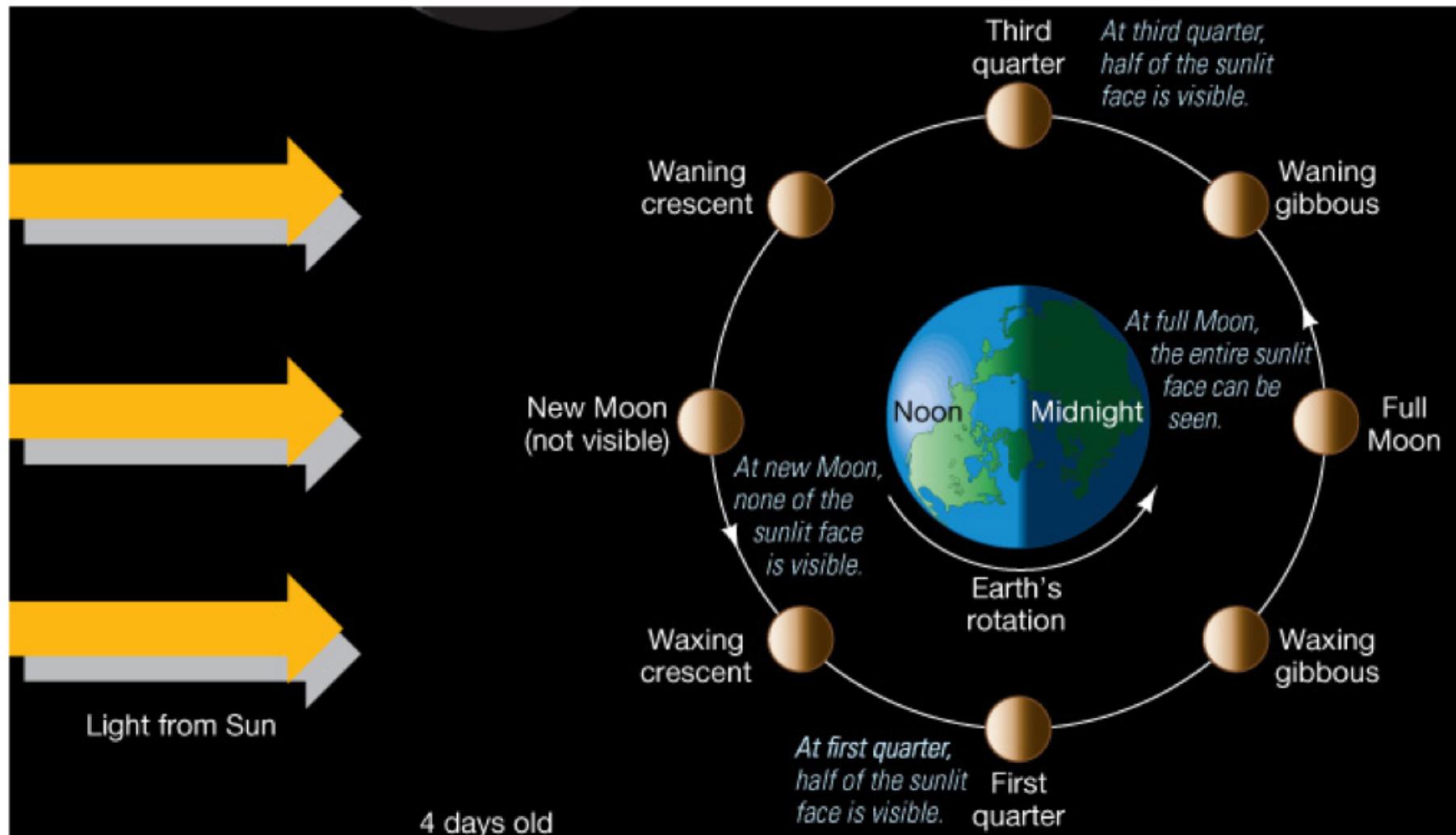


Orbital Precession

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



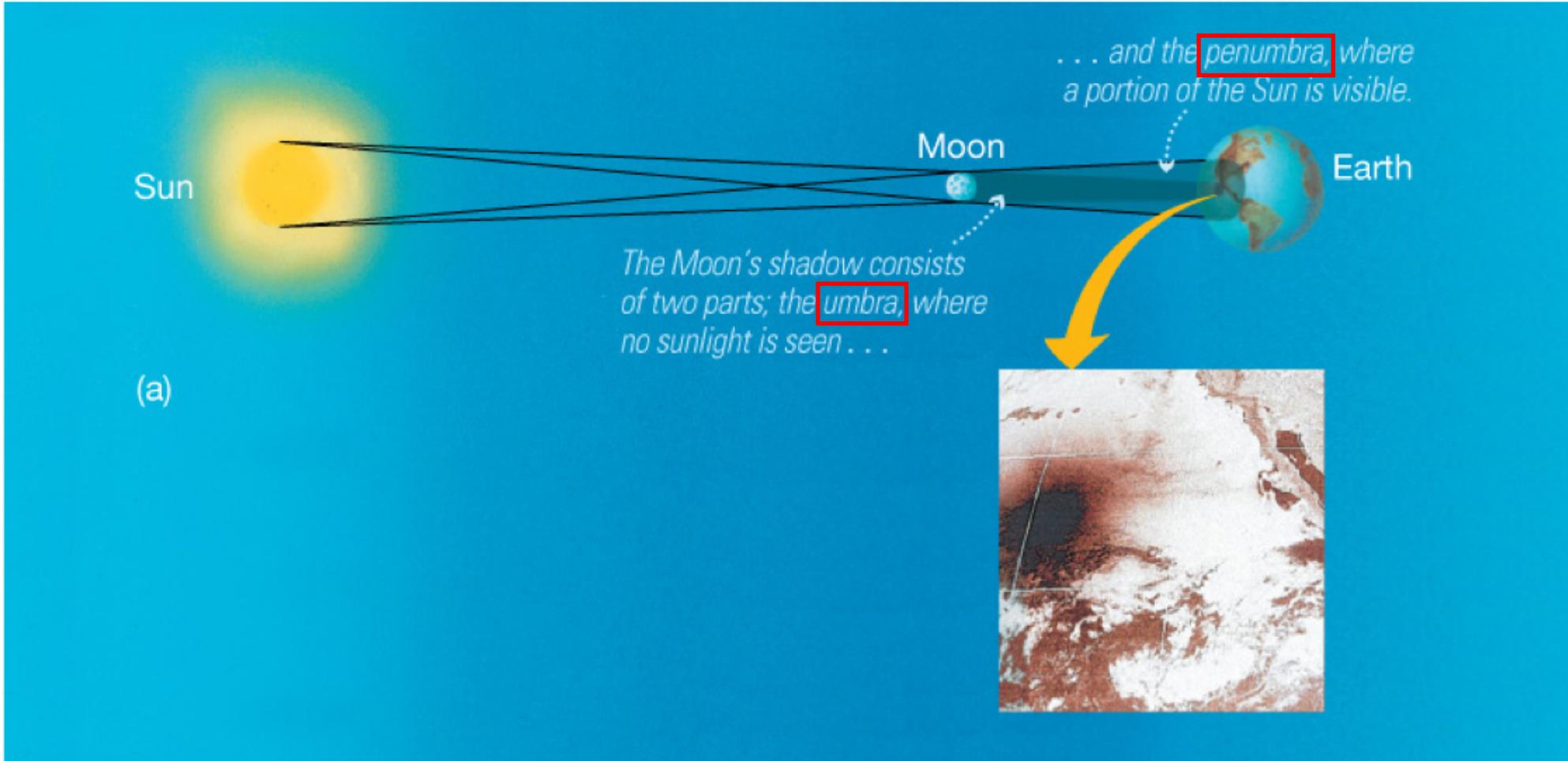
Phases of the Moon



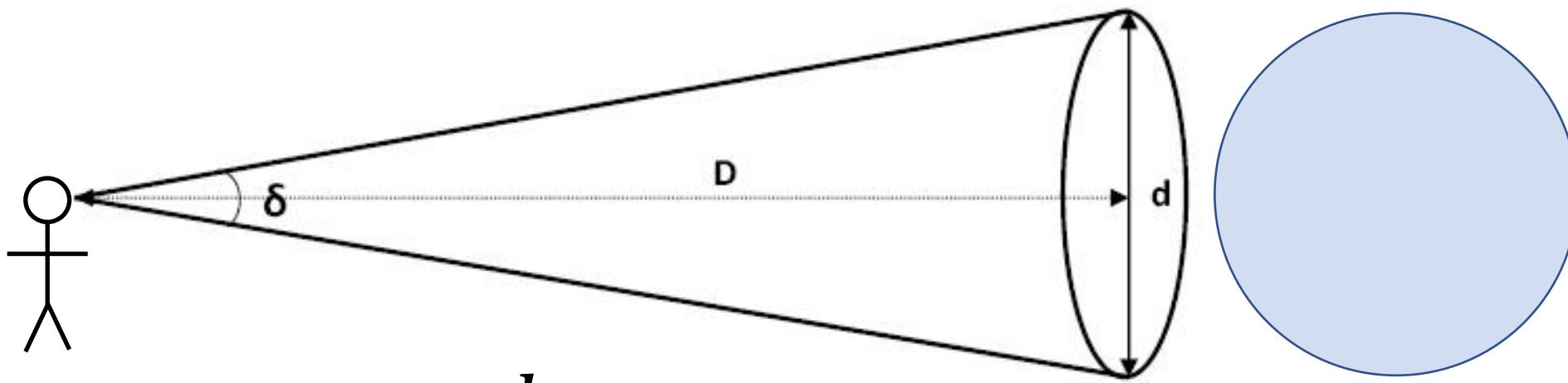
Phases of the Moon (cont'd)



