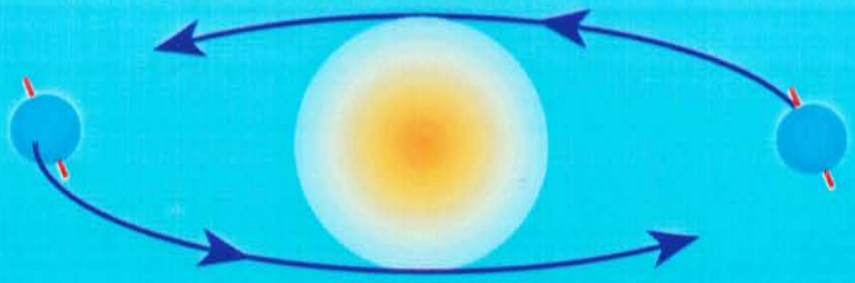
The Sun on the Celestial Sphere

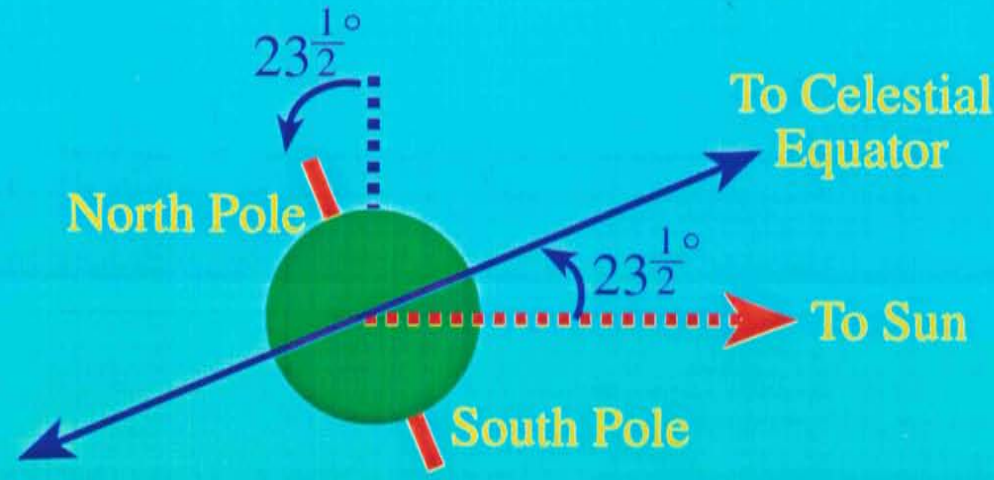
- Sun moves relative to the fixed stars
- Sun is north of Celestial Equator from mid-March to mid-September
- Sun is south of Celestial Equator from mid-September to mid-March

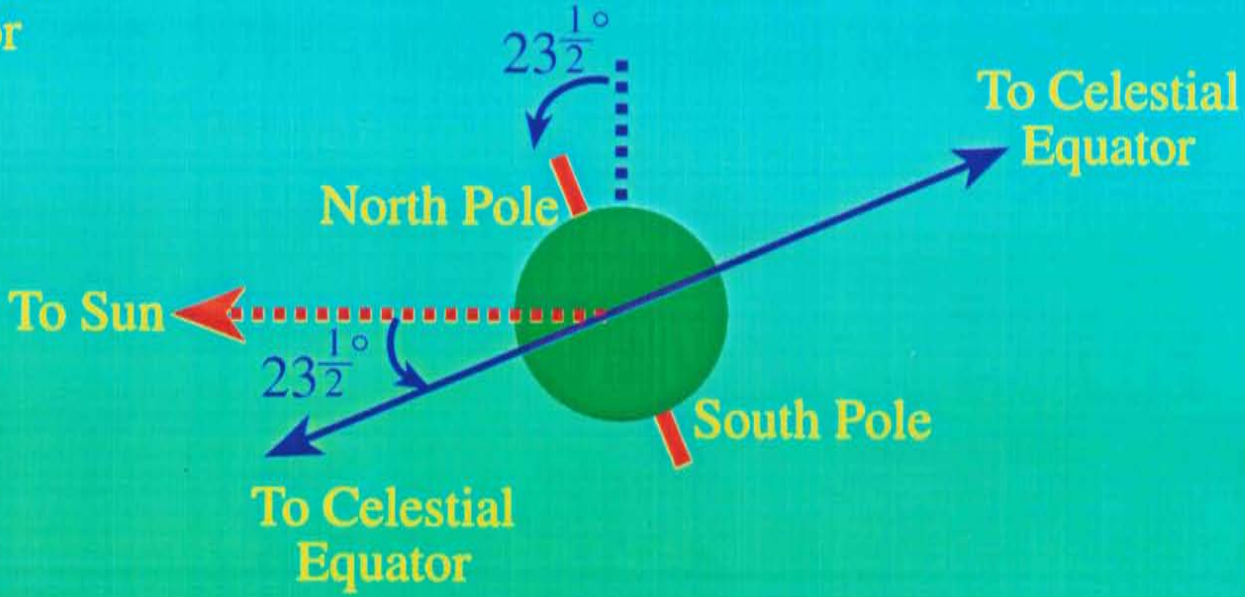
- Sun is furthest north / south in mid-June / mid-Dec.

- Sun is on Celestial Equator in mid-March / mid-Sept.

