Physics 1025: Lecture 9 Moon: where it is found, orbit, phases, motions

Announcements

By its proximity the moon appears to move across the sky more rapidly than any other astronomical object – this was used by Greeks to order planets by their solar distance.

In 300 BC Aristarchus estimated lunar distance from curvature of earth’s shadow on moon during lunar eclipse. Hipparchus later refined this to deduce moon was about 30 earth diameters away or about 240,000 miles (using Erathosthanes’ figure of 8000 miles for earth’s diameter) – not bad compared to average lunar distance of 238,863 miles.

Basic method today is triangulation using parallax shift of moon over a long earth baseline. E.g., moon is shifted by about 1° if observers look from CT and Brazil (separated by 4000 miles):

$$R = \frac{S}{\theta_2} = \frac{4000}{1/60} = 240,000 \text{ miles}$$

Once you know R, you can find the size of the moon above (Dotted triangle), where the moon subtends ½ degree, hence

$$D = R\theta_2 = 240,000 \times 0.5 \times \frac{1}{60} \sim 2100 \text{ miles}.$$  

Moon’s motion is not simple: earth and moon both orbit the barycenter, which is located about 2700 miles from earth’s center. (The Barycenter is the center-of-mass of the earth-moon system.) Actually the sun pulls on moon 2.5 times the earth’s pull so in fact the moon goes around the sun!

Orbit of moon around earth is ellipse. Nearest point is perigee, furthest is apogee, and the line of apsides connects these two and rotates eastward with a period of 9 years. Perigee distance is 221,500 miles, apogee is 252,710 miles.

The moon’s phases are just the moon shadowing itself. Waxing means ‘growing’ waning is ‘shrinking’. Terminator is line separating light and dark halves of the moon. Earthshine is light reflected off of earth first, then up to moon and back – seen in crescent moon on “dark” part (explained in 1400’s by Leonardo da Vinci).
<table>
<thead>
<tr>
<th>Elongation</th>
<th>Phase</th>
<th>Age</th>
<th>Appearance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0° = conjunction</td>
<td>New</td>
<td>0 days</td>
<td></td>
<td>Rises with sun</td>
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<tr>
<td>180° = opposition</td>
<td>Full</td>
<td>14 days</td>
<td></td>
<td>On meridian at midnight</td>
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<tr>
<td>270° quadrature</td>
<td>Last quarter</td>
<td>21 days</td>
<td></td>
<td>Rises 6 hr before sun</td>
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<tr>
<td>90° quadrature</td>
<td>Gibbous</td>
<td>8-13 days</td>
<td></td>
<td>Sets 6 hr after sun</td>
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<tr>
<td>First quarter</td>
<td>Gibbous</td>
<td>15-20 days</td>
<td></td>
<td>Waning</td>
</tr>
<tr>
<td>Last quarter</td>
<td>Crescent</td>
<td>22-27 days</td>
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Where is the moon? The moon travels eastward along the ecliptic through the Zodiac approximately 12°/day, taking about 30 days to go all the way around its orbit.

New moon: rises and sets with the sun
- Rises: Dawn
- Transits: Noon
- Sets: Sunset

Full moon is opposite sun in the sky
- Rises: Sunset
- Transits: Midnight
- Sets: Dawn

First quarter: leads the sun along the ecliptic by 3 months
- Rises: Noon
- Transits: Sunset (low in fall/high in spring)
- Sets: Midnight

Last quarter: lags the sun along the ecliptic by 3 months
- Rises: Midnight
- Transits: Dawn (high in fall/low in spring)
- Sets: Noon