Solar Eclipses

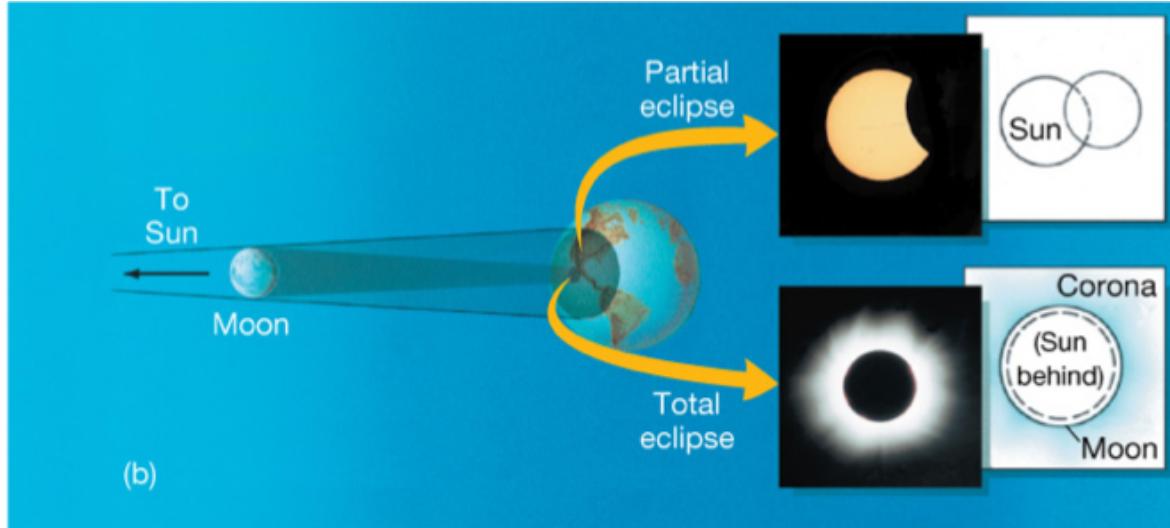


Angular Size



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

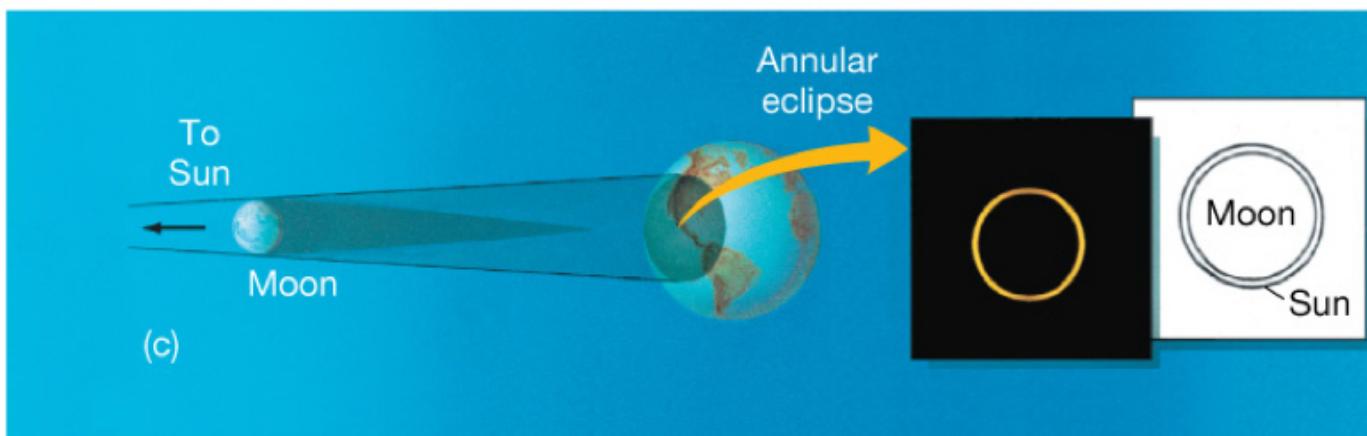
Total vs. Annular Solar Eclipses



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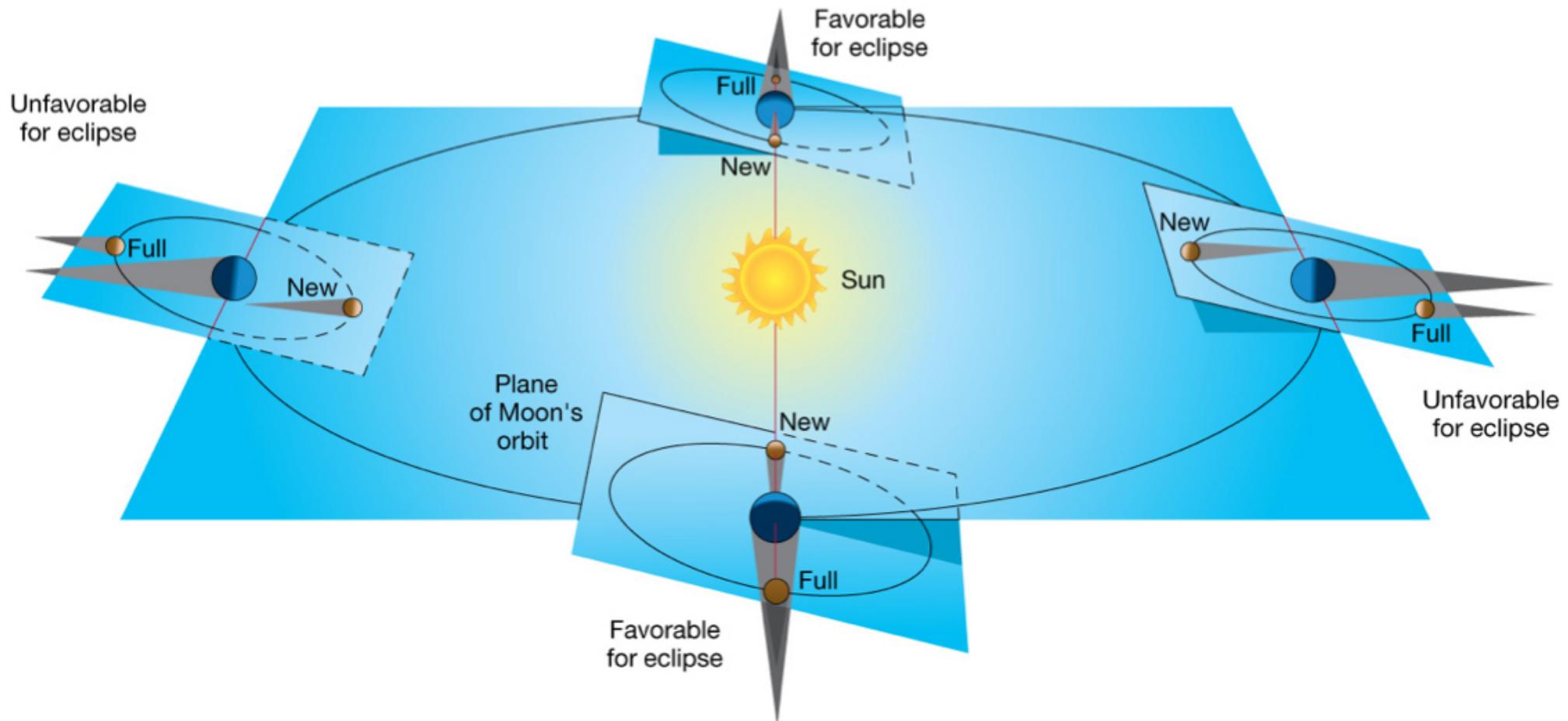
Eclipse Interactive Applet:

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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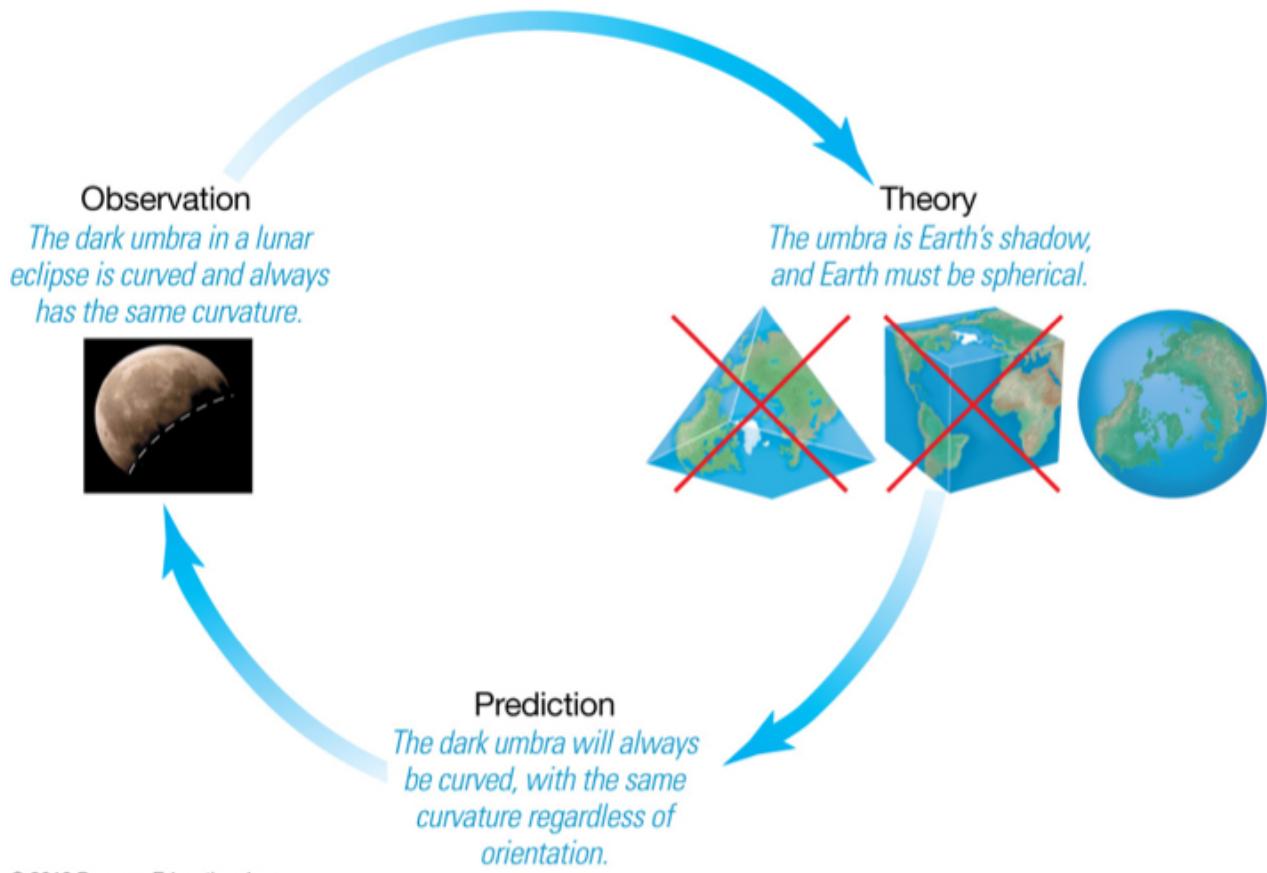
Conditions for Eclipse



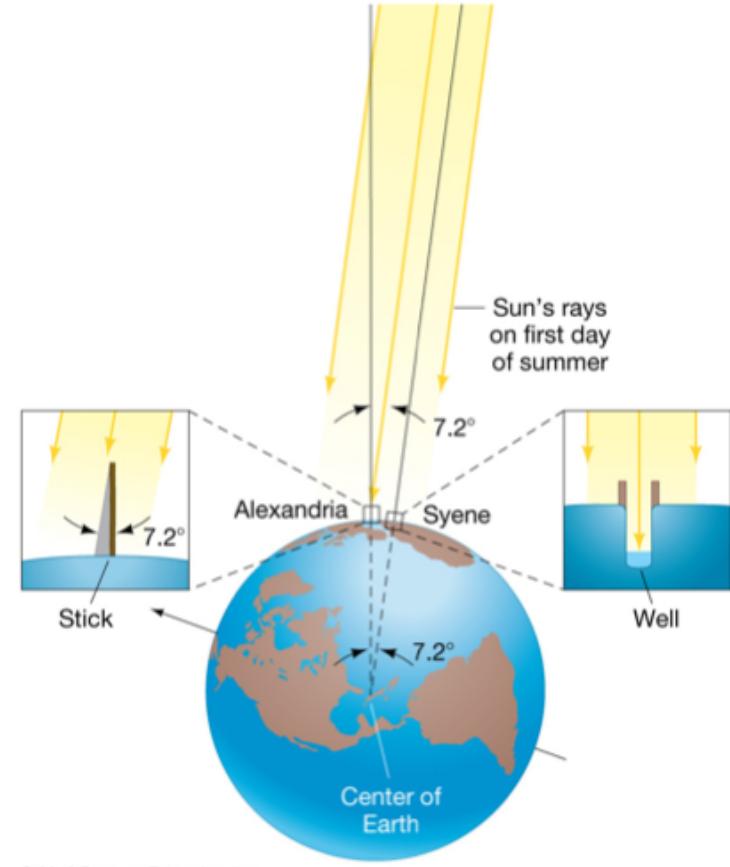
Frequencies of Eclipses

- 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

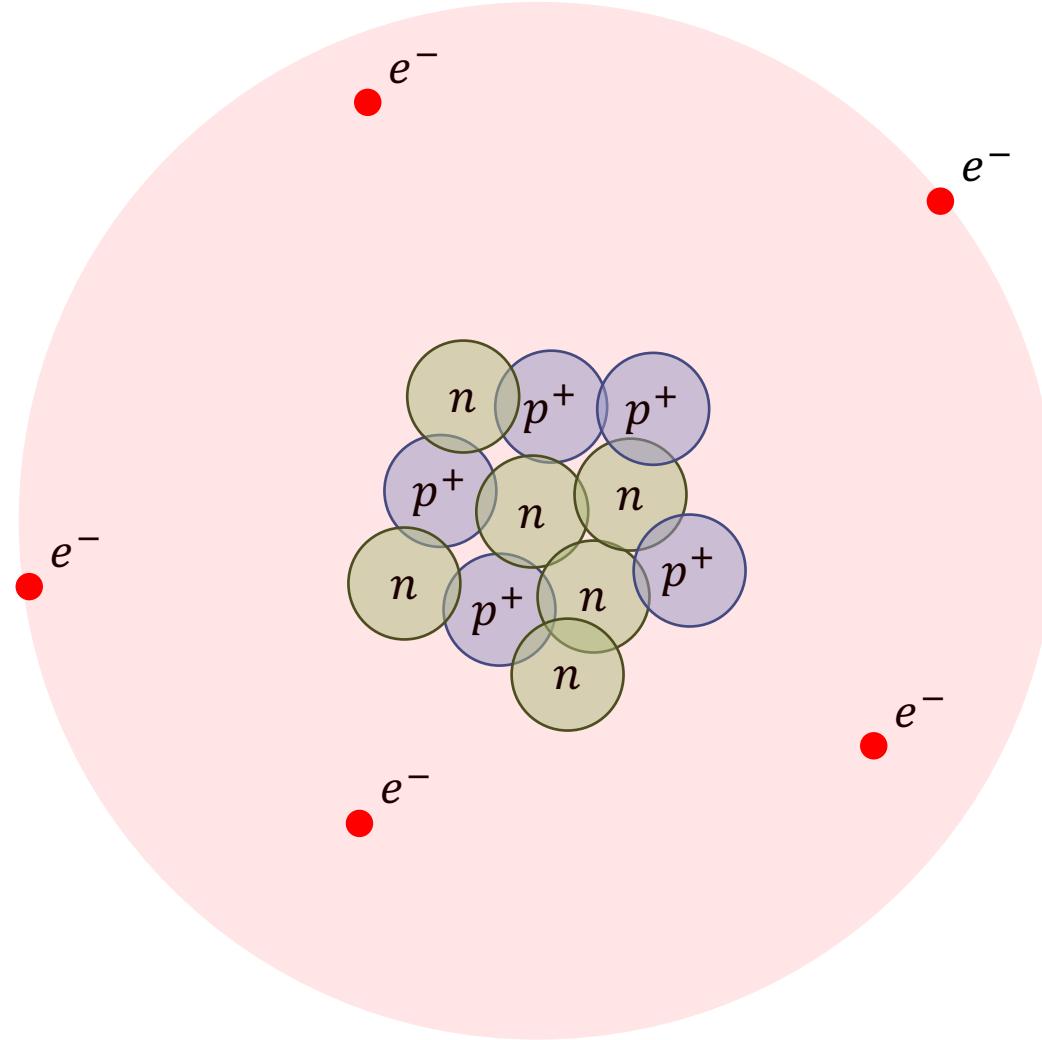


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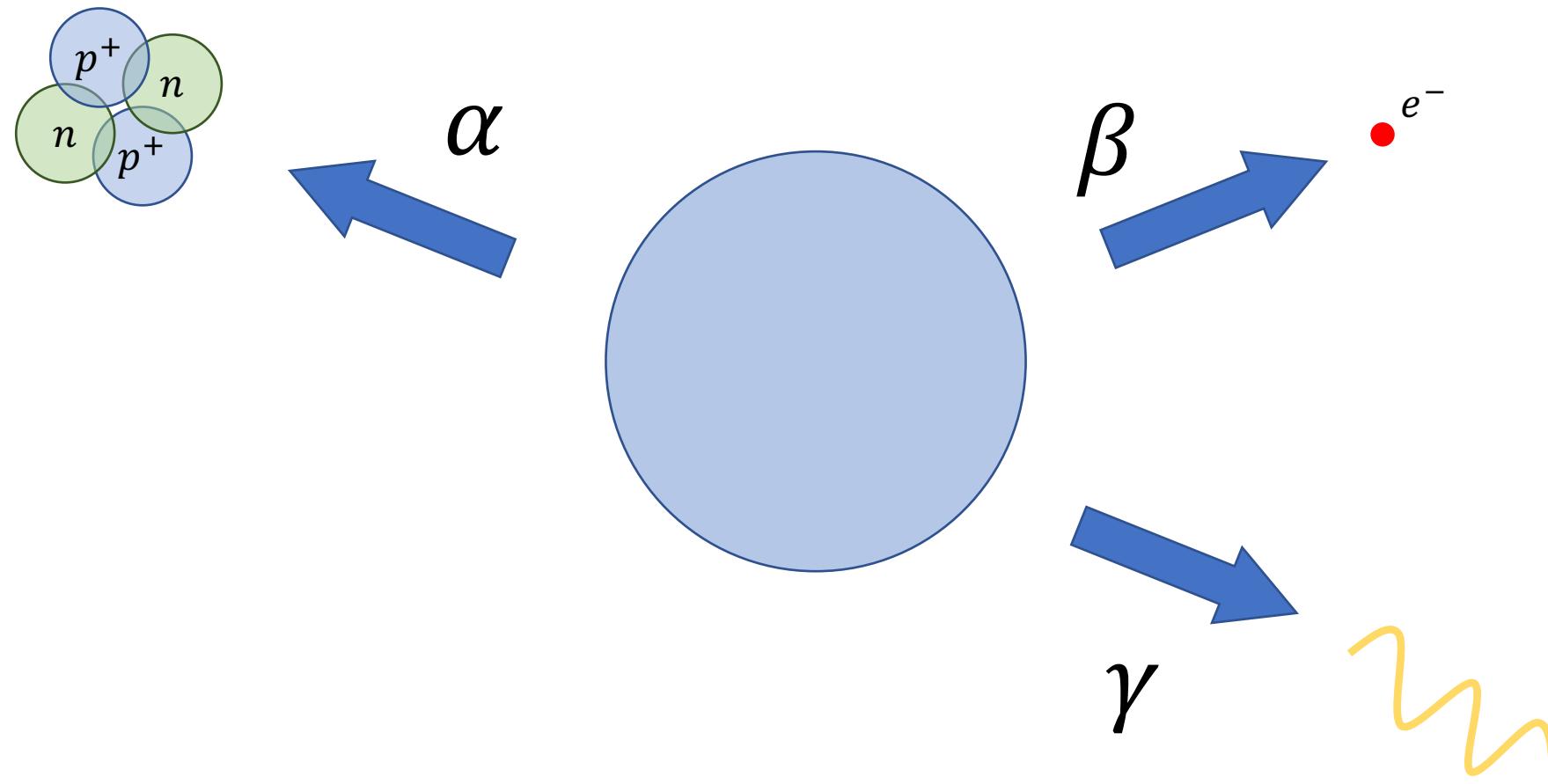