Motion of Earth around Sun

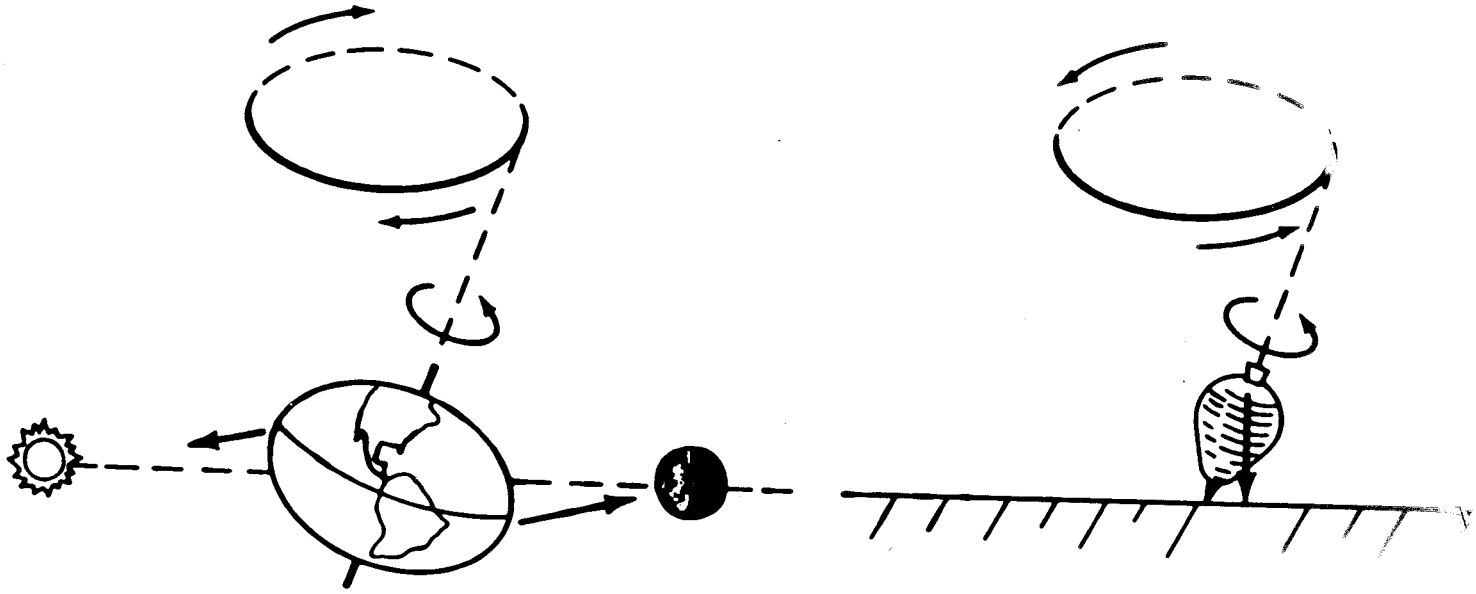






Introduction to Astronomy
Lambert

- How would Sun move on Celestial Sphere if rotation axis were perpendicular to orbit?
- How would Sun move on Celestial Sphere if rotation axis were in the orbital plane?



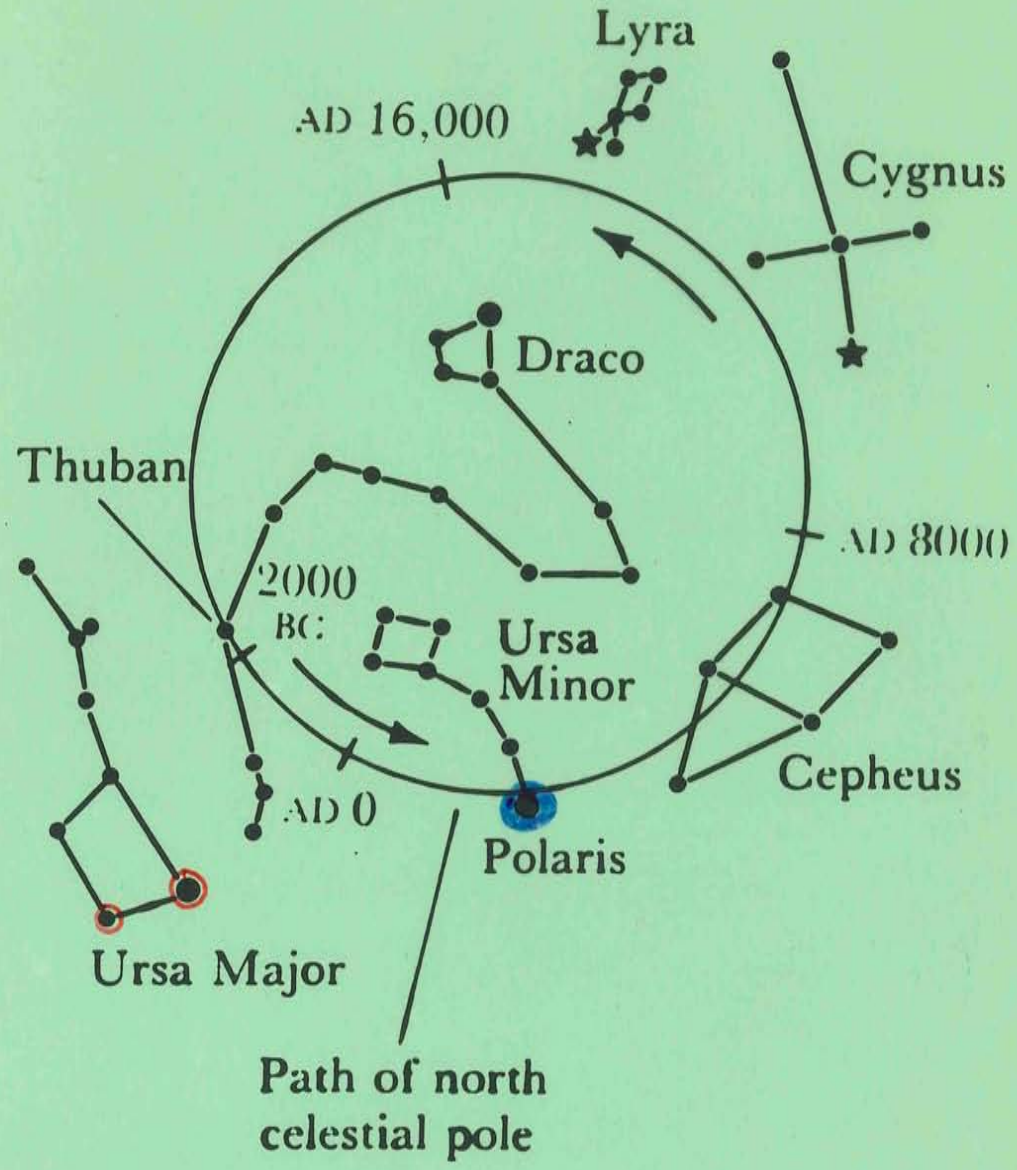
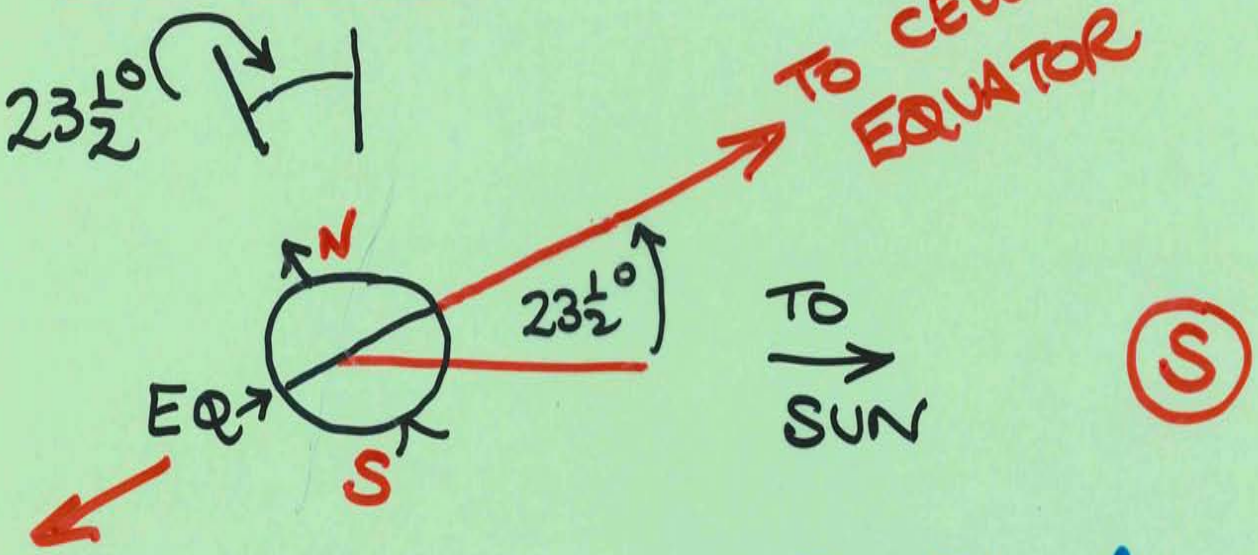


