Chapter 2

The Rise of Astronomy

"onoma" derives also gave Latin nomen "name, reputation" underlying "nominal," "nomenclature," "nominate," Old Irish ainm "name," Russian imya, imeni "name," and English "name."

May 31, 2008

Gibbous (adjective)

Pronunciation: ['gi-bês]

Definition: Convex, protuberant, protruding; more than half but less than fully illuminated, as the moon; humpbacked.

Usage: The original Latin word for hump, "gibber" ['gi-bê(r)], was used in medicine in reference to hunched backs in the 19th century. It gave rise to "gibberous" with the same meaning as today's word. Just remember to distinguish "gibber" from the word for an incomprehensible language, "gibber," from which we get "gibberish." These words are pronounced with a soft 'g' ['ji-bê(r)]. The adverb for today's word is "gibbously" and you have your choice of nouns: "gibbousness" or "gibbosity."

Suggested Usage: In his conversation with today's contributor, Tim Ward asked, "Surely we've all suffered from the effects of engorging ourselves at family gatherings, when our already less-than-healthy statures assume a much more gibbous appearance?" My daughter's stomach is currently unusually gibbous with my first granddaughter, a much happier gibbosity.

Etymology: Today's word is a reduction of Latin gibbērōsus "hump-backed, hunch-back" from gibber "hump, hunch," which in Late Latin became gibbus "hump, bow." Today's word comes from Katy Brezger's backyard: "Now the gibbous moon in its grandeur presides over the manicured backyard and stops just short of The Woods. Strange dancing shadows sway in the summer windstorm. The large umbrella squatting on the picnic table even succumbs to the heavy breezes, turning this way and that as the wind gasps and blows. The Woods forebode even as they beckon, the wind tearing back the overcarriage just enough to cast illuminations on the old tractors. Oh, there be monsters, and madness looms."

http://www.pnas.org/content/97/1/500.full

Explaining the moon illusion

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Abstract

An old explanation of the moon illusion holds that various cues place the horizon moon at an effectively greater distance than the elevated moon. Although both moons have the same angular size, the horizon moon must be perceived as larger. More recent explanations hold that differences in accommodation or other factors cause the elevated moon to appear smaller. As a result of this illusory difference in size, the elevated moon appears to be more distant than the horizon moon. These two explanations, both based on the geometry of stereopsis, lead to two diametrically opposed hypotheses. That is, a depth interval at a long distance is

http://en.wikipedia.org/wiki/Harvest_moon

The **harvest moon** is the moon at or about the period of fullness that is nearest to the autumnal equinox. The harvest moon is often mistaken for the modern day hunter's moon.

A harvest moon

Contents [hide]

http://gizmodo.com/5645030/watch-the-super-harvest-moon-today

Sep 22, 2010 12:55 PM

Prepare for the Super Harvest Moon! For the first time in two decades, the Sun will sink as the full Moon rises exactly opposite to it on the day the summer ends, creating a strange 360-degree twilight show.

If you live in the Northern Hemisphere, today is the autumnal equinox *and* a Super Harvest Moon will cross the sky after almost 20 years since the last time it happened. When the Sun starts to set on the Western horizon, a full moon will rise opposite to it on the East, reflecting the light of our home star.

Being close to the horizon, the orange Moon will be gigantic thanks to a psychological effect called the Moon illusion. The sky will be illuminated by the Sun and the Moon at the same time, creating a weird 360-degree effect that is rarely seen.

http://www.uu.edu/dept/physics/Science%20Guy%202004/0409PlanetMagnetism.htm

collect at our poles, where they impact the upper atmosphere, dissipate their energy, producing beautiful auroras - the "Northern Lights" (or aurora borealis) and "Southern Lights" (aurora australis.)

Space probes, such as the Voyager probes, have measured the magnetic fields of the planets and even auroras have been photographed on other planets. The spacecraft Mariner 10 flew by Mercury in 1974 and surprised the science community. Mercury was thought to be cold and dead inside, thus having no magnetic field. However, Mariner measured a weak magnetic field, meaning Mercury must have some internal activity. Probes found that Mars and Venus do not have a significant magnetic field.