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Atoms



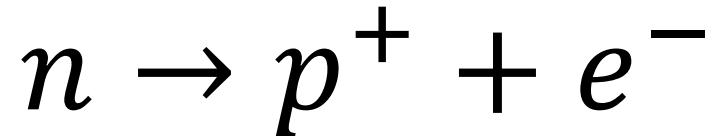
Types of Radiation



Mass-Energy Equivalence

$$E = mc^2$$

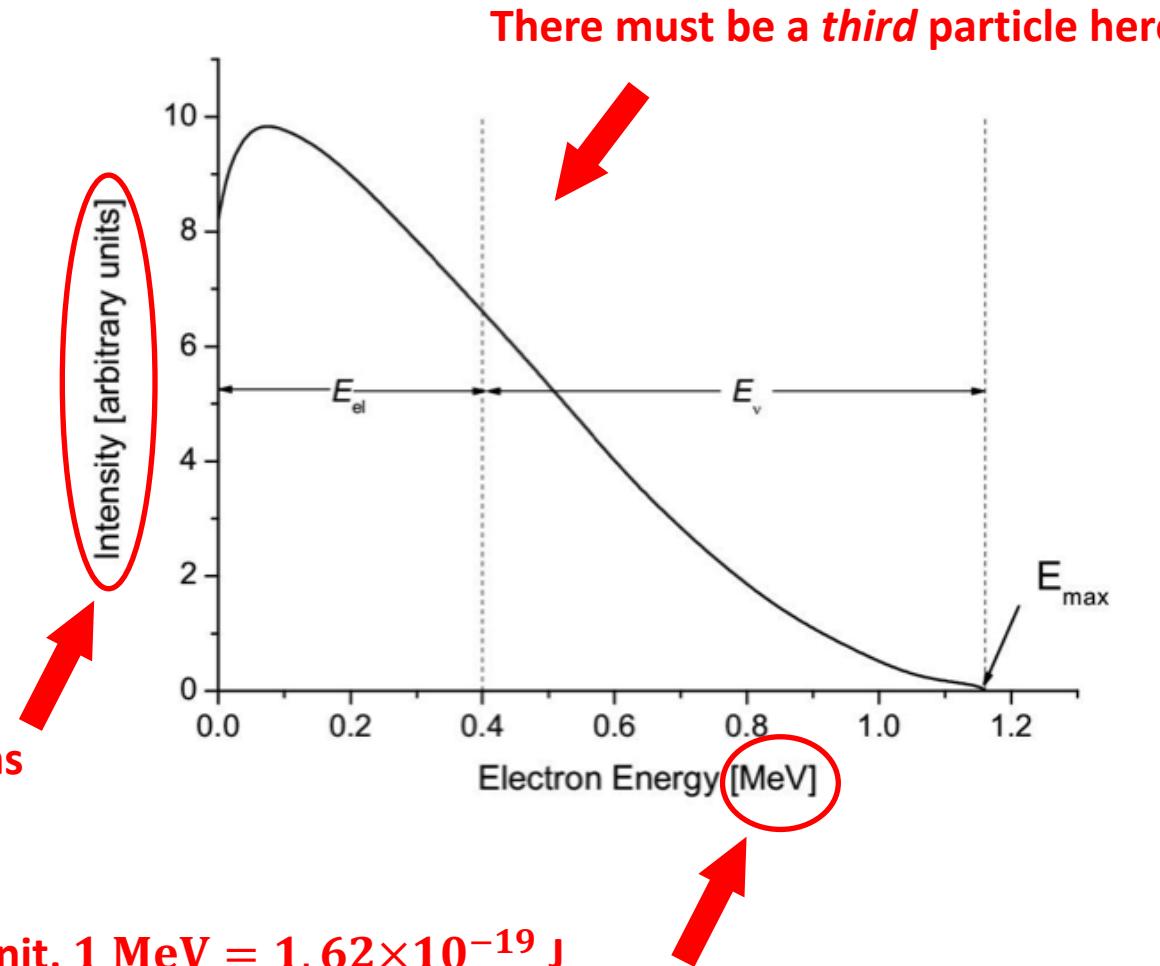
β -Decay



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

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

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

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

Leptons

No electric charge
= no electric force!

$<2 \text{ eV}$	$<0.19 \text{ MeV}$	$<18.2 \text{ MeV}$
0 ν_e $\frac{1}{2}$ electron neutrino	0 ν_μ $\frac{1}{2}$ muon neutrino	0 ν_τ $\frac{1}{2}$ tau neutrino
0.511 MeV $\frac{-1}{2}$ electron	106 MeV $\frac{-1}{2}$ muon	1.78 GeV $\frac{-1}{2}$ tau

0 0 1 Y photon	125.7 GeV 0 0 H Higgs
0 0 1 g gluon	0 0 2 G Graviton
90.2 GeV 0 1 Z ⁰ weak force	80.4 GeV ± 1 1 W ⁺ weak force

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

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

No strong force!

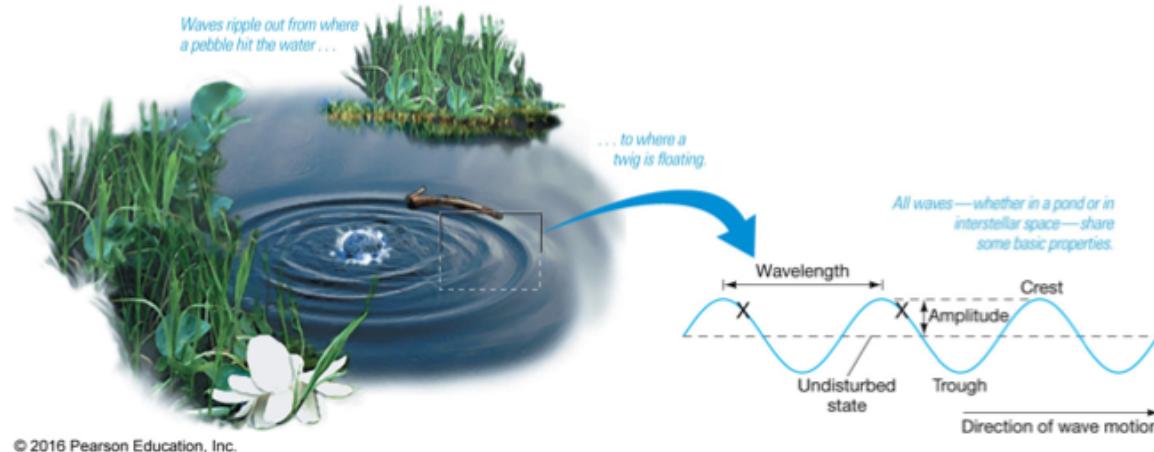
Chapter 2: Light and Telescopes

Prof. Douglas Laurence

AST 1002

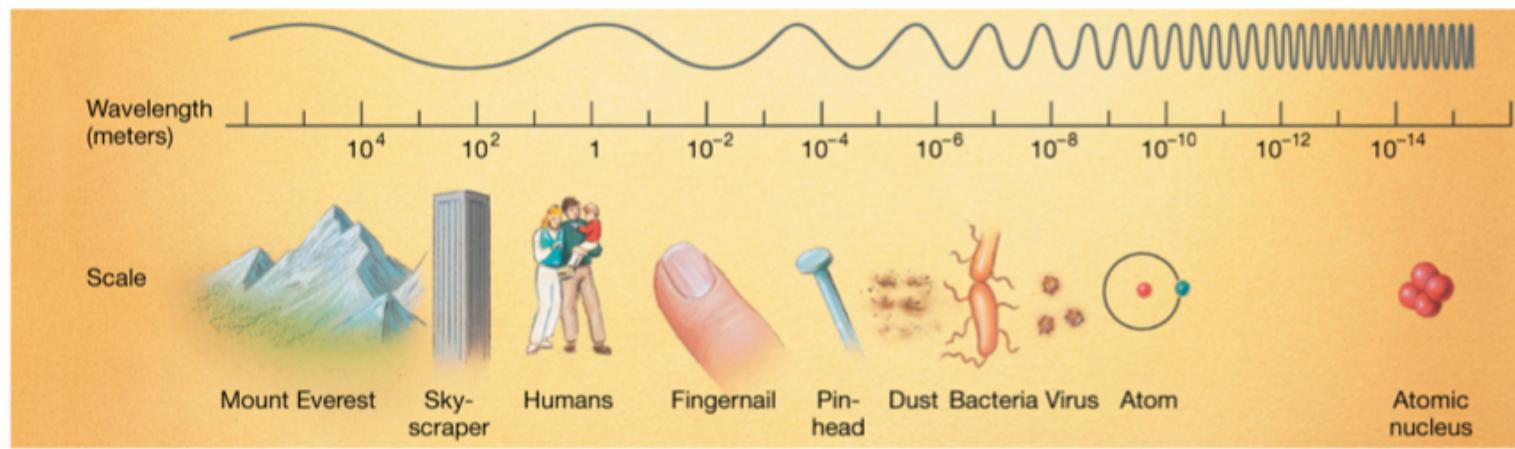
Spring 2018

Electromagnetic Radiation

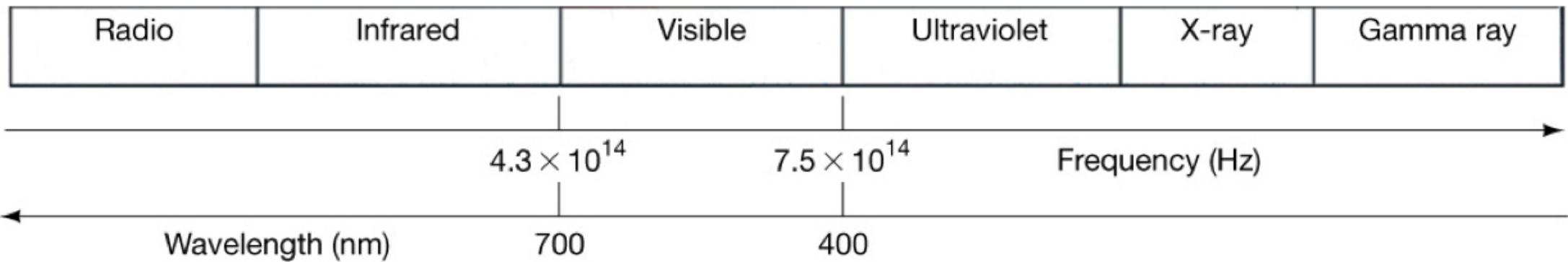
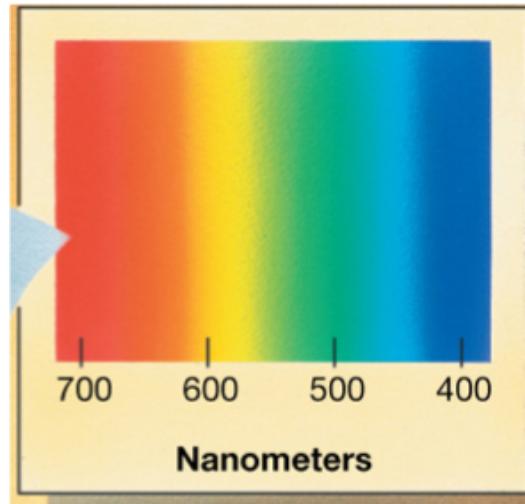