Figure 2-9 The path of the north celestial pole *As the Earth precesses, the north celestial pole slowly traces out a circle among the northern constellations in the sky. At the present time*

WHY SEASONS?

- HEATING BY SUN IS DOMINANT SOURCE OF ENERGY
- SUN'S TRACK ACROSS SKY VARIES OVER THE YEAR
  B/C AXIS TIPPED 23½° WRT ORBIT
  ∴ HEATING VARIES DAY TO DAY

NORTHERN WINTER

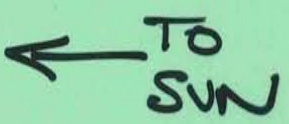


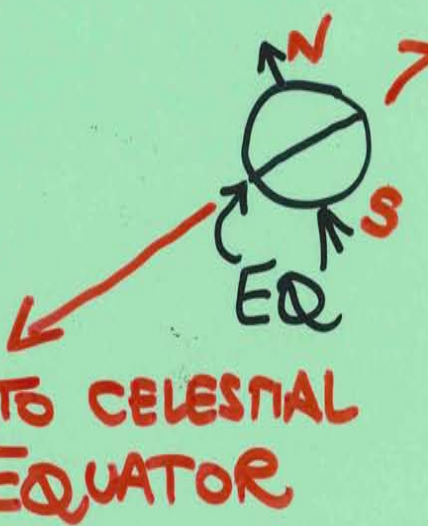
HERE, SUN IS SOUTH of CELESTIAL EQUATOR

ORBIT OF EARTH IS PERPENDICULAR TO DIAGRAM

* EARTH ORBITS SUN WITH ROTATION AXIS POINTING IN A "FIXED" DIRECTION

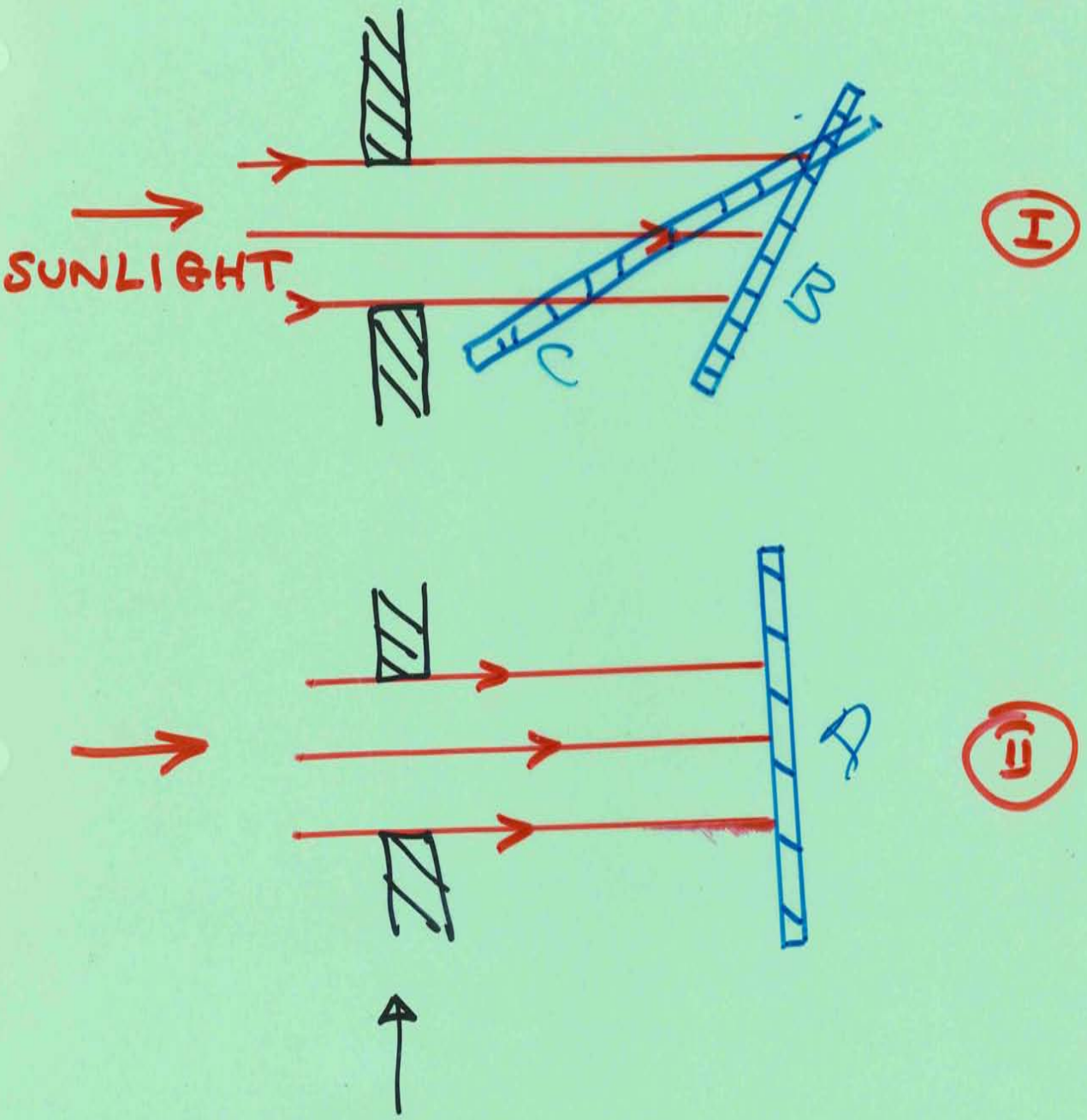
NORTHERN SUMMER





HERE, SUN IS NORTH of CELESTIAL EQUATOR

AT THE EQUINOXES, SUN CROSSES THE CELESTIAL EQUATOR



HOLES ARE IDENTICAL

In (I) THE SUNLIGHT IS SPREAD OVER A LARGER SURFACE AREA, THEREFORE, NOT HEATED SO MUCH AS (II)

