Chapter 3. Early Astronomy

Note. In this section we give lists of accomplishments in the understanding of astronomy by the Babylonians and the Greeks.

Note. In Babylon (in present-day Iraq), some accomplishments were:

- A calendar with 12 months of 30 days length
- A number system using base 60
- A system of angular measurement using degrees

Note. Some of the ancient Greek philosophers/mathematicians/astronomers and there accomplishments include:

Thales (600 BCE): Introduced the idea that rational inquiry can lead to understanding of the universe.

Anaximander (600 BCE): Claimed that outside of Earth are rotating tubes with holds in them. Beyond that is flame. This is what stars, the Moon, and Sun are.

Pythagoras (500 BCE): Proposed that natural things can be described mathematically.

Anaxagoras (500 BCE): Claimed the Moon shines by reflected sunlight, correctly describing solar and lunar eclipses.

Plato (400 BCE): Said that the real world is an imperfect representation of ideal creation. We can learn better by pure reason than by observation. All motions in the universe are circular.

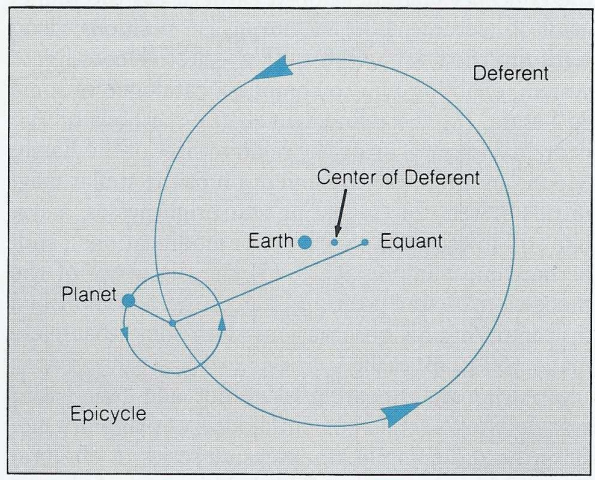
Eudoxus (400 BCE): The Sun, Moon, and planets move on spheres in circular motion. His model of this required 27 spheres.

Aristotle (250 BCE): The world is composed of earth, air, fire, and water. Heavenly bodies are composed of aether.

Aritarchus of Samos (300 BCE): Claimed the Sun, not Earth, is the center of the universe. Used geometric arguments to deduce distances and relationships of objects.

Eratoshtenes (250 BCE): He correctly determined the size of the Earth using geometric arguments.

Apollonius (200 BCE): He was the first to introduce *epicycles* on larger *deferent* circles to explain retrograde motion:



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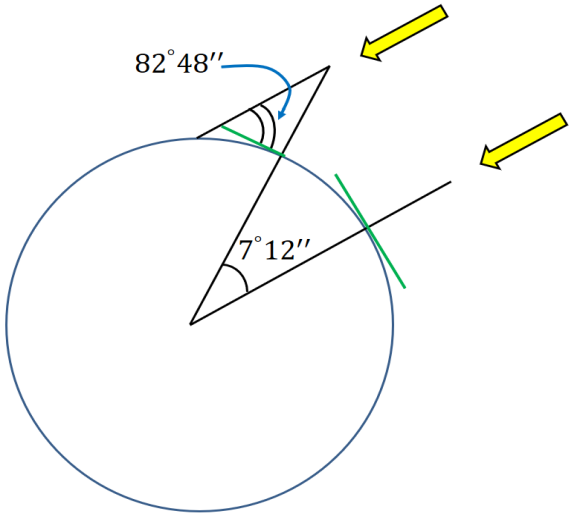
Hipparchus (150 BCE): Was the first to use trigonometry (in fact, he invented it). He used celestial coordinates, invented a stellar magnitude scale, discovered the precession of star positions.

Ptolemy (150 CE): He summarized all the Greek work and introduced a model of planetary motion using many spheres (80 to 80) that was used to predict planet positions that was used to predict planet positions for the next 1,000 years. He may not have believed the models were real.

Note. To illustrate how Eratosthenes computed the circumference of the Earth, consider the following "word problem." The Egyptian city of Alexandria lies directly north of Syene so that the Sun attains its maximum angle of elevation at the same time for both cities. On a certain day the Sun is directly overhead at Syene (with an elevation of 90°), while at Alexandria the maximum angle of elevation is 82°48′. If Alexandria is 498 miles north of Syene, what is the circumference of the Earth?



Solution. In terms of angles, the angle between Syene and Alexandria (this is the difference in their longitudes since one is due north of the other) is the difference between the angles of elevation of the Sun at a given time. This angle difference is $90^\circ - 82^\circ 48' = 7^\circ 12'$. From elementary trigonometry, we know that the ratio of this angle $7^\circ 12'$ to the 360° in a full circle is the same as the ratio of the circumference of the Earth C to an arc of length 498 miles. So we have:

$$\frac{7^\circ 12'}{360^\circ} = \frac{7.2^\circ}{360^\circ} = \frac{498 \text{ miles}}{C} \text{ implying } C = 498\frac{360}{7.2} \text{ miles} = 24,900 \text{ miles}.$$

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