Ancient Astronomy

Ancient Astronomy

- There are many ancient artifacts of astronomy
  - Aztec Templo Mayor
  - Chaco Canyon of the Anasazi
    - Includes sun dagger
  - Machu Picchu in Peru
  - Stonehenge in England

Mesopotamian/Babylonian Astronomy

- Made the first long term records of astronomy
- Created the 12 zodiacal constellations
- Developed the angle measuring system we use
- Used leap months in calendar
- Discovered patterns of planetary motions by keeping track of synodic periods
  - Interest in planetary positions was due to their interest in astrology, the belief that the positions of celestial objects influence events on the Earth
- They developed mathematical description of planetary motions and could make crude predictions

Ancient Astronomy

Pythagoras (c.582-c.500 BC) and his Students

- It was Pythagoras (or his students) who rejected the notion of a flat Earth and embraced the idea of a spherical Earth
- His model of the universe had Earth revolving around a "central fire" which could not be seen because it was blocked by a "counter Earth". The moon and Sun traveled around the central fire.

Ancient Astronomy

Eudoxus (408-355 BC)

- He proposed that planetary motions were a combination of circular motions
- He put the earth in center and planets were attached to spheres which moved at the appropriate rates to roughly reproduce their motions.

Ancient Astronomy

Aristotle (384-322 BC)

- Physical theory of dynamics
  - motions: up, down, around
  - essences: earth, water, air, fire, ether
  - simple vs. compound
  - **circular motion**: complete, unchanging
- We have a comprehensive theory, a framework for questions.
- Applications:
  - Comets: clearly changeable, must be meteorological
  - Planets: compound circular motion
- Also made cogent arguments about the spherical shape of Earth

Ancient Astronomy

Aristarchus (310-230 BC)

- Dimensions of the Moon
  - Angular size (0.5 degrees)
  - Linear size (inferred from lunar eclipses)
  - Distance (Small Angle Formula relates distance to angular and linear size)
- An example of a geometric approach to astronomy
- Made first estimate of Earth-Sun distance (relative to Earth-Moon distance)
- Also suggested a Sun-centered universe

Ancient Astronomy

Small Angle Formula

$$\text{angular diameter}(\theta) = \frac{\text{linear diameter}(\boldsymbol{D})}{\text{distance}(\boldsymbol{d})} \times 206,265''$$

Solved for *d*:

$$\text{distance}(\boldsymbol{d}) = \frac{\text{linear diameter}(\boldsymbol{D})}{\text{angular diameter}(\theta)} \times 206,265''$$

For the moon:

- Linear diameter = 3476 km
- Distance from Earth = 384,000 km

Therefore the angular diameter is 1870" $\cong 0.5^{o}$

Ancient Astronomy

Eratosthenes (276-195 B.C.)

Measuring the Size of Earth

- Eratosthenes devised a clever way to measure the Earth's size. He observed that when the Sun was overhead (at the zenith) at Syene, it was 7° from overhead at Alexandria.
- Since 7° is about 1/50 of a full circle (360°), the circumference of the Earth should be 50 times the distance from Syene to Alexandria, or 50 x 5,000 stadia = 250,000 stadia.

Ancient Astronomy

Eratosthenes

- 250,000 stadia roughly translates into 50,000 km, based on our best guess as to the size of a stadium. The Earth's actual circumference is about 40,000 km, so Eratosthenes calculation is 25% too big. But his geometrical method is correct.
- Earth's circumference of 40,000 km gives a diameter of about 13,000 km (~ 8,000 mi).

Ancient Astronomy

Hipparchus

- Hipparchus
  - A discovery of a "new" star in 134 B.C. prompted him to make a catalogue of the brighter stars
  - The led to another discovery: precession of the poles
    - Hipparchus noticed the vernal equinox drifted westward 1° every 78 years implying it would take 26,000 years to travel the full cycle of 360° along the ecliptic
    - This was due to the earth's poles slow movement on the celestial sphere, completing a loop in about 26,000 years

Ancient Astronomy

Claudius Ptolemy (127-151 AD)

- **Claudius Ptolemy**
  - Worked in at the Great Library at Alexandria
  - Invented the latitude and longitude system
  - Wrote a book on astronomy – μεγιστη
    - Often referred to as *Almagest* = "The Greatest"
    - Contained improved methods to find distance to the Sun and Moon
    - May have taken some ideas from Hipparchus

Ancient Astronomy

Claudius Ptolemy (127-151 AD)

- Claudius Ptolemy is credited for devising the first predictive model of the universe, the Ptolemaic model (A.D. 150)
  - Discredited Aristarchus's Sun-centered model with incorrect assumptions
  - Philosophical keys: use circles, have uniform circular motion
- The Sun, Moon and each planet moved upon an epicycle, the center of which revolved around a deferent circle
  - Compound circular motion allowed planets to have retrograde motion

Ancient Astronomy

Claudius Ptolemy

- To improve accuracy, Ptolemy had to offset the Earth from the center of the deferent and make the uniform circular motion relative to another point, equally offset from center called the equant.
- It is difficult to know whether Ptolemy believed the universe actually worked this way, or was this simply a model that gave fairly accurate predictions.

Ancient Astronomy

Criteria for Scientific Models

- **Three modern criteria of scientific models:**
  - **Model must fit the data**
  - **Model must make predictions that can be tested and be of such a nature that it would be possible to disprove it**
  - **Model should be aesthetically pleasing - simple, neat, and elegant (Occam's razor)**

Criteria for Scientific Models

- Ptolemy's model meets the first two criterion for a good scientific model fairly well but it is much less successful with the third (aesthetically pleasing).
  - Earth not quite in the center
  - Scale of deferents and epicycles arbitrary
  - Not quite uniform circular motion
  - Mercury & Venus tied to Sun, others are not