Jupiter, Saturn, Uranus, and Neptune all have magnetic fields much stronger than that of the Earth. Jupiter is the champion- having the largest magnetic field. The mechanism that causes their magnetic fields is not fully understood. It is believed that in the case of Saturn and Jupiter that their magnetic fields may be caused by hydrogen conducting electricity deep within the planet. Hydrogen near the planets core may be compressed so densely by all the planetary layers above that it becomes an electrical conductor.

The planet Uranus has an interesting magnetic field. Uranus' poles lie almost in the plane of its orbit around the Sun. The magnetic poles are fully 60 degrees away from the geographic poles, which results in a wild rotation of Uranus' magnetic field as the planet rotates. On the other hand, Saturn's magnetic field and rotation axes seem to be pretty much the same, making Saturn somewhat magnetically unique.

Our Moon lacks a magnetic field, which implies its interior is cold and inactive. However, rocks from the Moon show permanent magnetism, suggesting that at one time the Moon had a magnetic field. The physics of planetary magnetic fields still contains many mysteries for scientists.

A wonderful summary of these facts may be found at http://www.adlerplanetarium.org/learn/planets/planetary_geology/magnetic_fields.ssi

483 words
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Lunar month

From Wikipedia, the free encyclopedia

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In lunar calendars, a **lunar month** is the time between two identical syzygies (new moons or full moons). There are many variations. In Middle-Eastern and European traditions, the month starts when the young crescent moon becomes first visible at evening after conjunction with the Sun 1 or 2 days before that evening (*e.g.* in the Islamic calendar). In ancient Egypt the lunar month began on the day when the moon could no longer be seen just before sunrise. Others use a reckoned moon (*e.g.* the Hebrew calendar), or use a tabular scheme (Ecclesiastical lunar calendar). Yet others run from full moon to full moon. Calendars count integer days, so months may be 29 or 30 days in length, in some regular or irregular sequence. But all lunar months approximate the mean length of the synodic month of approximately 29.53059 days (29 days, 12 hours, 44 minutes and 3 seconds).

There are several different ways of expressing the **lunar month**.

Periods of Western Astronomy

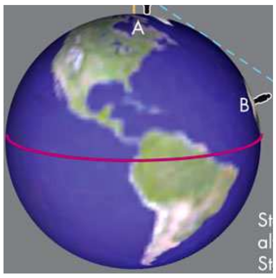
- Western astronomy divides into 4 periods
  - Prehistoric (before 500 B.C.)
    - Cyclical motions of Sun, Moon and stars observed
    - Keeping time and determining directions develops
  - Classical (500 B.C. to A.D. 1400)
    - Measurements of the heavens
    - Geometry and models to explain motions
  - Renaissance (1400 to 1650)
    - Accumulation of data led to better models
    - Technology (the telescope) enters picture
  - Modern (1650 to present)
    - Physical laws and mathematical techniques
    - Technological advances accelerate

Ancient Greek Astronomers

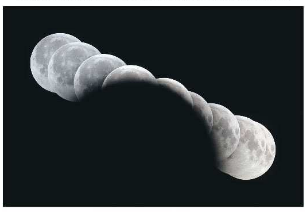
- Through the use of models and observations, they were the first to use a careful and systematic manner to explain the workings of the heavens
- Limited to naked-eye observations, their idea of using logic and mathematics as tools for investigating nature is still with us today
- Their investigative methodology is in many ways as important as the discoveries themselves

Early Ideas: Pythagoras

- Pythagoras taught as early as 500 B.C. that the Earth was round, based on the belief that the sphere is the perfect shape used by the gods

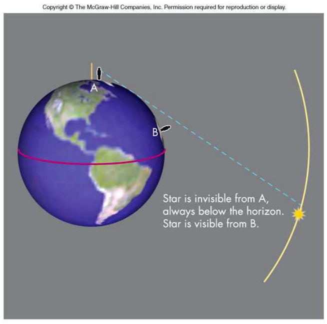


Early Ideas: Aristotle



- By 300 B.C., Aristotle presented naked-eye observations for the Earth's spherical shape:
  - Shape of Earth's shadow on the Moon during an eclipse

