Motions of the Moon

by K.E.Chilton,F.R.A.S.

1.Daily apparent revolution:

Like all celestial bodies, the moon appears to revolve around the Earth, once every 24 hours. This is caused by the rotation of the Earth. However, the moon revolves eastward in its orbit, ie: in the same direction as the Earth. Therefore, it takes a little longer for the earth to catch up, lengthening the apparent revolution to 24h 50m.

2.Daily growth and shrinking:

Since an observer is slightly closer to the Moon when it is at the zenith than when it is at the Horizon, the Moon is slightly larger in apparent diameter at that time.This amounts to about 1 part in 120, or about 15 seconds of arc.

3.Synodic revolution:

The Moon appears to move from the right ascension of the Sun (New Moon) around the celestial sphere and back to the Right Ascension of the Sun in 29d 12h 44m. The Moon's orbital speed is 632 miles per second.

4.Sidereal revolution:

The Moon appears to move from a point in space around the celestial sphere and back to the same point in space in 27d 7h 43m.

5.Secular slowing of the moon's motion:

As the Moon exerts a tidal influence on the Earth, the earth is slowing down. This means that it apparently takes a little longer for the celestial sphere to revolve, slowing down the motions respectively. Conversely, the Earth exerts a tidal influence on the Moon, causing it to slow down in orbit. According to the laws of celestial mechanics this causes the Moon to move away from the earth.

6.Monthly growth and shrinking:

Since the Moon's orbit is an ellipse varying in size, the moon appears to be a little larger at times. When the Moon is closest, (226,000 miles), its apparent diameter is 33'28". When it is farthest, (252,000 miles), its apparent diameter is 29'22". (This is the reason for annular solar eclipses. When the moon is farthest away, it will not cover the sun, whose diameter is approx. 32' .

7.Rotation on its axis:

Although the Moon appears to have no rotation, it must, in fact, rotate once per revolution in order to keep the same face toward the Earth.

8. East-west Libration:

The moon appears to rock from side to side as it revolves around the Earth. This is because the Moon does not exactly face toward the centre of the Earth, but rather, toward the centre of its orbit. Consequently, we see a bit around one side of the Moon, and then a bit around the other as a month passes.

9. Daily Variation in East West Libration:

Since the observer moves approximately 8,000 miles (the diameter of the earth) between Moonrise and Moonset) he is looking at the moon from a slightly different angle. This allows him to see around the edges, (limbs) of the Moon, more than the ordinary libration would allow.

10. North-South Libration:

The Moon's orbit is inclined to the Earth's orbit. Thus at times the Moon is farther "North" in space. At this time we see a bit under the south limb of the Moon. At other times the Moon is farther "South"in space and we see over its top.

11. Revolution of the Major Orbital Axis:

The major axis of the Moon's Orbit revolves eastward with a period of 3232 days, or 8 years 310 days.

12. Revolution of the Nodes:

If the Moon's orbit, and the Earth's orbit are represented by planes, the line of intersection of the two planes is called the line of nodes. This line is revolving westwardin 6798 days, or 18 years 224 days.

13. Variation of the inclination:

The inclination of the Moon's orbit to the earth's orbit is about 5° 8'. However there is a small variation in this inclination, from 5° 0' 1" to 5° 17'35". The period of oscillation is 173 days.

14. Equation of the Centre:

If the Moon's orbit were circular, the Moon would revolve at a constant speed. However, the orbit is elliptical, so that the Moon travels faster at certain times, and slower at other times. This makes the Moon up to 6° early or late during the period of a month.

15. Evection:

Evection is the sun's influence on the Moon. It causes the Moon to speed up and slow down in its orbit, causing the quarter phases to occur unevenly (i.e. New Moon, 1st Quarter, Full Moon, and Last Quarter are not equidistant in time.) (Other factors influence this too, but evection is in there, causing accelerations and decelerations.)

16. Parallactic Displacement:

If the earth did not rotate, the Moon would appear to move eastward through the stars by a given amount each night. However, since the Earth rotates eastward, the Moon is displaced slightly westward and does not appear to make as much eastward progress as it normally does.

There are approximately 500 other variations in the Moon's motion which are too complicated or too minor to be enumerated here. However, they have tormented geometers for years, and it is only with the advent of the computer, and with the landing of man and his laser reflectors on the lunar surface, that we have been able to precisely measure the Motions of the Moon.

This paper given at the Discussion Group
Hamilton Centre
R.A.S.C.
June 17,1970

at the home of H.H.Cornfield,Chairman
62 Main St.N.,
Waterdown,Ont..