- FINE DETAILS

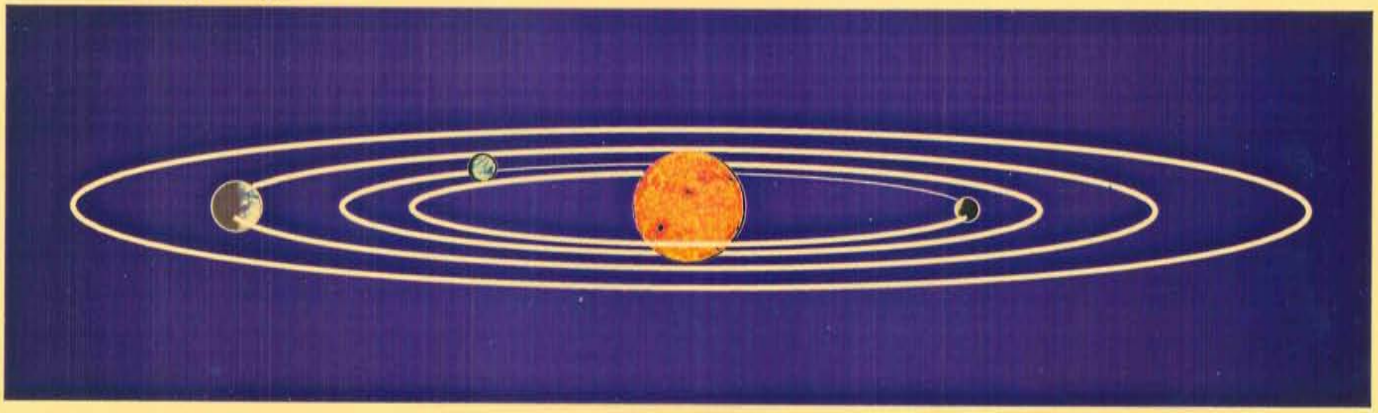
MILANKOVITCH CYCLES

- ORBIT NON-CIRCULAR
- $23\frac{1}{2}$ TILT VARIES
- PRECESSION

Phases of Planets and Moons

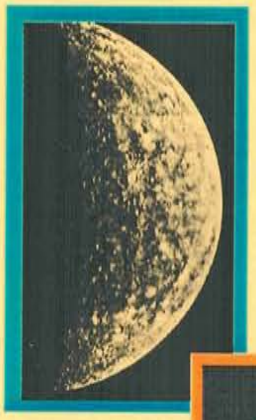
BASICS

1. Planets, moons, Earth and Sun lie almost in a single plane.

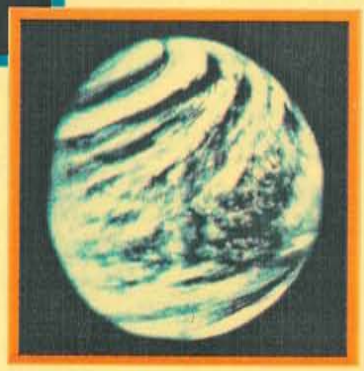


2. Planets and moons shine by reflected sunlight. They are not self-luminous.

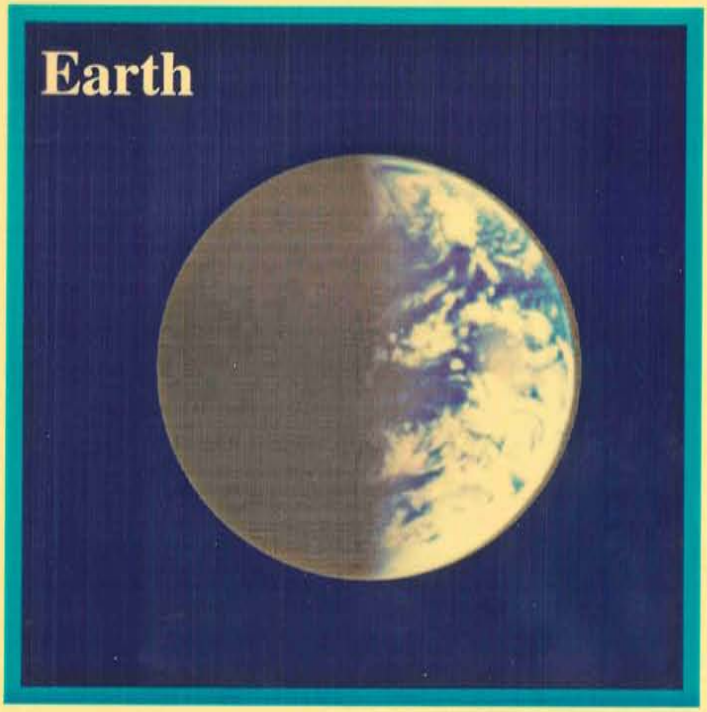
3. The Sun can illuminate one-half of the planet or moon.



Mercury



Venus



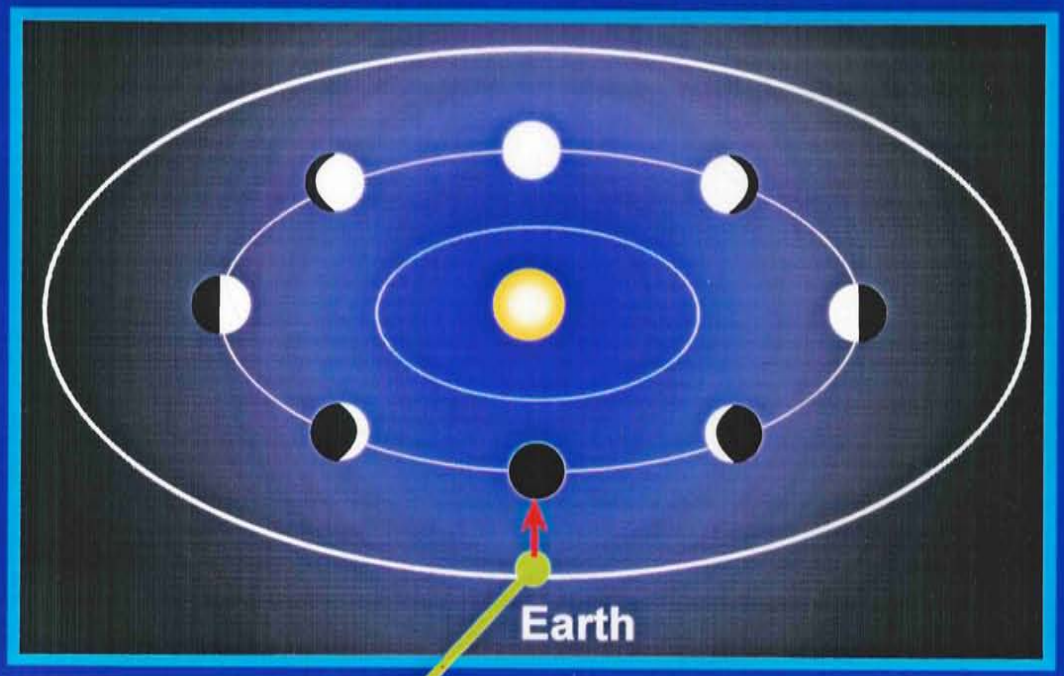
Phases of the Planets and Moons

SUMMARY

PHASE	SUN-OBJECT-EARTH ANGLE
Full	0° E—S—O or S—E—O
Gibbous	0° to 90°
Half	90°  NOT 
Crescent	90° to 180°
New	180° S—O—E