Early Ideas: Aristotle

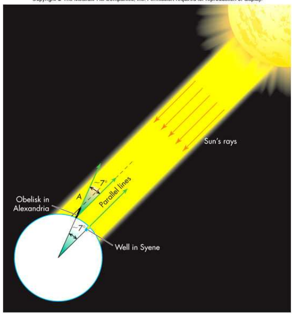


B

- He also noted that a traveler moving south will see stars previously hidden by the southern horizon

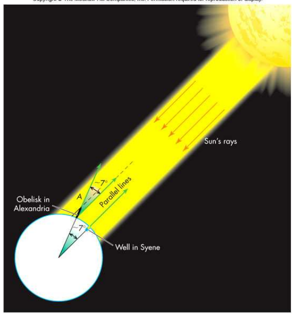
Early Ideas: The Size of the Earth

- Eratosthenes (276-195 B.C.) made the first measurement of the Earth's size
- He obtained a value of 25,000 miles for the circumference, a value very close to today's value



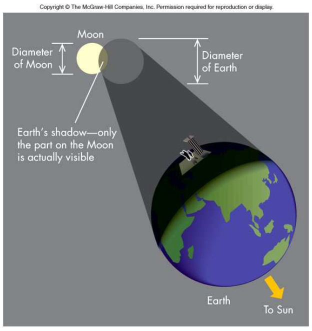
Early Ideas: The Size of the Earth

- He measured the shadow length of a stick set vertically in the ground in the town of Alexandria on the summer solstice at noon, converting the shadow length to an angle of solar light incidence, and using the distance to Syene, a town where no shadow is cast at noon on the summer solstice

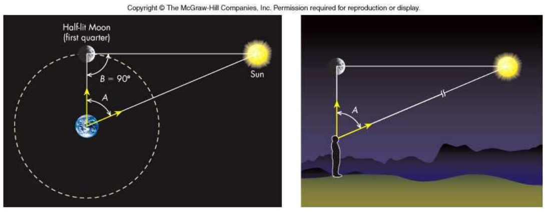


Early Ideas: Distance and Size of the Sun and Moon

- The sizes and distances of the Sun and Moon <u>relative</u> to Earth were determined by Aristarchus about 75 years before Eratosthenes measured the Earth's size
- Once the actual size of the Earth was determined, the <u>absolute</u> sizes and distances of the Sun and Moon could be determined

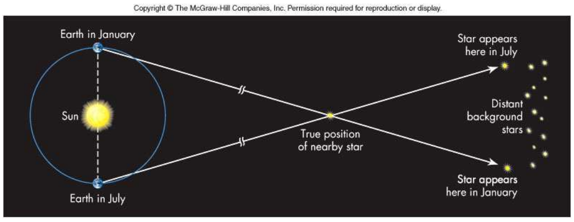


Early Ideas: Distance and Size of the Sun and Moon



- These <u>relative</u> sizes were based on the ***angular size*** of objects and a simple geometry formula relating the object's diameter, its angular size, and its distance

Early Ideas: Distance and Size of the Sun and Moon

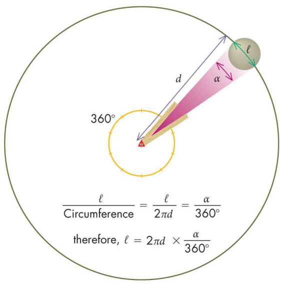


- Aristarchus, realizing the Sun was very large, proposed the Sun as center of the Solar System, but the lack of ***parallax*** argued against such a model

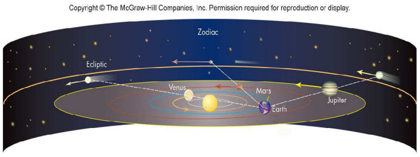
Measuring the Diameter of Astronomical Objects