$$v = \lambda f$$

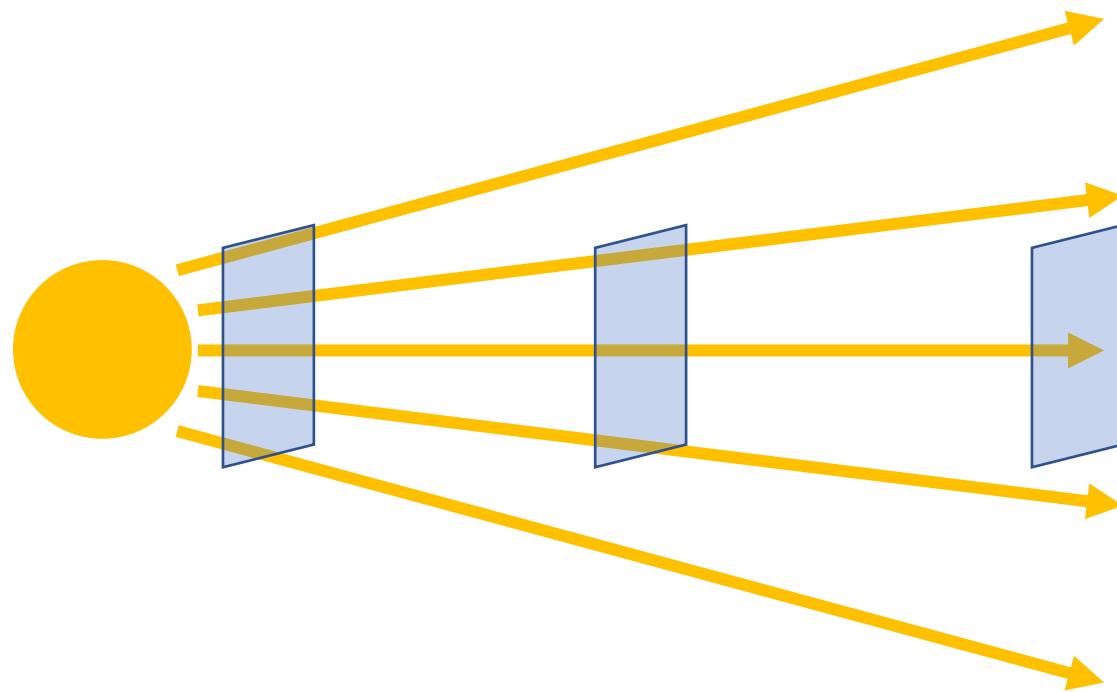
$$E = hf$$



Visible Light Spectrum



Isotropic Emission



Brightness *decreases with distance (squared)*

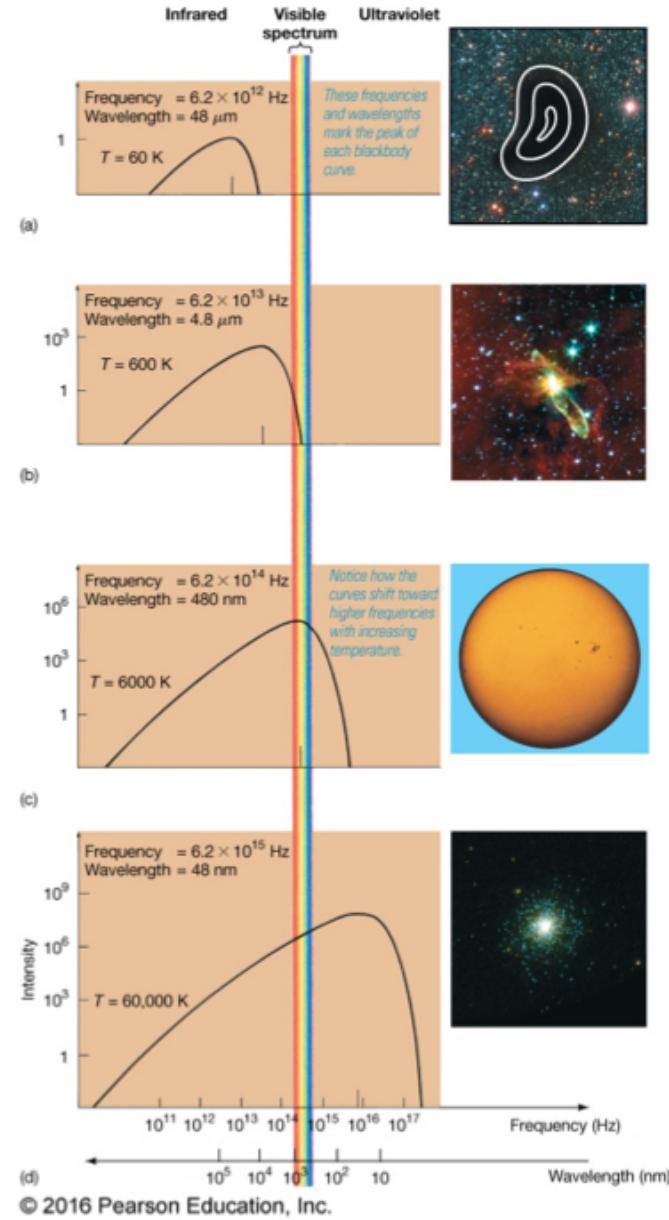
Blackbody Radiation

Stefan-Boltzmann Law:

$$I = \sigma T^4$$

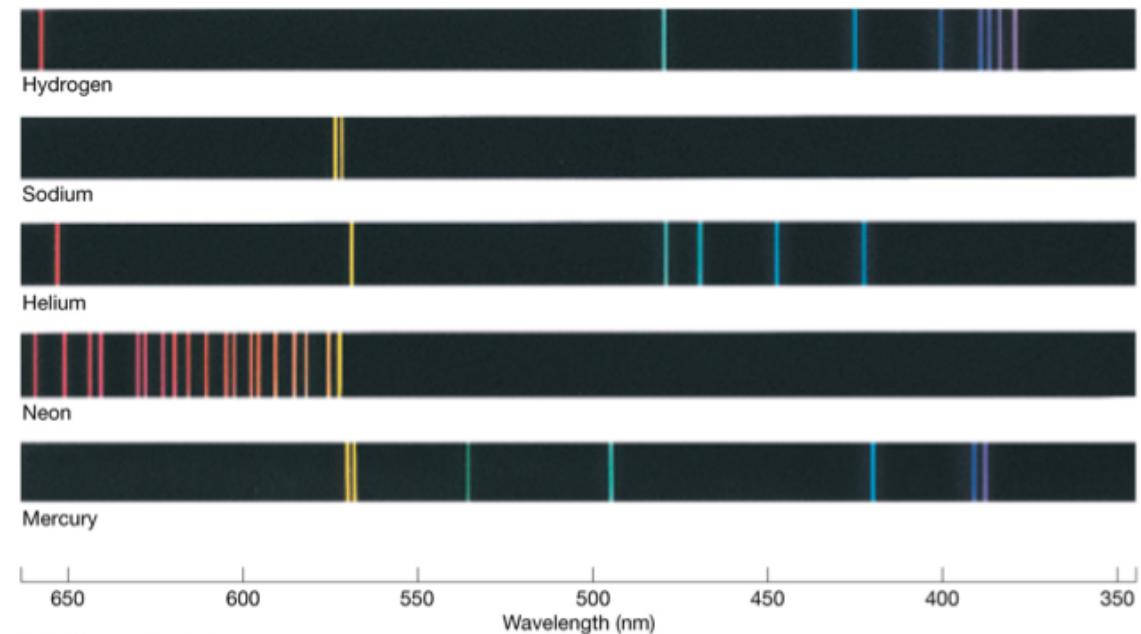
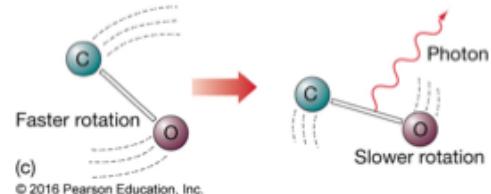
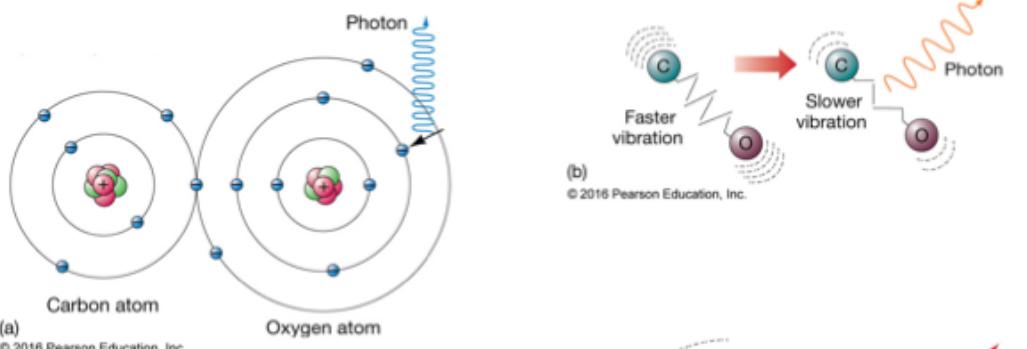
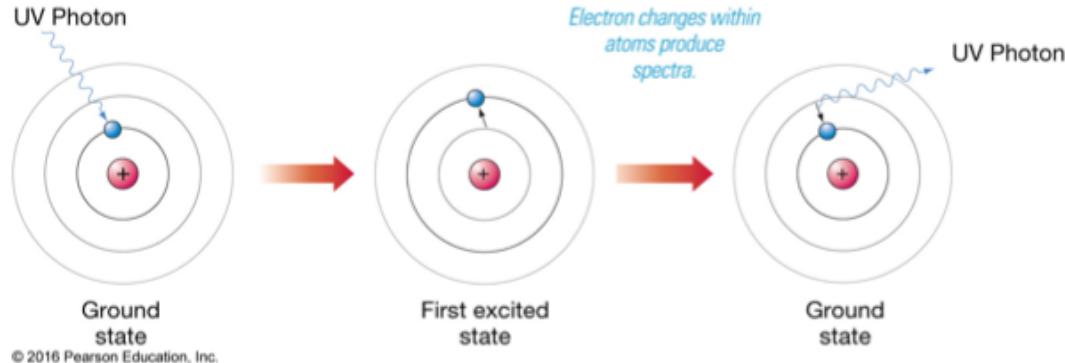
Wein's Law:

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

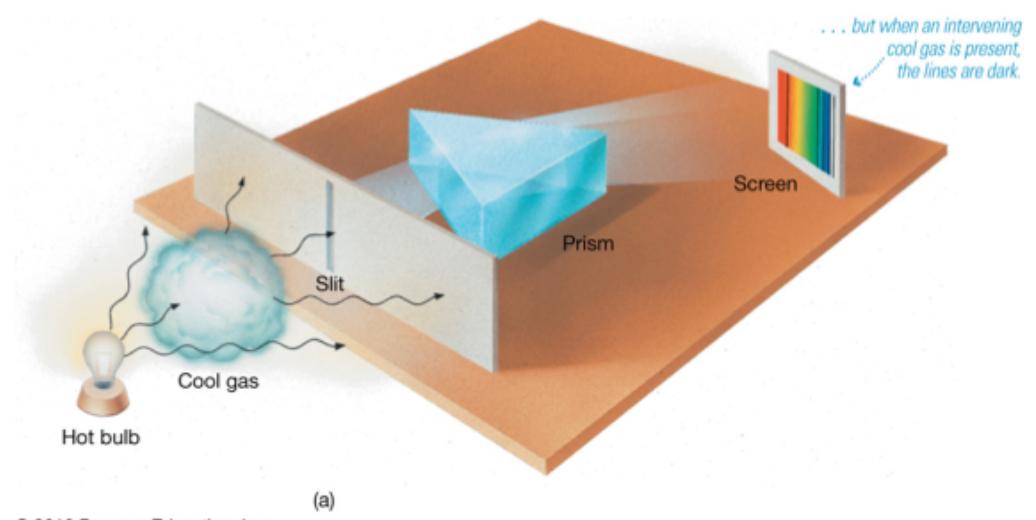
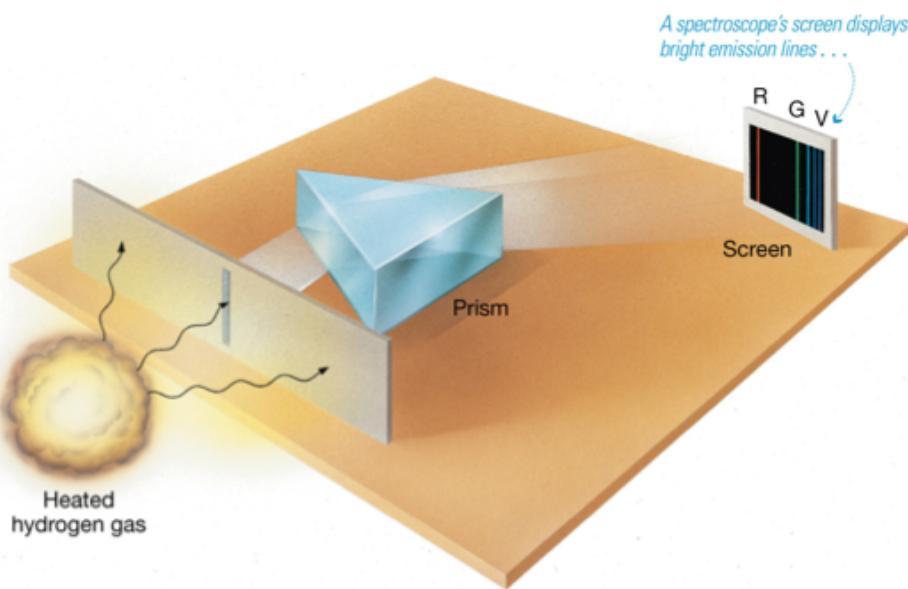


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Emission and Absorption of Photons