Phases of Planets and Moons

NEW PHASE

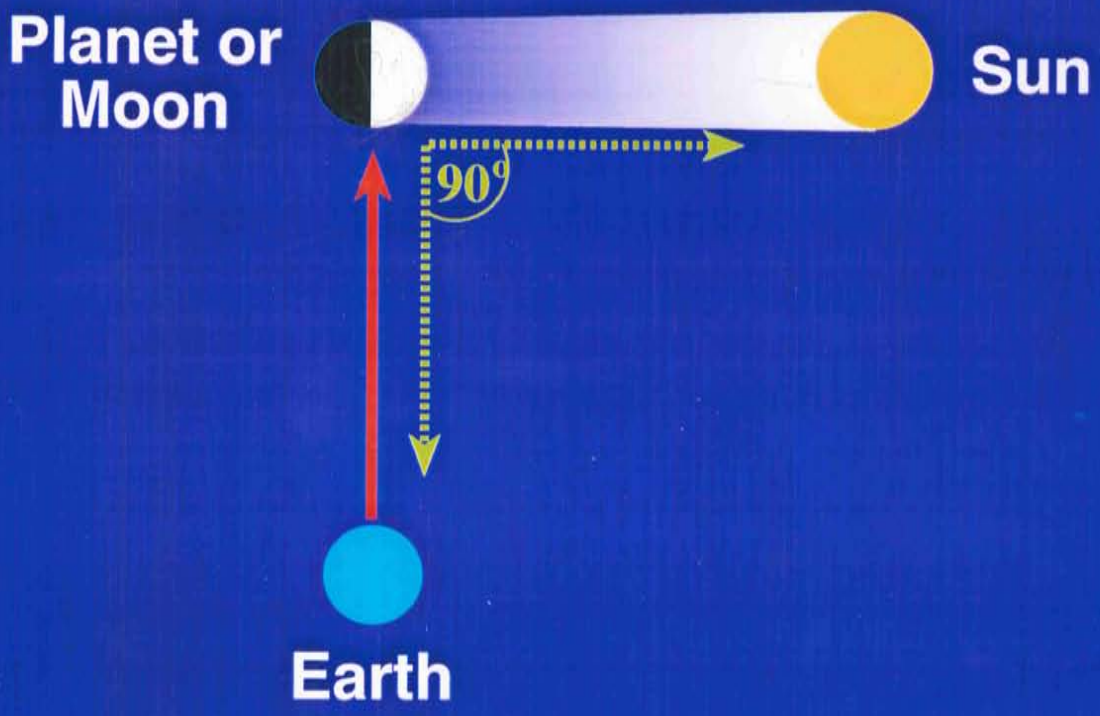


For a New Phase:
The angle **at the Planet** between the Sun and the Earth is 180°. Earth and the Sun are on opposite sides of the Planet: night side is facing us.

Phases of the Planets and Moons

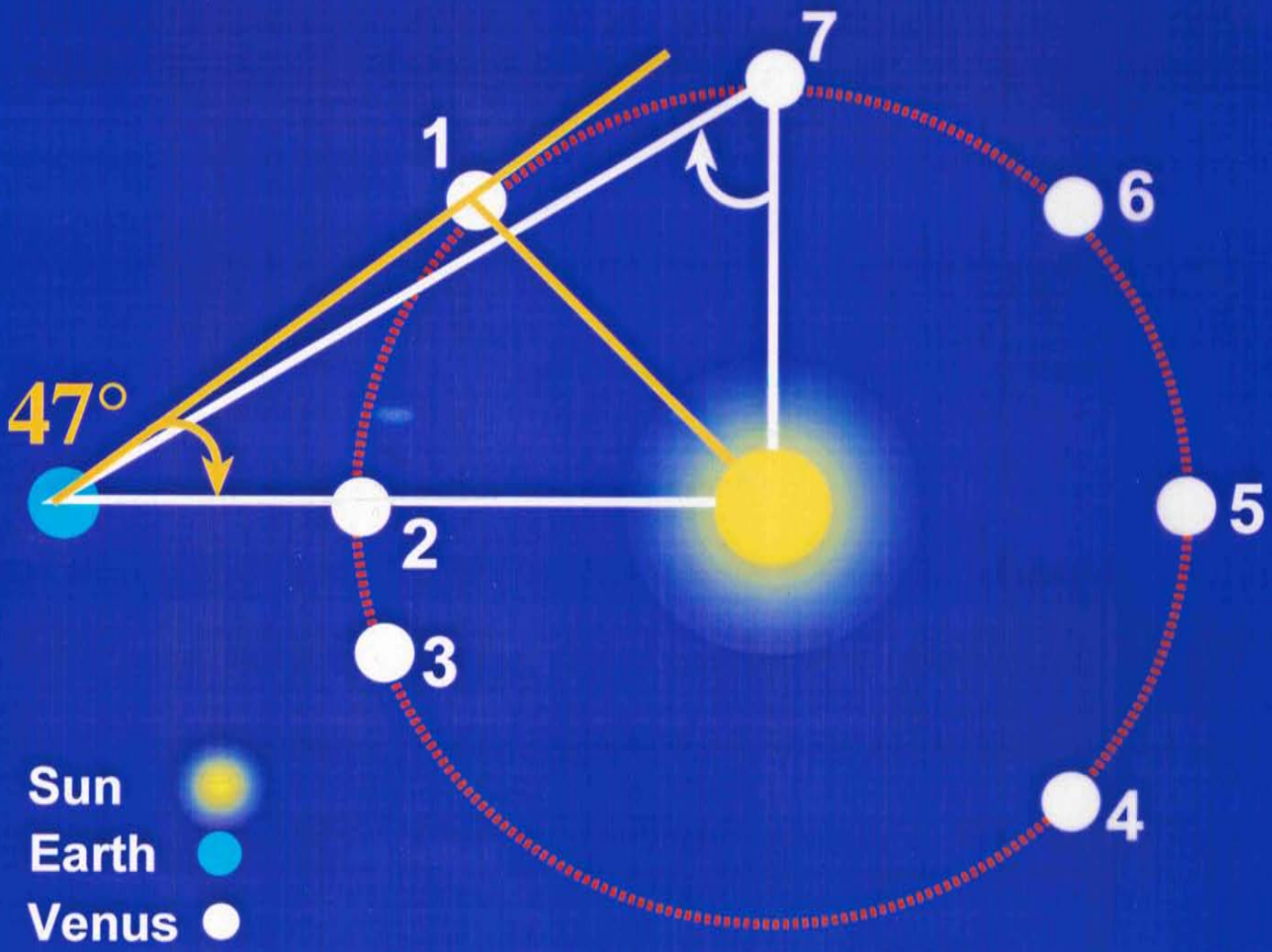
'Half' Phase - Quarter Moon

The angle at the planet between the Sun and the Earth is 90 º.