$$l = 2\pi d \times \frac{\alpha}{360^\circ}$$

l – linear size of object
d – distance to object
α – angular size of object



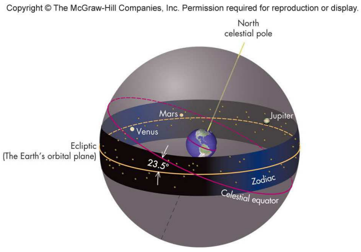
Planets and the Zodiac



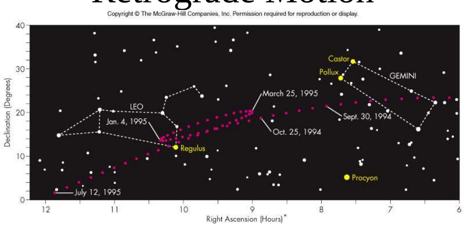
- The planets (Greek for “wanderers”) do not follow the same cyclic behavior of the stars
- The planets move relative to the stars in a very narrow band centered about the ecliptic and called the ***zodiac***
- Motion and location of the planets in the sky is a combination of all the planets’ orbits being nearly in the same plane and their relative speeds about the Sun

Planets and the Zodiac

- Apparent motion of planets is usually from west to east <u>relative to the stars</u>, although on a daily basis, the planets always rise in the east



Retrograde Motion

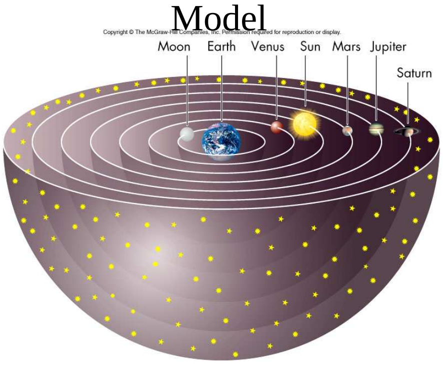


- Occasionally, a planet will move from east to west relative to the stars; this is called ***retrograde motion***
- Explaining retrograde motion was one of the main reasons astronomers ultimately rejected the idea of the Earth being located at the center of the solar system

Early Ideas: The Geocentric Model

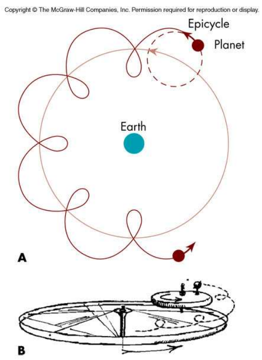
- Because of the general east to west motion of objects in the sky, ***geocentric theories*** were developed to explain the motions
- Eudoxus (400-347 B.C.) proposed a geocentric model in which each celestial object was mounted on its own revolving transparent sphere with its own separate tilt
- The faster an object moved in the sky, the smaller was its corresponding sphere
- This simple geocentric model could not explain retrograde motion without appealing to clumsy and unappealing contrivances

Early Ideas: The Geocentric Model



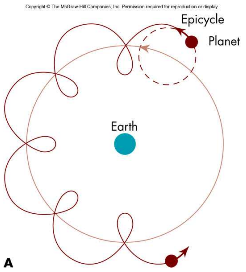
Ptolemy of Alexandria

- Ptolemy of Alexandria improved the geocentric model by assuming each planet moved on a small circle, which in turn had its center move on a much larger circle centered on the Earth
- The small circles were called ***epicycles*** and were incorporated so as to explain retrograde motion



Ptolemy of Alexandria

- Ptolemy's model was able to predict planetary motion with fair precision
- Discrepancies remained and this led to the development of very complex Ptolemaic models up until about the 1500s
- Ultimately, all the geocentric models collapsed under the weight of "Occam's razor" and the ***heliocentric models*** prevailed

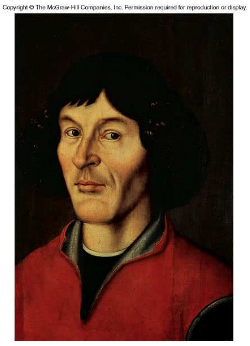


Non-Western Contributions

- Islamic Contributions
  - Relied on celestial phenomena to set its religious calendar
  - Created a large vocabulary still evident today (e.g., zenith, Betelgeuse)
  - Developed algebra and Arabic numerals
- Asian Contributions
  - Devised constellations based on Asian mythologies
  - Kept detailed records of unusual celestial events (e.g., eclipses, comets, supernova, and sunspots)
  - Eclipse predictions