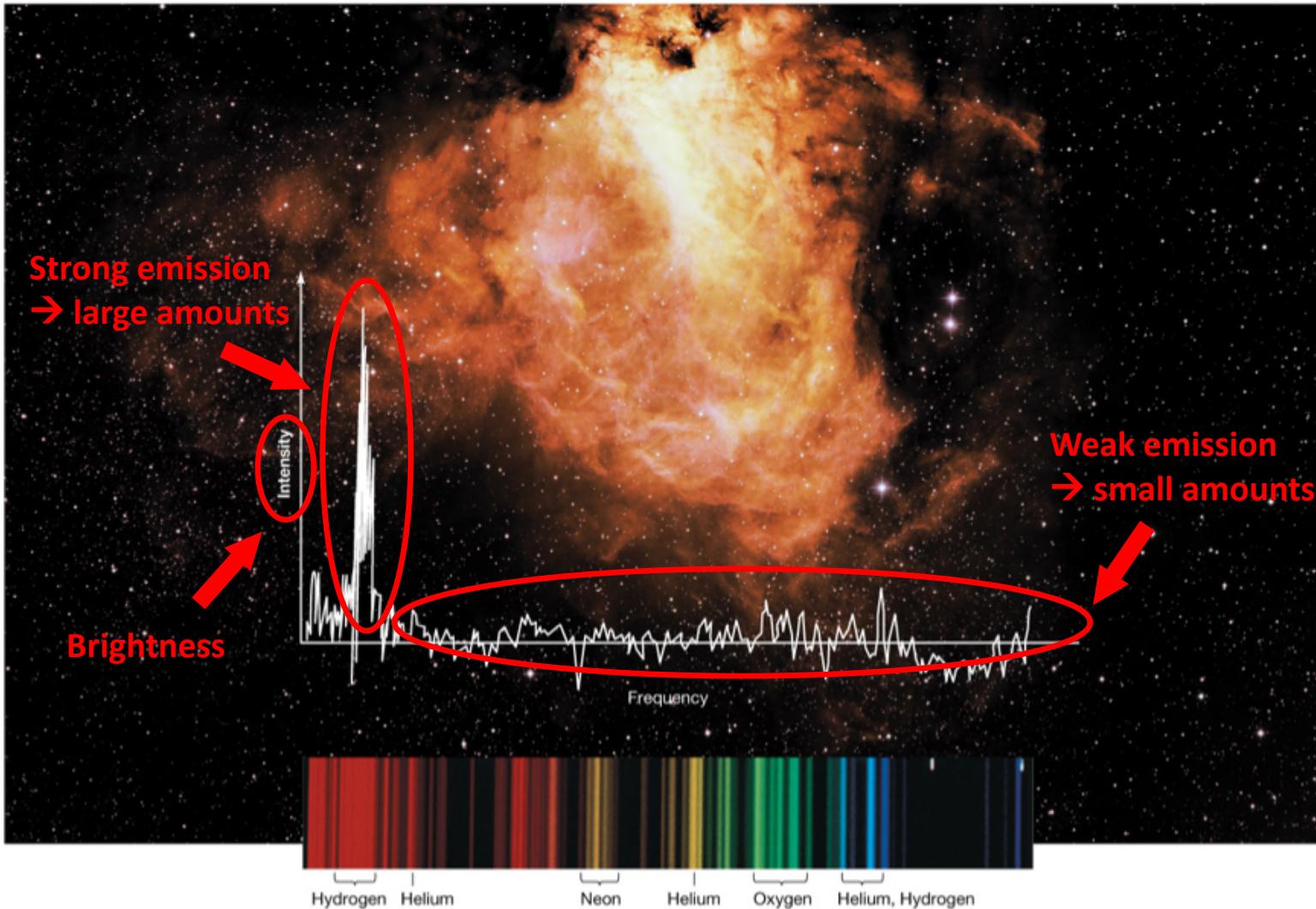
Spectroscopy



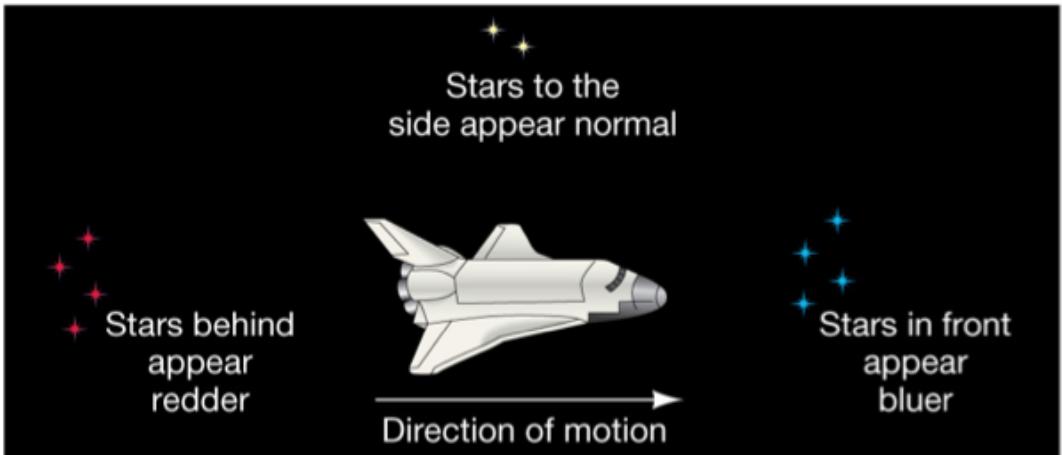
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(a)

Detecting Chemical Elements



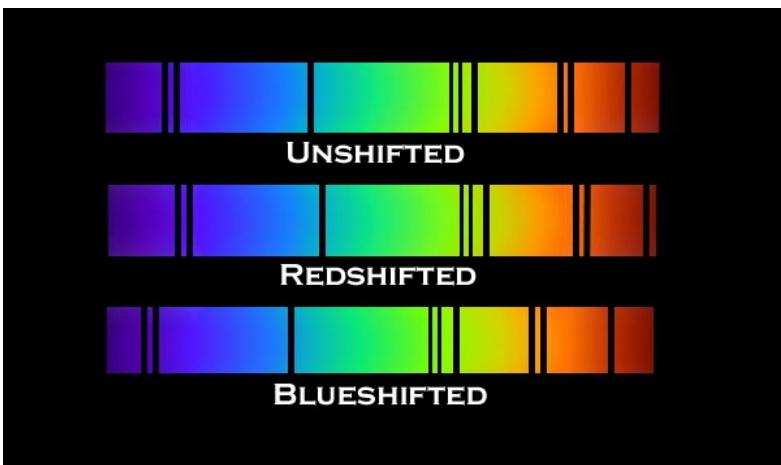
Doppler Effect



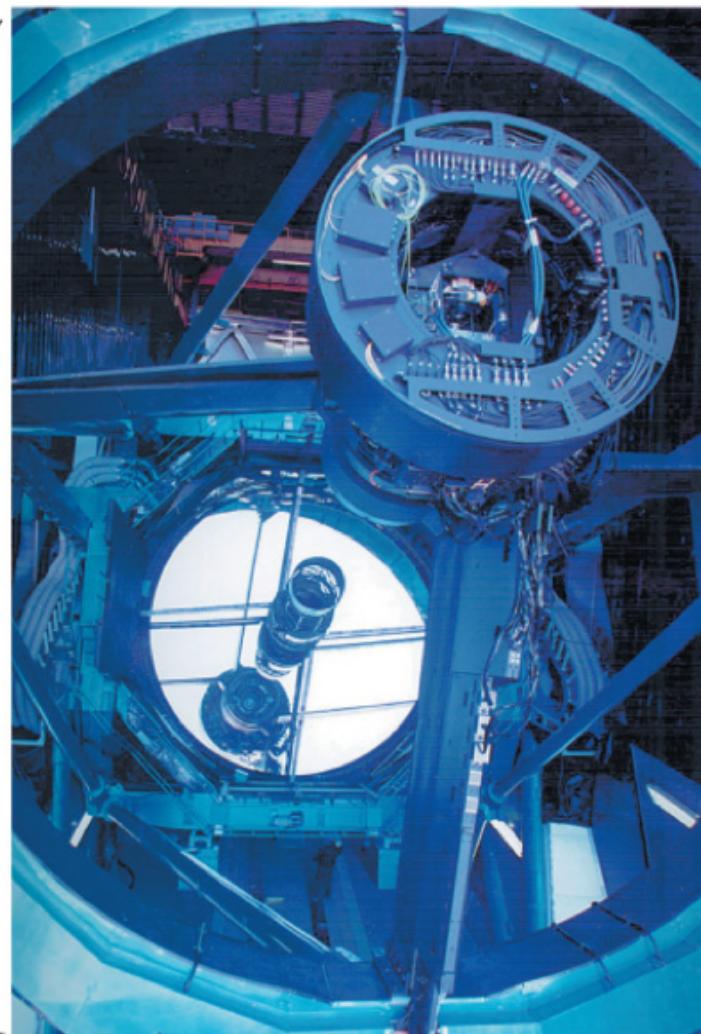
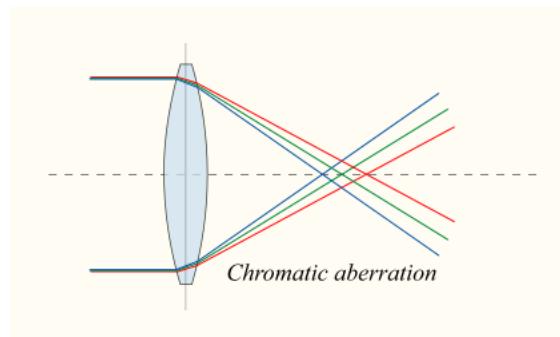
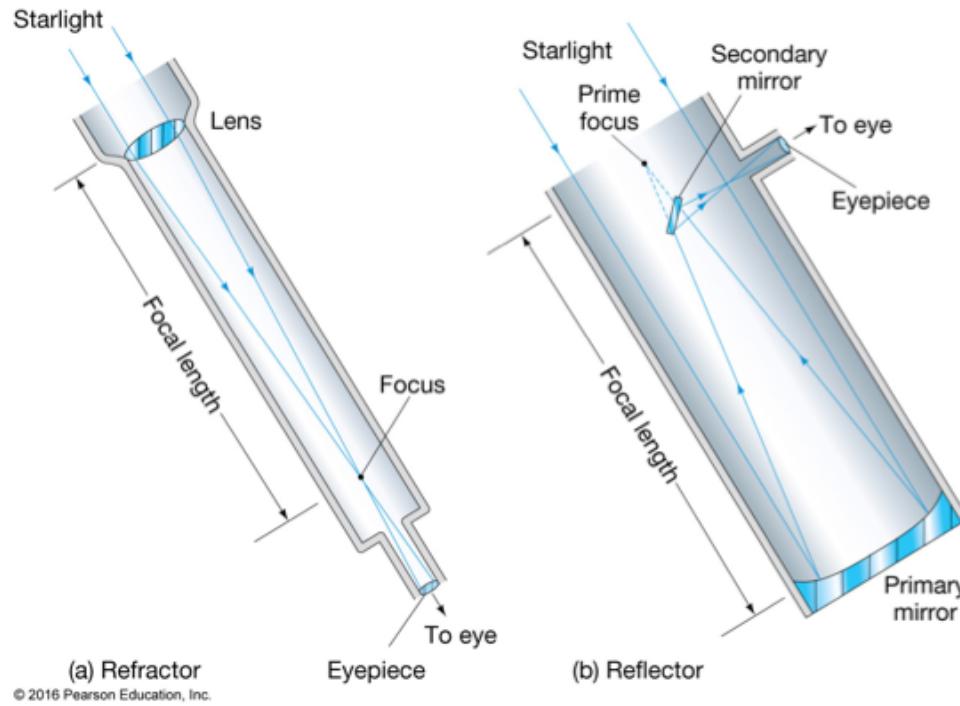
(a)

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

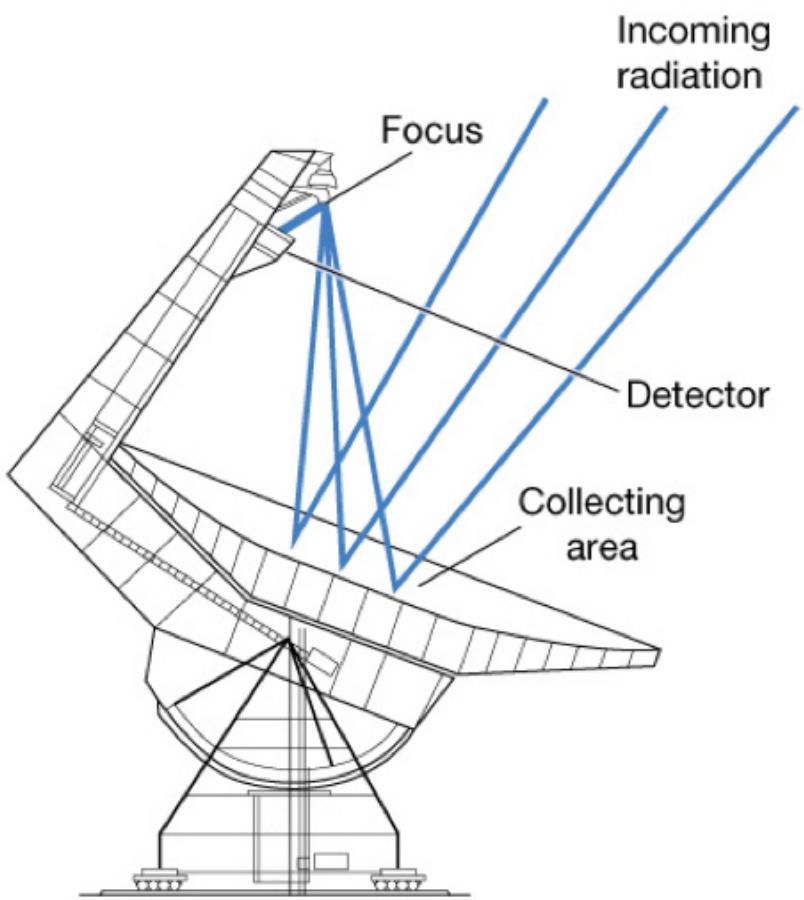


Optical Astronomy



An inside look
at the Subaru
telescope

Radio Astronomy



IR and UV Astronomy



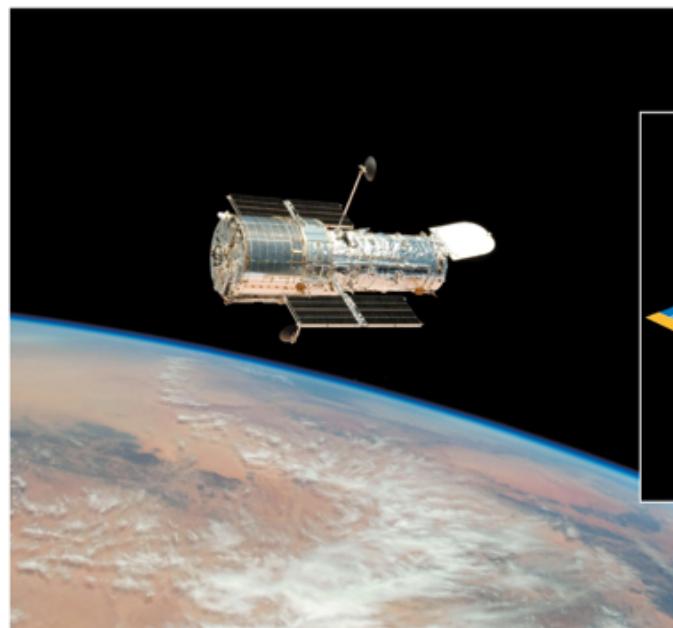
(a)