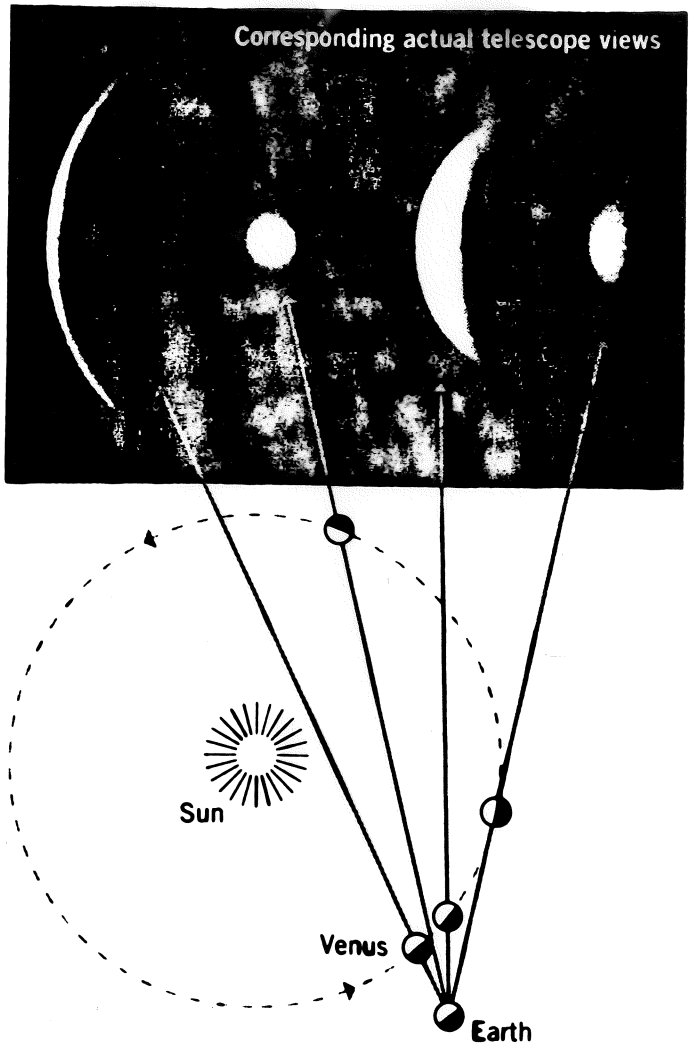
From the Earth, 1/2 of the planet's visible surface is in sunlight and 1/2 is in darkness.

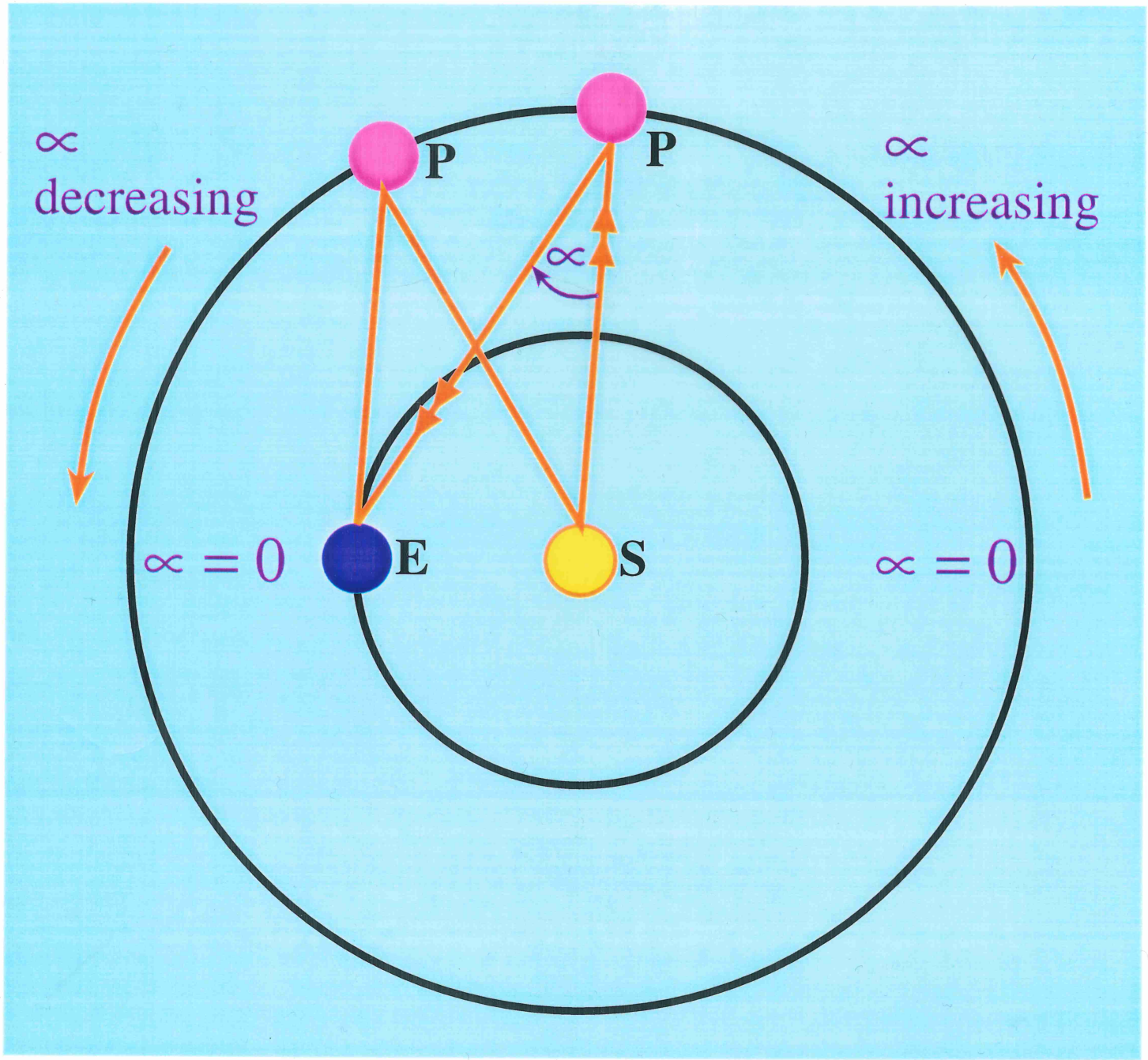
Phases of Venus



NOTE

Angle of 47° is the observed maximum separation between Venus and Sun as seen from the Earth.