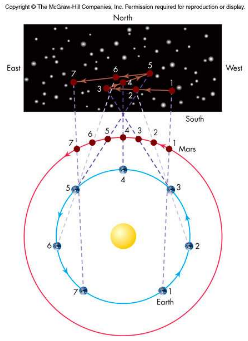
Astronomy in the Renaissance

- Nicolaus Copernicus (1473-1543)
  - Could not reconcile centuries of data with Ptolemy's geocentric model
  - Consequently, Copernicus reconsidered Aristarchus's heliocentric model with the Sun at the center of the solar system

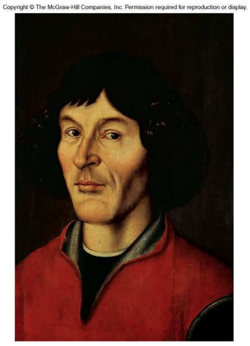


Astronomy in the Renaissance

- ***Heliocentric models*** explain retrograde motion as a natural consequence of two planets (one being the Earth) passing each other
- Copernicus could also derive the relative distances of the planets from the Sun



Astronomy in the Renaissance



- However, problems remained:
  - Could not predict planet positions any more accurately than the model of Ptolemy
  - Could not explain lack of parallax motion of stars
  - Conflicted with Aristotelian "common sense"

Astronomy in the Renaissance

- Tycho Brahe (1546-1601)
  - Designed and built instruments of far greater accuracy than any yet devised
  - Made meticulous measurements of the planets

Astronomy in the Renaissance

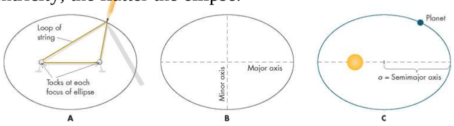
- Tycho Brahe (1546-1601)
  - Made observations (supernova and comet) that suggested that the heavens were both changeable and more complex than previously believed
  - Proposed compromise geocentric model, as he observed no parallax motion!

Astronomy in the Renaissance

- Johannes Kepler (1571-1630)
  - Upon Tycho's death, his data passed to Kepler, his young assistant
  - Using the very precise Mars data, Kepler showed the orbit to be an ***ellipse***

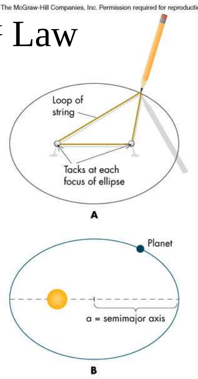
Johannes Kepler (1571-1630)

- Using Tycho Brahe's data, discovered that planets do not move in circles around the Sun, rather, they follow ellipses with the Sun located at one of the two foci!
- Astronomers use the term *eccentricity* to describe how round or "stretched out" an ellipse is – the higher (closer to 1) the eccentricity, the flatter the ellipse.



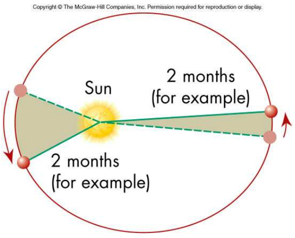
Kepler's 1st Law

- Planets move in elliptical orbits with the Sun at one ***focus*** of the ellipse



Kepler's 2nd Law

- The orbital speed of a planet varies so that a line joining the Sun and the planet will sweep out equal areas in equal time intervals
- The closer a planet is to the Sun, the faster it moves



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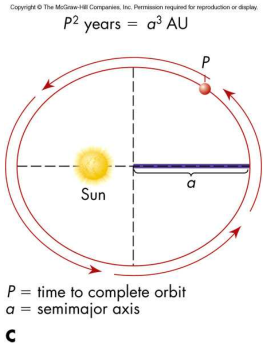
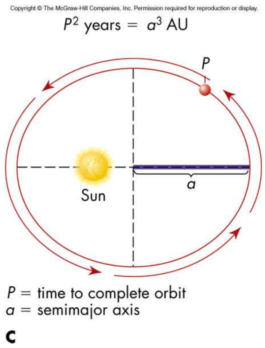
Kepler's 3rd Law

- The amount of time a planet takes to orbit the Sun is related to its orbit's size
- The square of the period, P, is proportional to the cube of the ***semimajor axis,*** a