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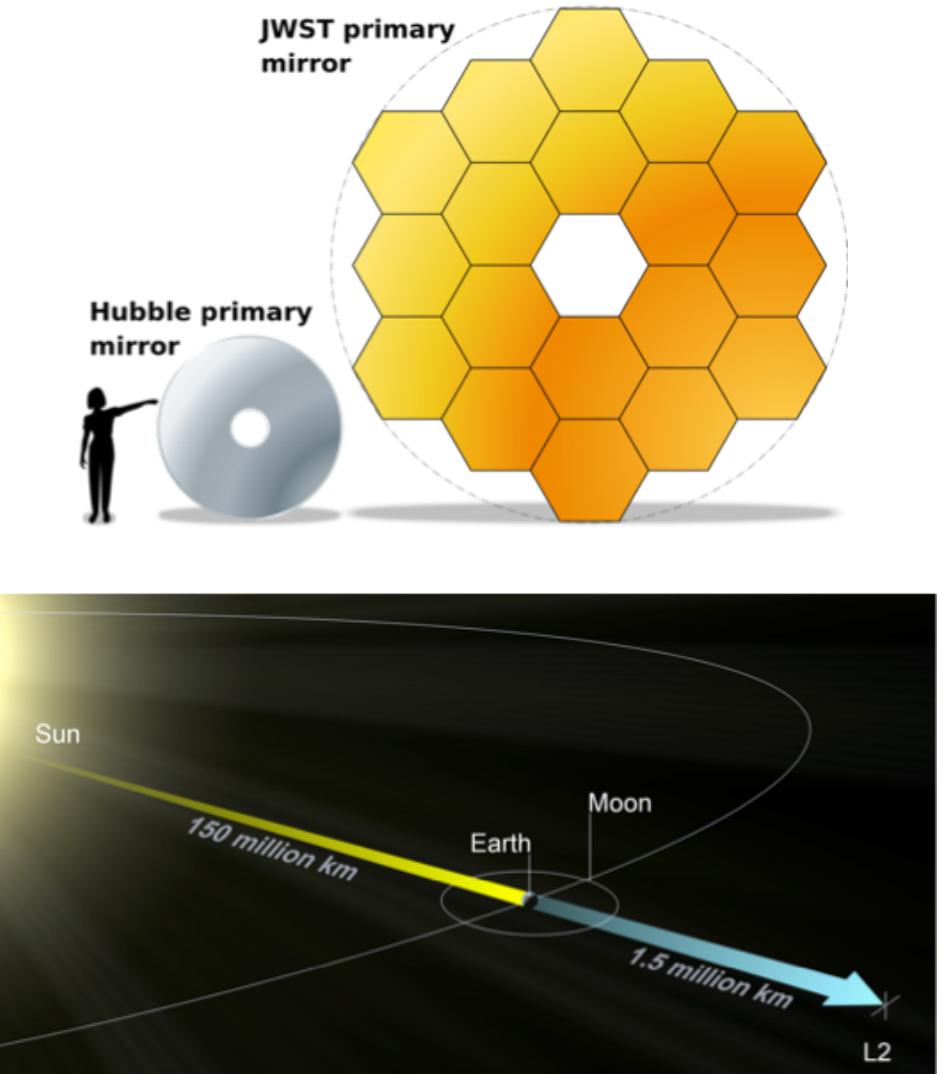
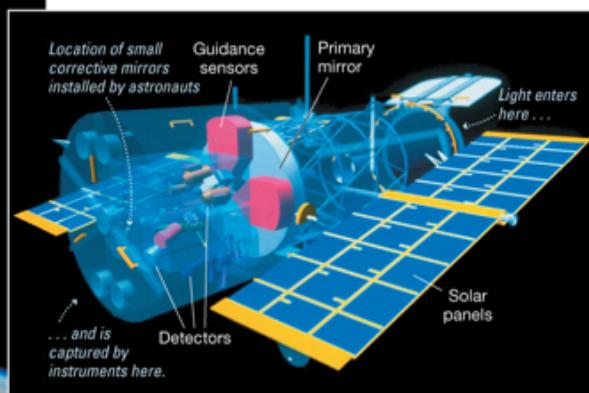


(b)

Space-Based Telescopes



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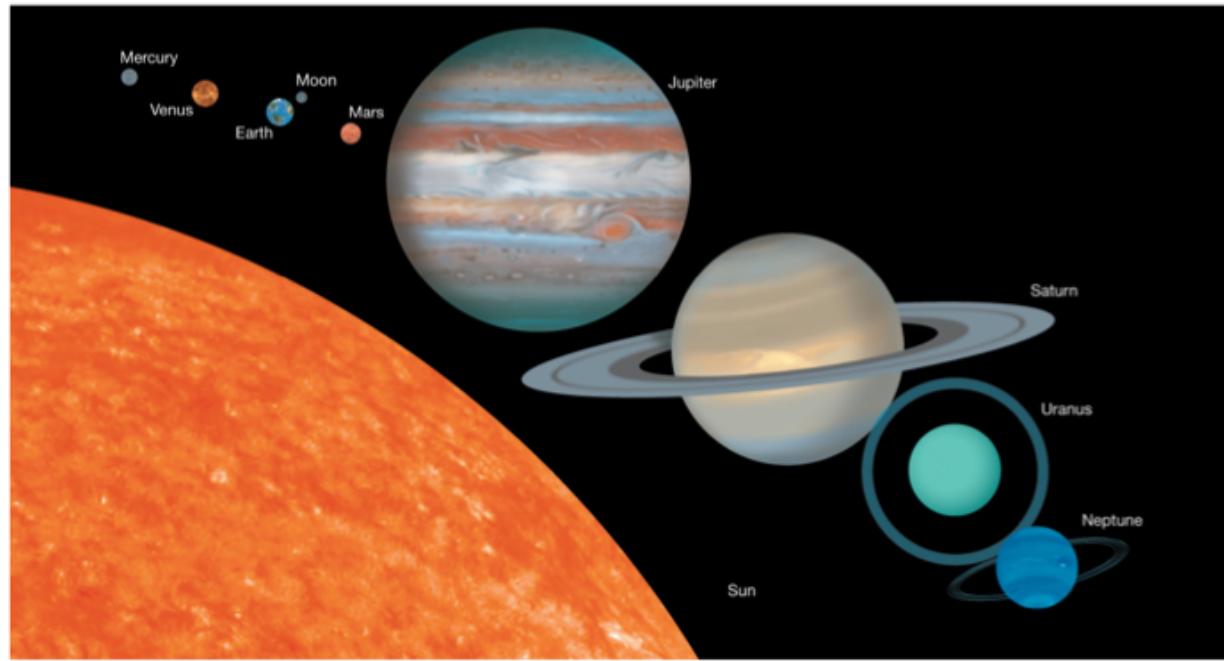
Chapter 3: The Solar System

Prof. Douglas Laurence

AST 1002

Spring 2018

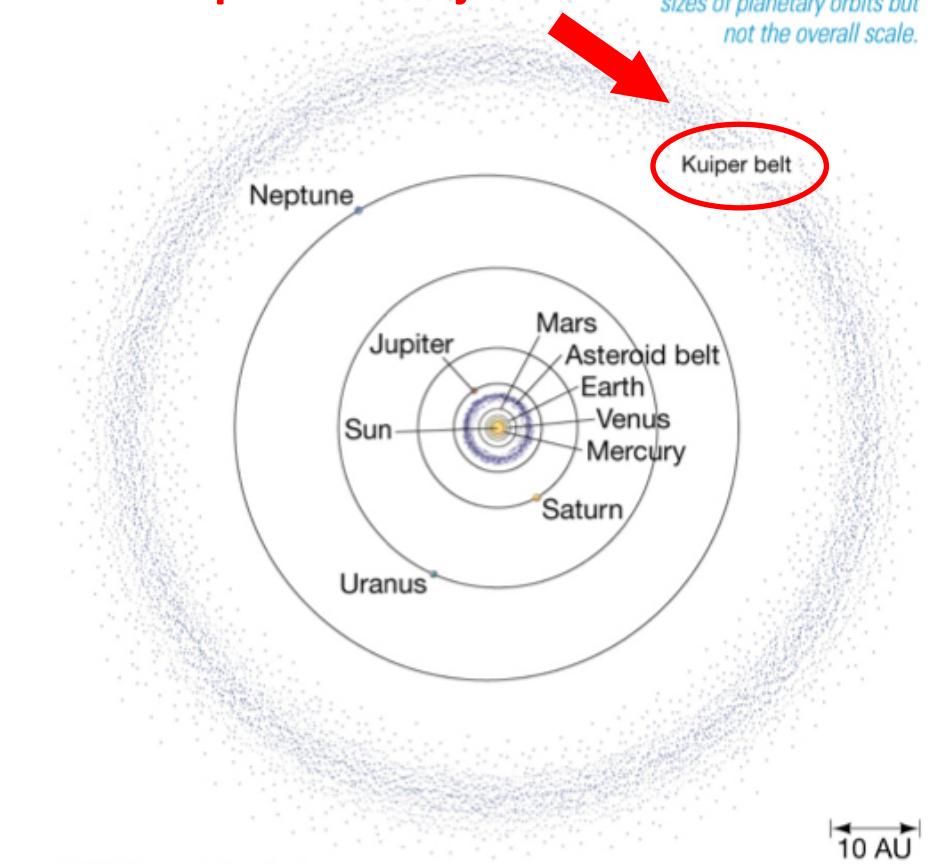
The Planets



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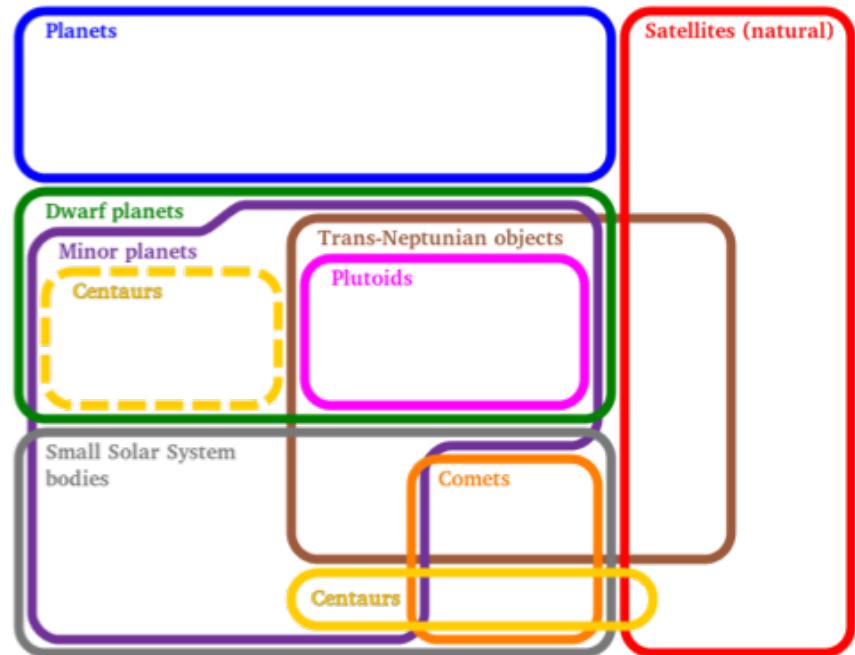
Pluto = Kuiper belt object

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)

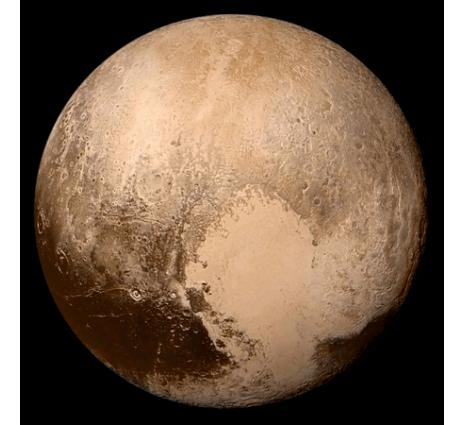
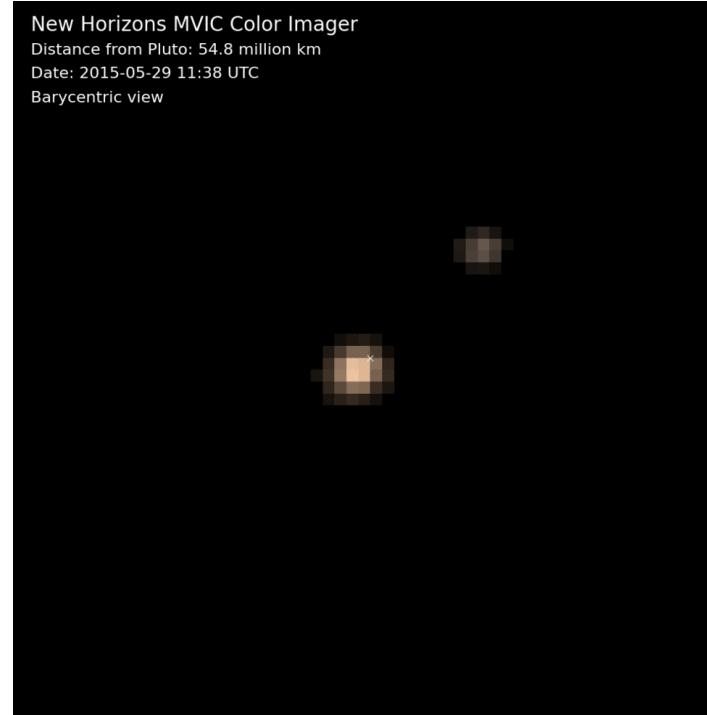


New Horizons MVIC Color Imager

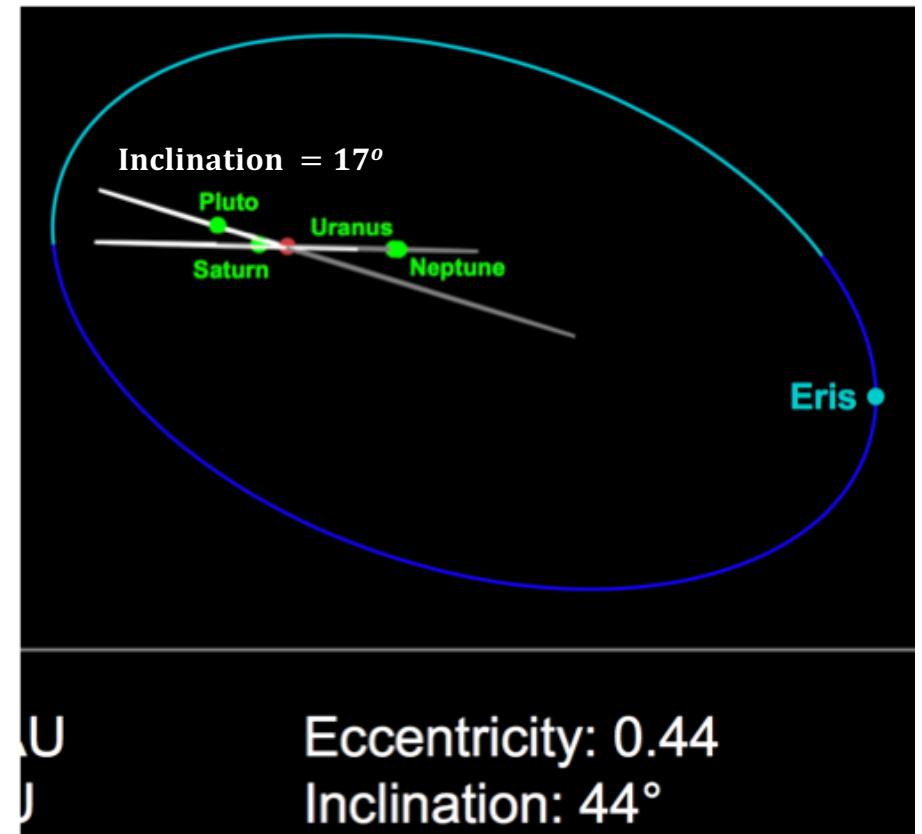
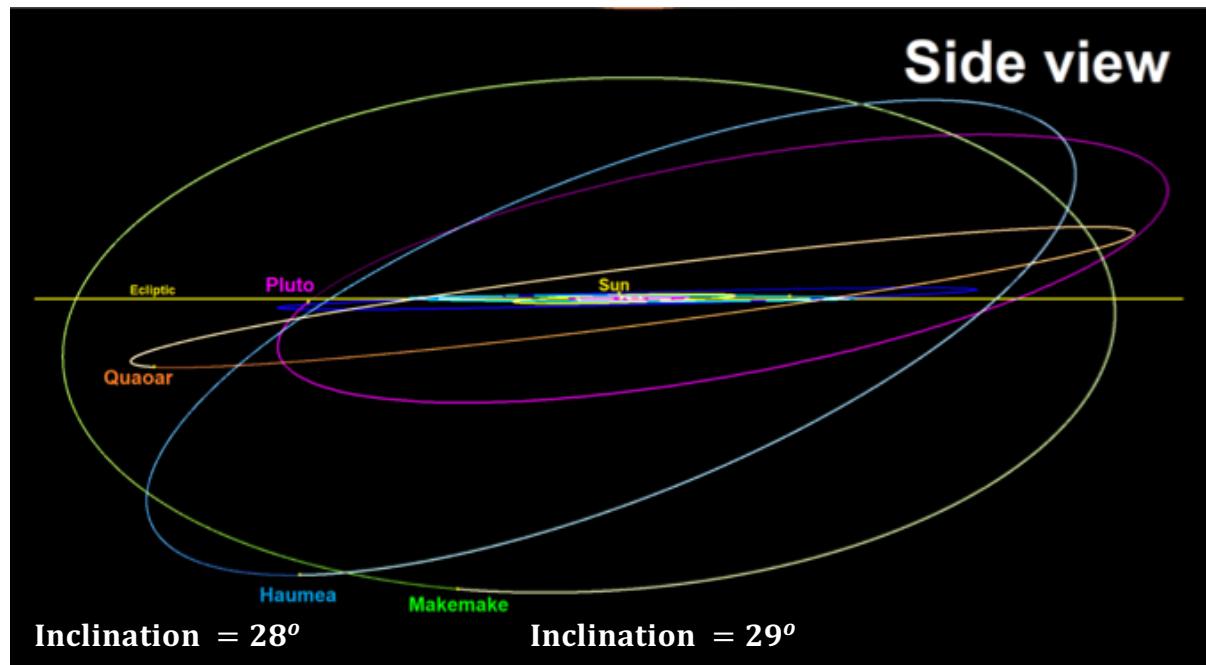
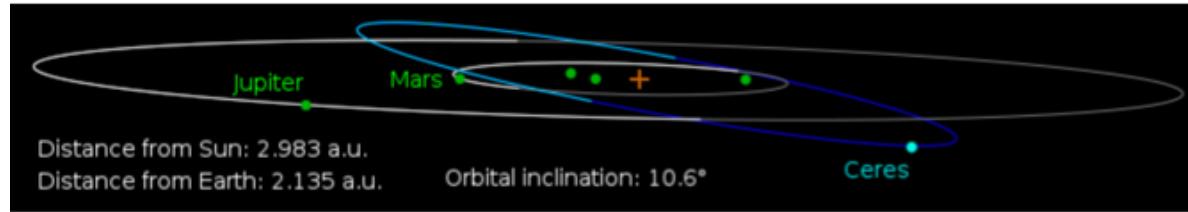
Distance from Pluto: 54.8 million km