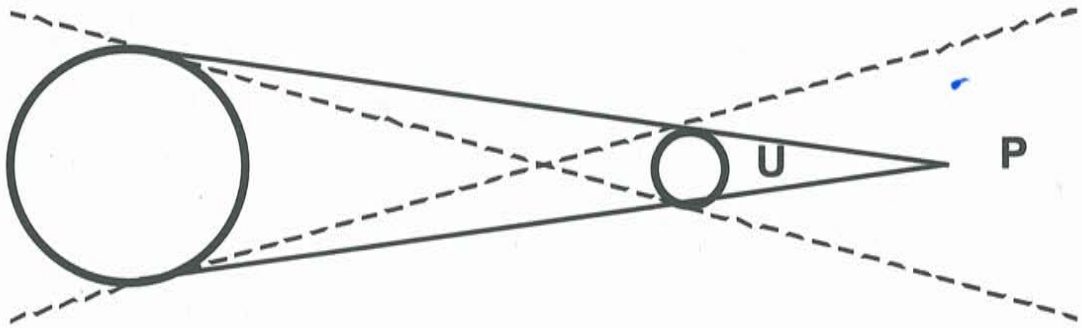

Corresponding actual telescope views
Sun
Venus
Earth



NOTE: ∝ always < 90°,
therefore phase: gibbous to full
NEVER half to crescent.

GEOMETRY OF AN ECLIPSE

- LIGHT SOURCE [SUN]
- OPAQUE OBJECT
  - MOON → SOLAR ECLIPSE
  - EARTH → LUNAR ECLIPSE
- OBSERVER IN THE OPAQUE OBJECT'S SHADOW

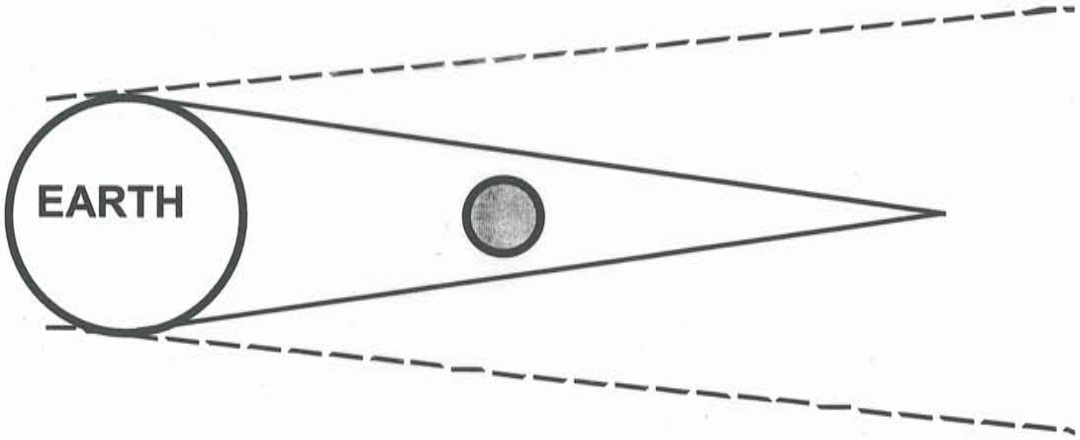


U is the umbral cone (total shadow)

P is the penumbra (partial shadow)

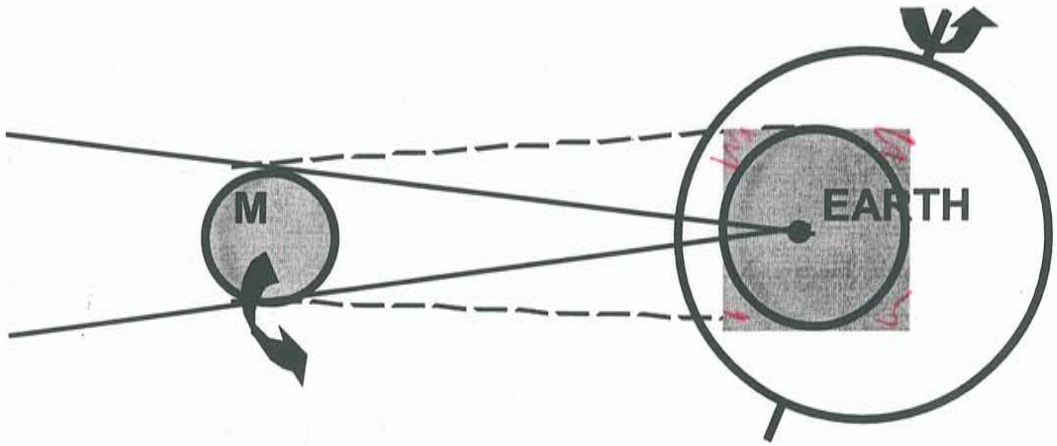
LUNAR ECLIPSE

Moon is in the Earth's shadow



SOLAR ECLIPSE

The Moon's shadow falls on a Small part of the Earth



WHY IS THERE NOT A SOLAR AND LUNAR ECLIPSE EVERY MONTH?