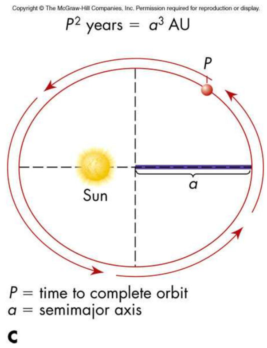
Kepler's 3rd Law

- This law implies that a planet with a larger average distance from the Sun, which is the semimajor axis distance, will take longer to circle the Sun
- Third law hints at the nature of the force holding the planets in orbit



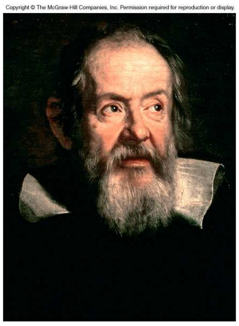
Kepler's 3rd Law

- Third law can be used to determine the semimajor axis, a, if the period, P, is known, a measurement that is not difficult to make



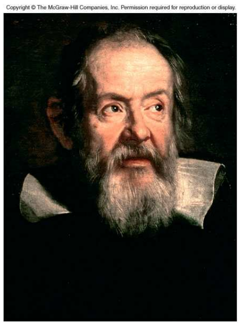
Astronomy in the Renaissance

- Galileo (1564-1642)
  - Contemporary of Kepler
  - First person to use the telescope to study the heavens and offer interpretations
    - The Moon's surface has features similar to that of the Earth ⇒ The Moon is a ball of rock

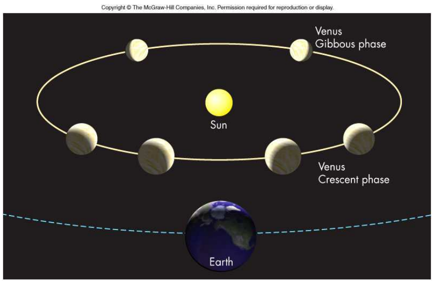


Astronomy in the Renaissance

- The Sun has spots ⇒ The Sun is not perfect, changes its appearance, and rotates
- Jupiter has four objects orbiting it ⇒ The objects are moons and they are not circling Earth
- Milky Way is populated by uncountable number of stars ⇒ Earth-centered universe is too simple



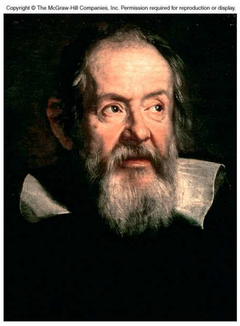
Evidence for the Heliocentric Model



- Venus undergoes full phase cycle ⇒ Venus must circle Sun

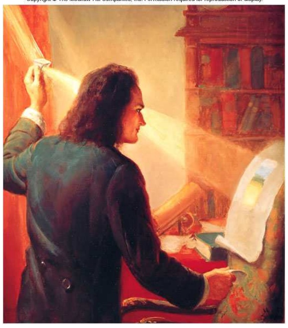
Astronomy in the Renaissance

- Credited with originating the experimental method for studying scientific problems
- Deduced the first correct "laws of motion"
- Was brought before the Inquisition and put under house arrest for the remainder of his life



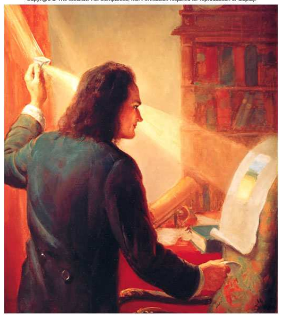
Isaac Newton

- Isaac Newton (1642-1727) was born the year Galileo died
- He made major advances in mathematics, physics, and astronomy



Isaac Newton

- He pioneered the modern studies of motion, optics, and gravity and discovered the mathematical methods of calculus
- It was not until the 20th century that Newton's laws of motion and gravity were modified by the theories of relativity



The Growth of Astrophysics

- New Discoveries
  - In 1781, Sir William Herschel discovered Uranus; he also discovered that stars can have companions
  - Irregularities in Uranus's orbit together with law of gravity led to discovery of Neptune
- New Technologies
  - Improved optics led to bigger telescopes and the discovery of nebulas and galaxies
  - Photography allowed the detection of very faint objects