Date: 2015-05-29 11:38 UTC

Barycentric view

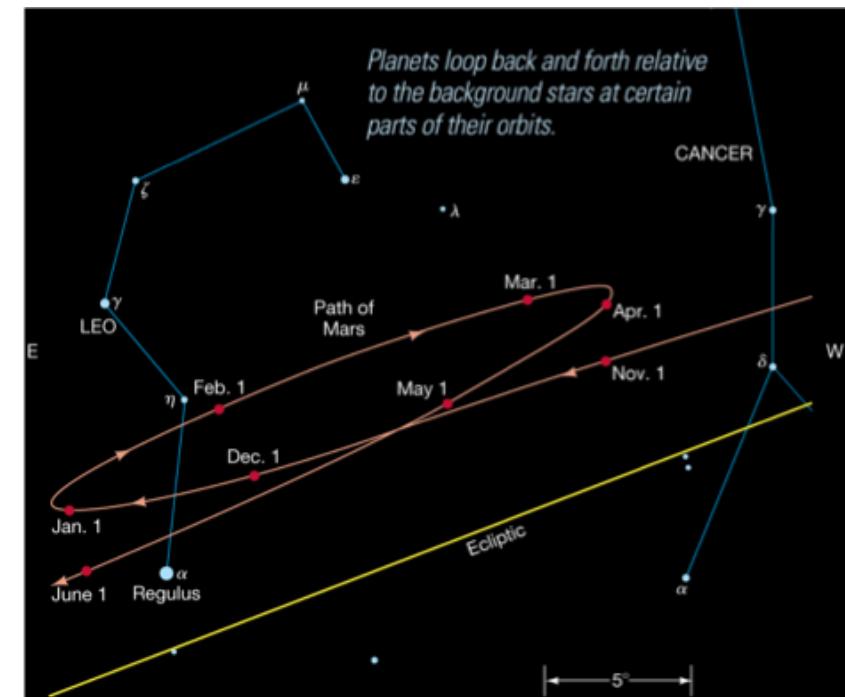
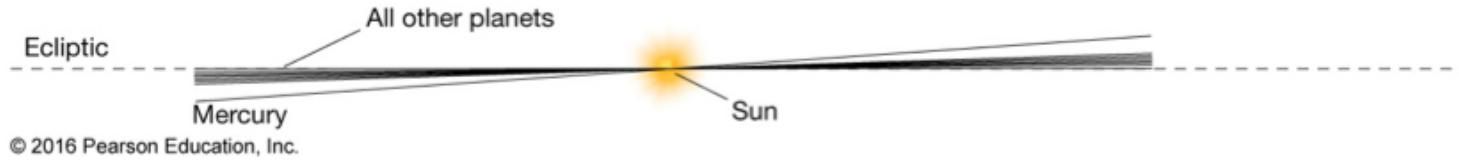


Dwarf Planet Orbits

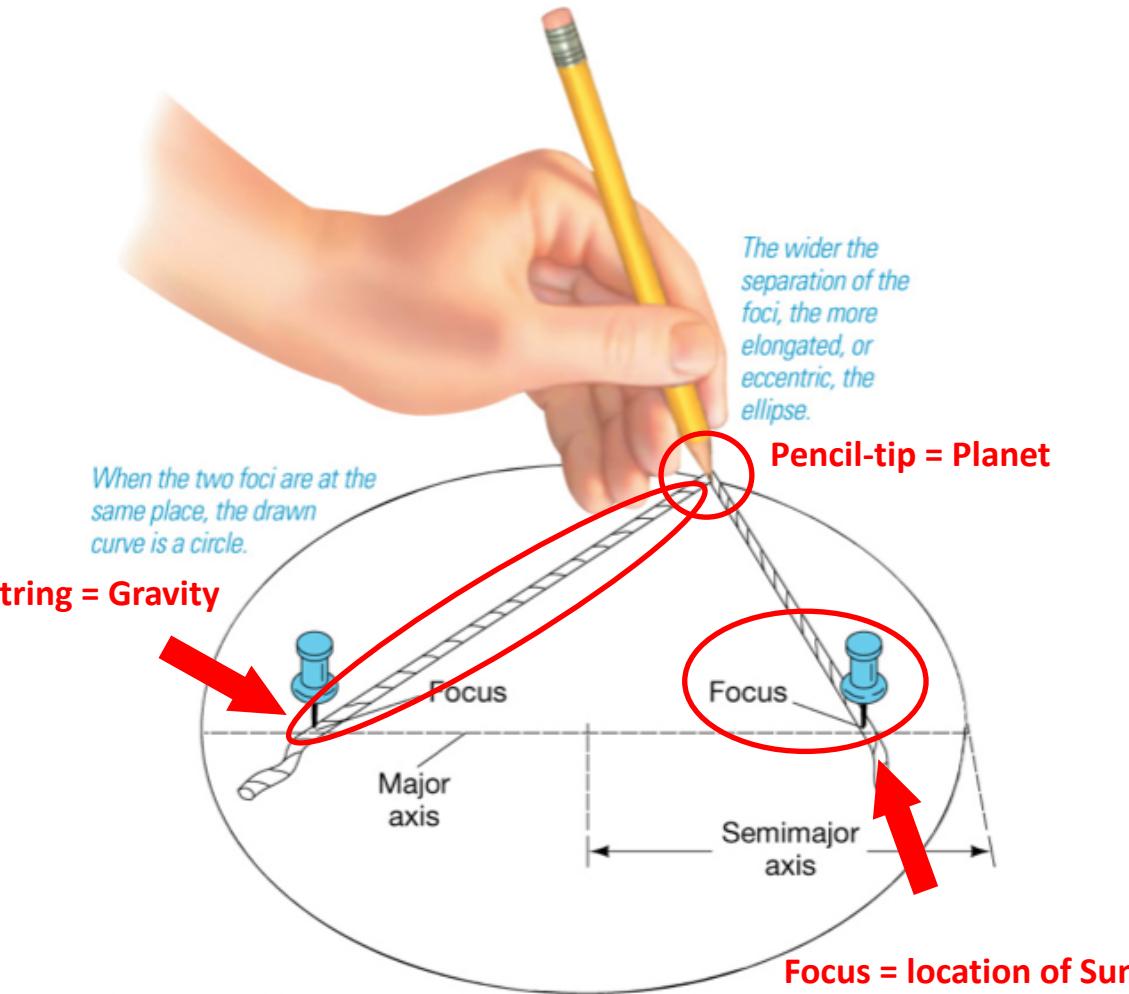


Features of Planets

This edge-on view shows the slight inclinations of the planetary orbits to the ecliptic.



Elliptical Orbits



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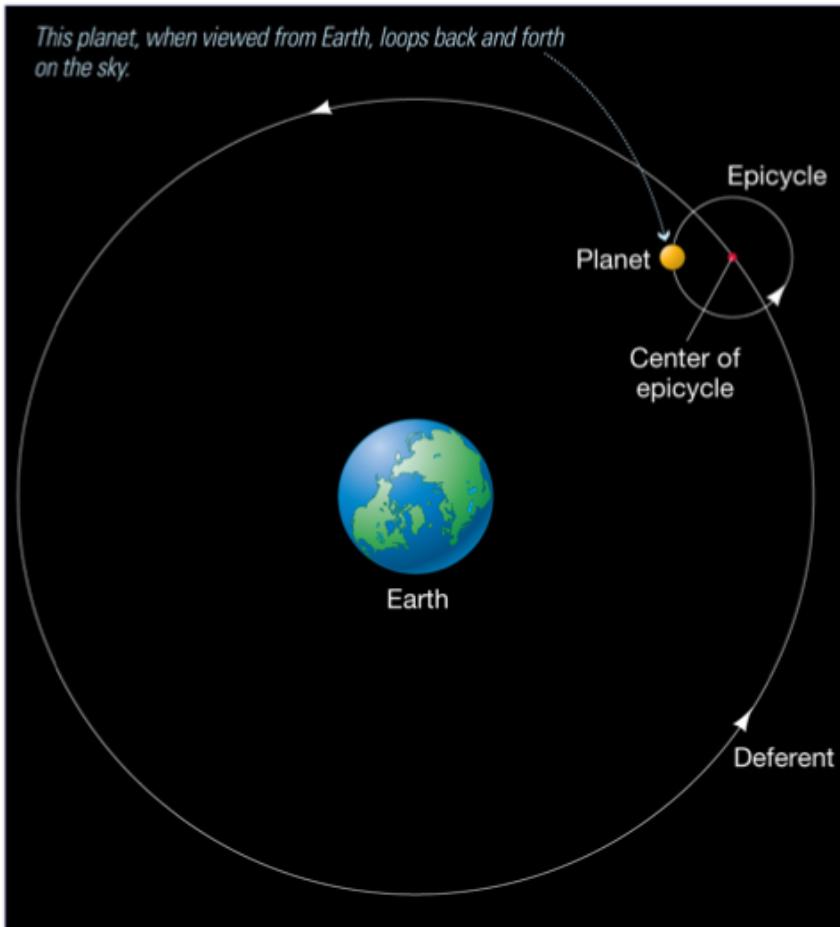
Table 3.1 Properties of Some Solar System Objects

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	—	—	—

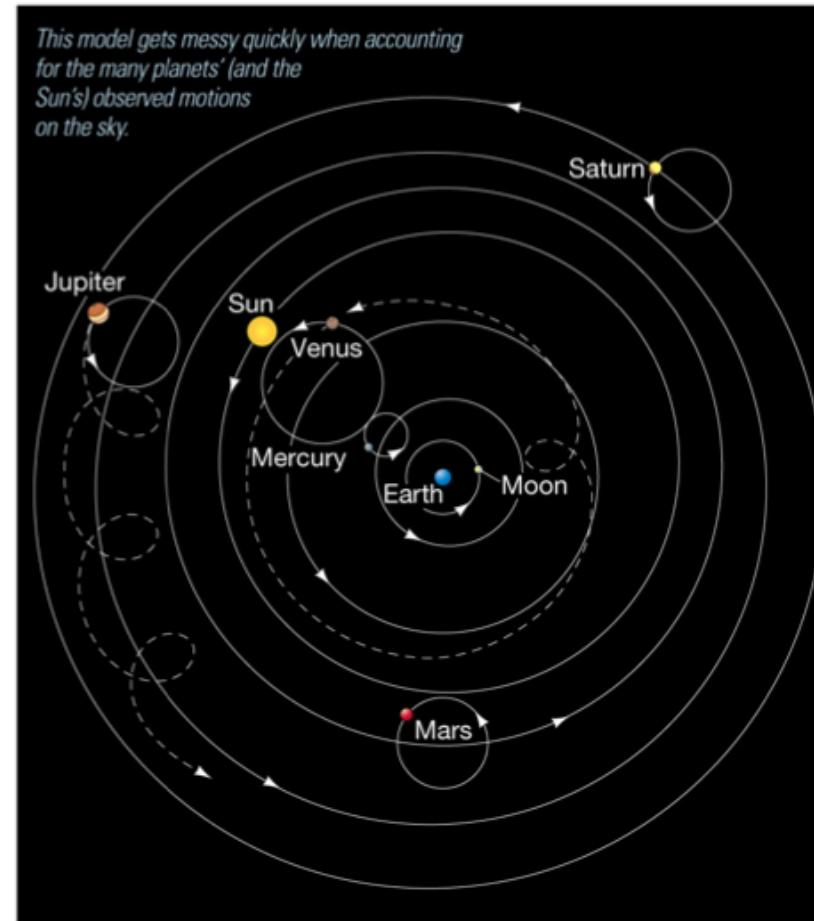
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$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