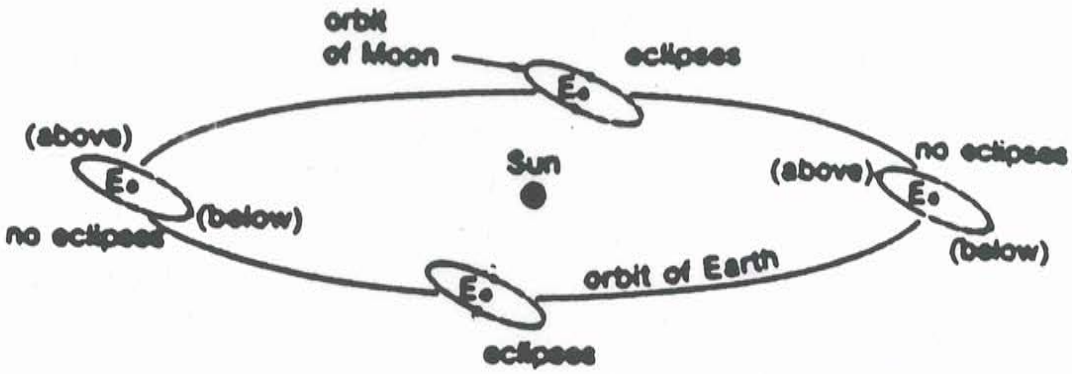
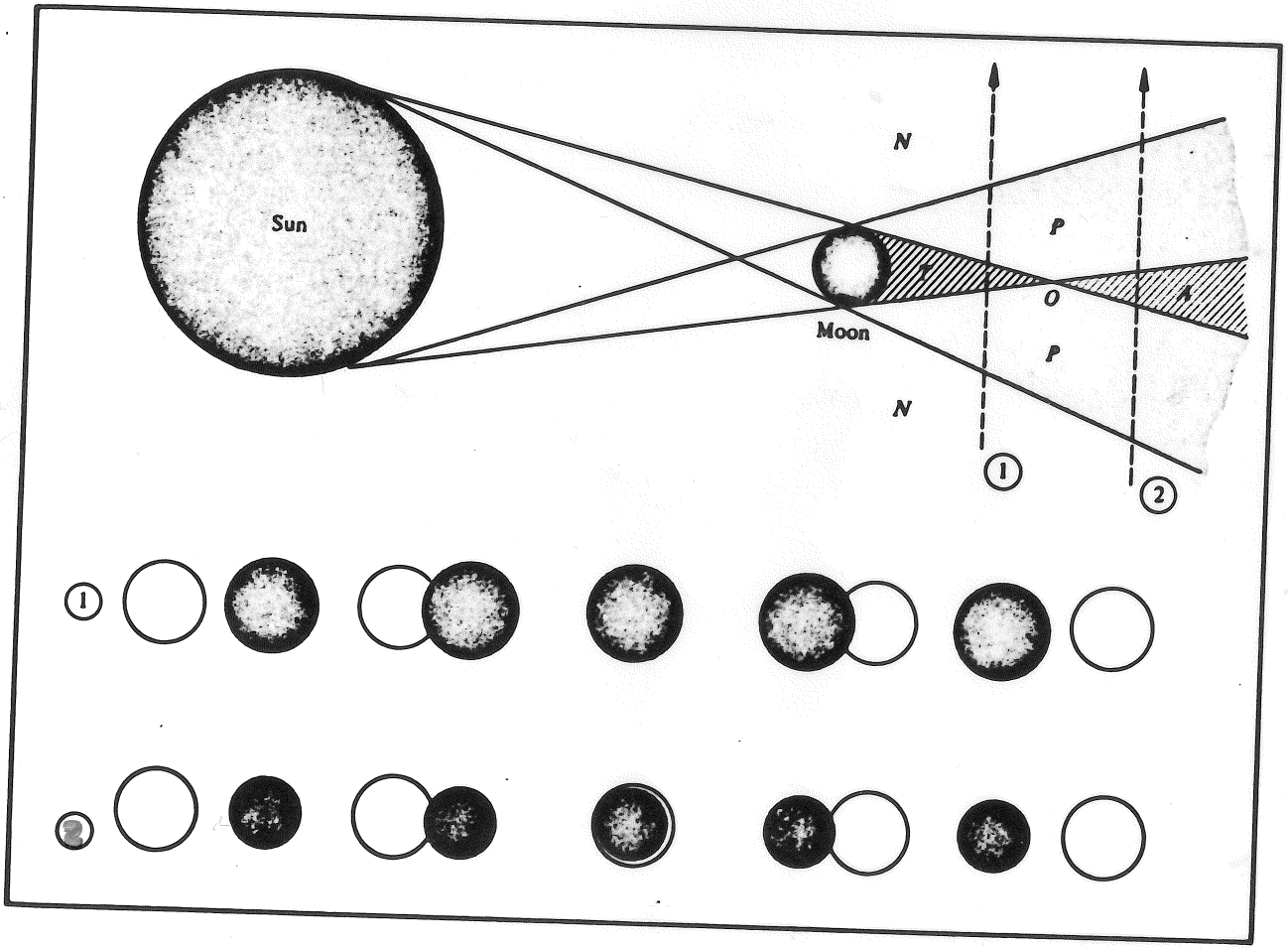


FIGURE 3.1

Eclipses of the sun. The moon casts a shadow in sunlight, dividing space into regions where there is no eclipse N, a partial eclipse P, a total eclipse T, and an annular eclipse A. When the earth moves in the plane of the figure, observers experience the sequence NPTPN along path 1 or NPAPN along path 2. If the path is out of the plane of the figure, the earth misses regions T and A, so only a partial eclipse is seen.



WHY CAN WE NOT SEE SOLAR CORONA OUTSIDE OF ECLIPSE ?

— IT'S NOT VERY BRIGHT

~1MILLIONTH BRIGHTER OF DESK

— BLUE SKY ~1000× BRIGHTER THAN CORONA

TOTAL SOLAR ECLIPSES

— OF SCIENTIFIC INTEREST

— SOLAR CORONA

VERY HOT (2 MILLION K) TENUOUS GAS FEEDING THE SOLAR WIND

— ABOUT AS BRIGHT AS FULL MOON .

- TIP OF UMBRAL CONE VERY CLOSE TO EARTH'S SURFACE [WHY?]
  - — BELOW → TOTAL SOLAR ECLIPSE
  - — ABOVE → ANNULAR (PARTICAL) ECLIPSE
- LOCATION OF TIP DEPENDS ON MOON-EARTH, SUN-EARTH DISTANCE. BOTH VARY AS ORBITS ARE NOT CIRCULAR

BASIC FACTS ON LUNAR ECLIPSES

- EARTH'S UMBRA AT MOON'S DISTANCE FROM EARTH IS ABOUT $2_{1/2}$ MOON DIAMETERS
- TOTALITY LASTS UP TO ABOUT 2 HOURS
- ECLIPSE IS VISIBLE FROM ANYWHERE ON EARTH'S NIGHTSIDE THAT MOON IS ABOVE HORIZON
- OCCUR AT FULL MOON BUT NOT EVERY FULL MOON
- PARTIAL ECLIPSES MORE COMMON THAN TOTAL ECLIPSES
- 'NO' SCIENTIFIC INTEREST

BASIC FACTS ABOUT SOLAR ECIPSES

- MOON'S UMBRA ON EARTH IS AT MOST ~200 MILES WIDE
- UMBRA SWEEPS ACROSS EARTH
- TOTAL ECLIPSE AT FIXED POINT OVER IN 2-3 MINUTES ON AVERAGE, AND 7 MINUTES AT MAXIMUM
- MOON'S MOTION CAUSES SHADOW TO MOVE AT ABOUT 2000 MPH. EARTH'S ROTATION CAN BE ABOUT 1000 MPH IN SAME DIRECTION. NET MOTION ACROSS EARTH THEN ABOUT 1000 MPH