Ptolemaic Geocentrism

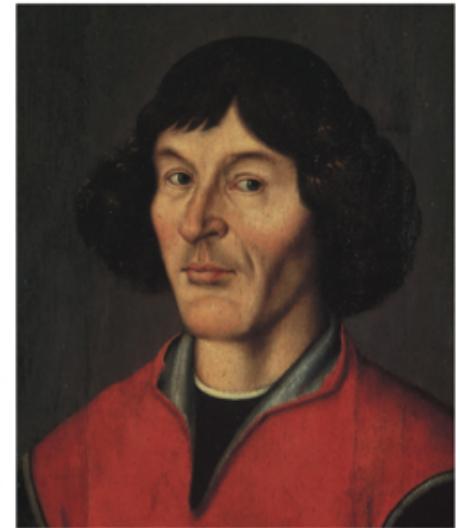
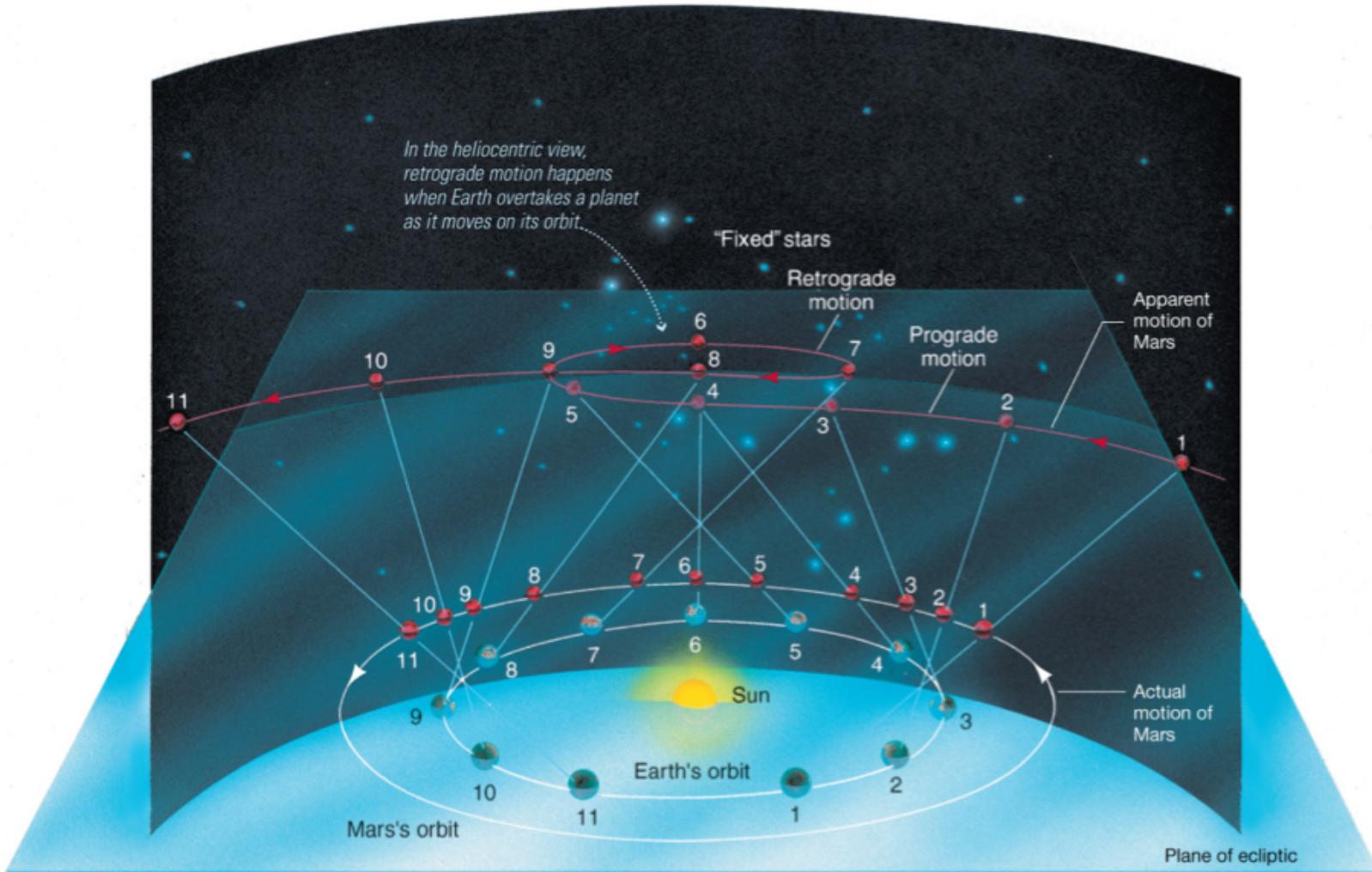


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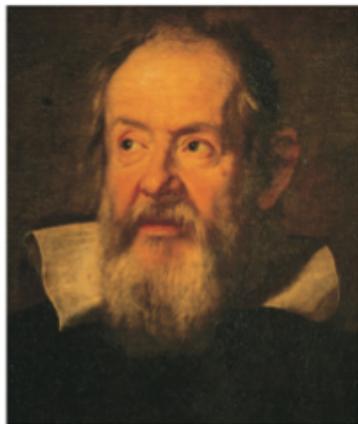


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Heliocentrism (Copernicus)

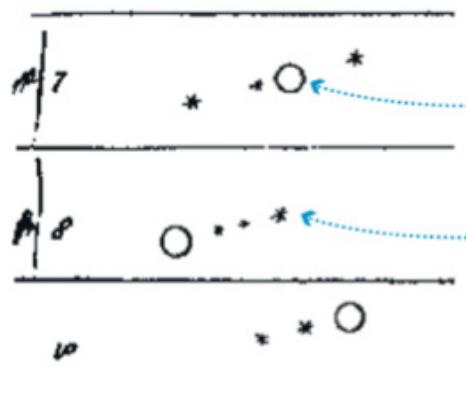


Heliocentrism (Galileo)



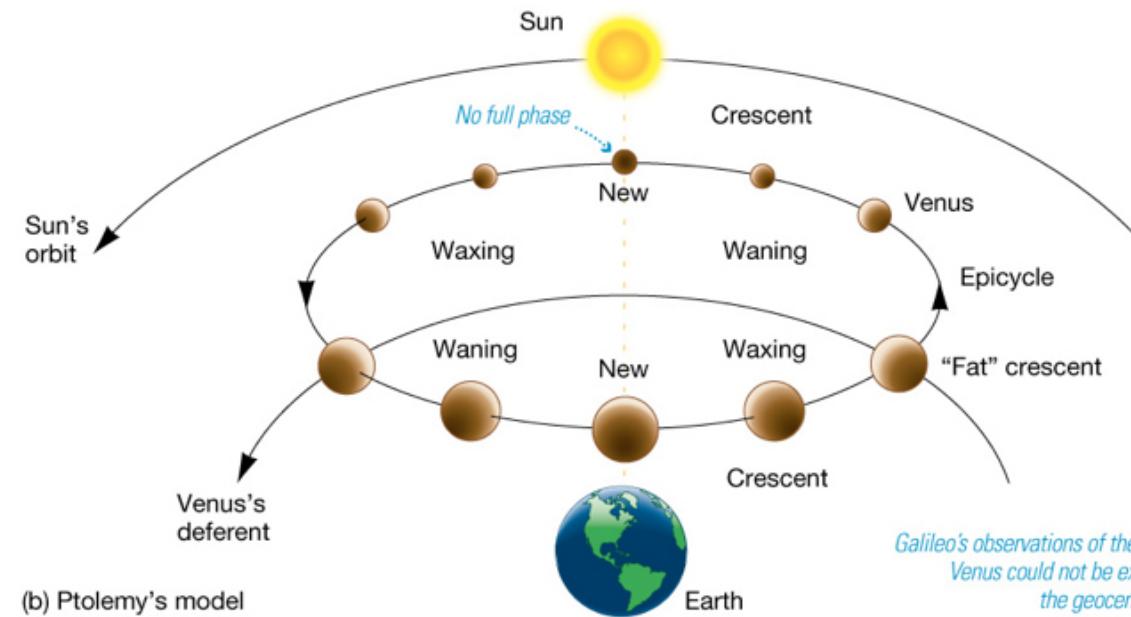
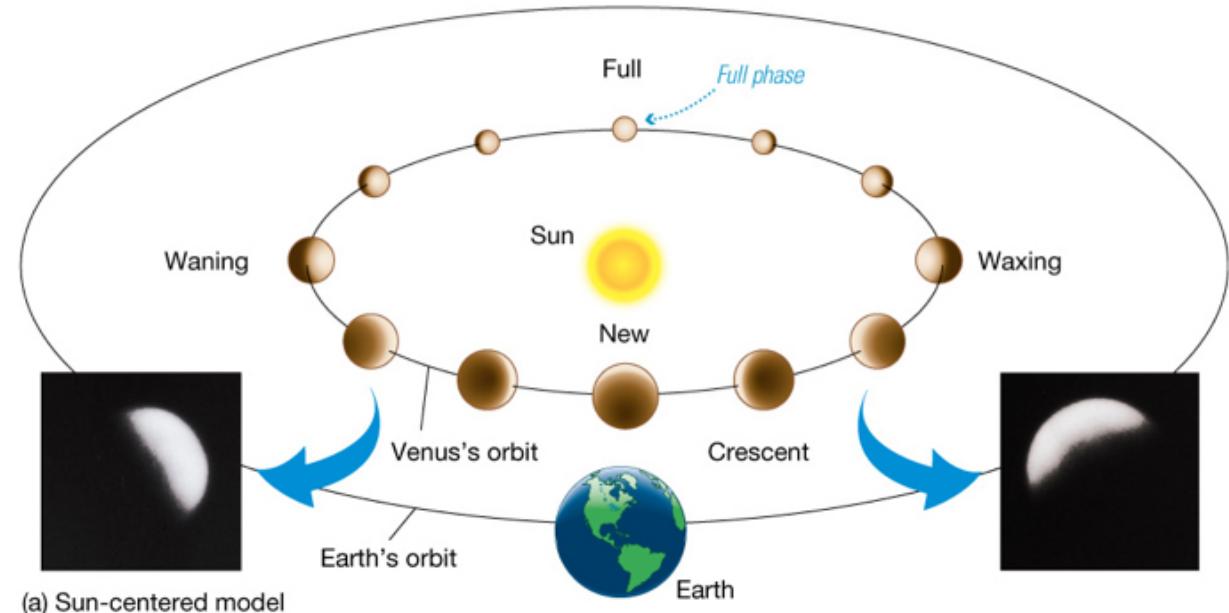
(a)

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(c)

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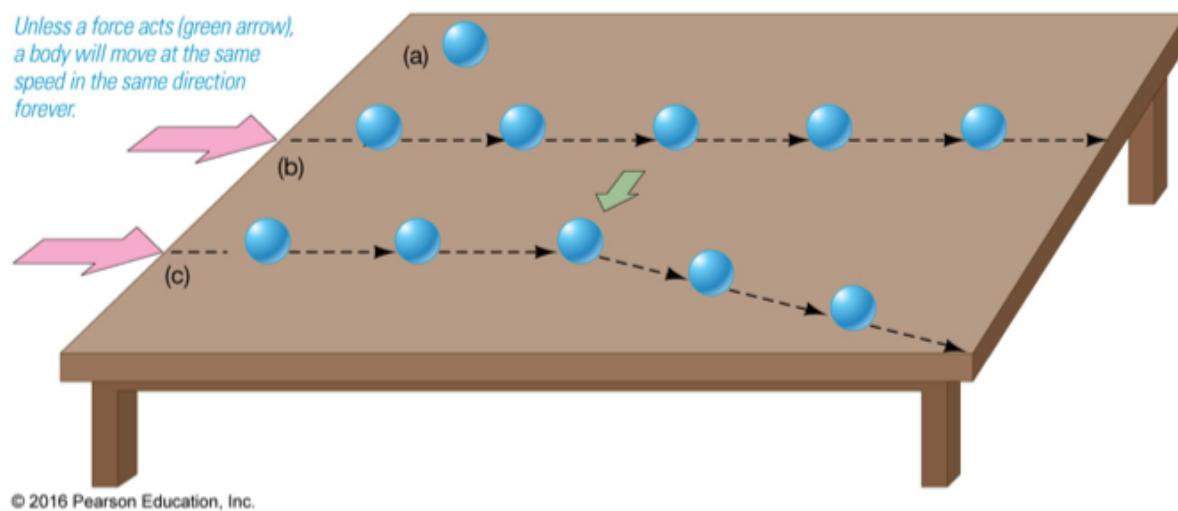
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Galileo's observations of the phases of Venus could not be explained by the geocentric model.

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.

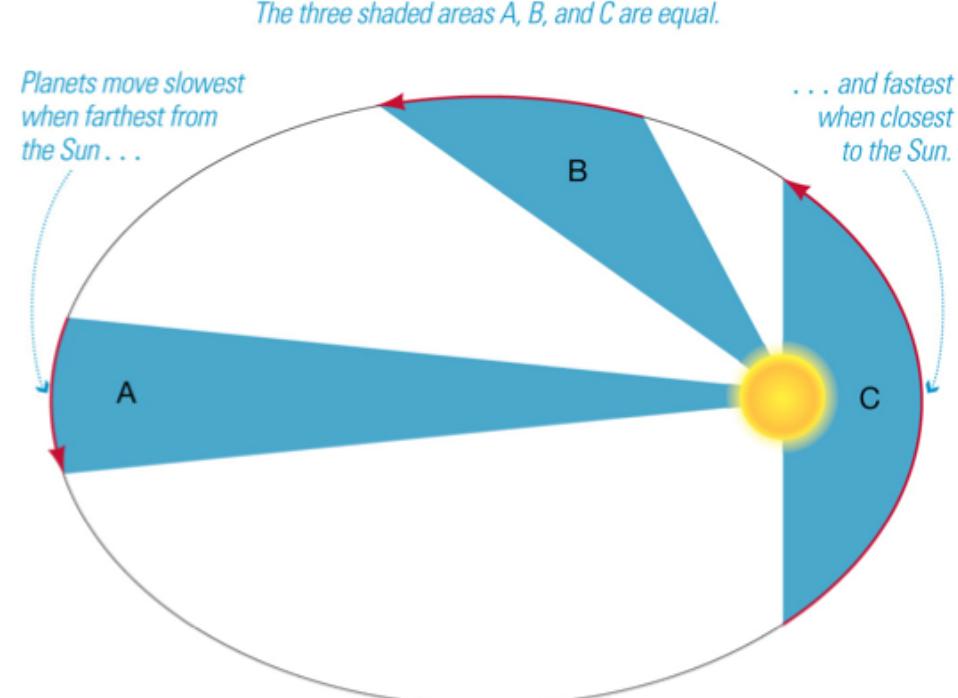




Kepler's Laws of Planetary Motion

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

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



Using Kepler's Third Law

