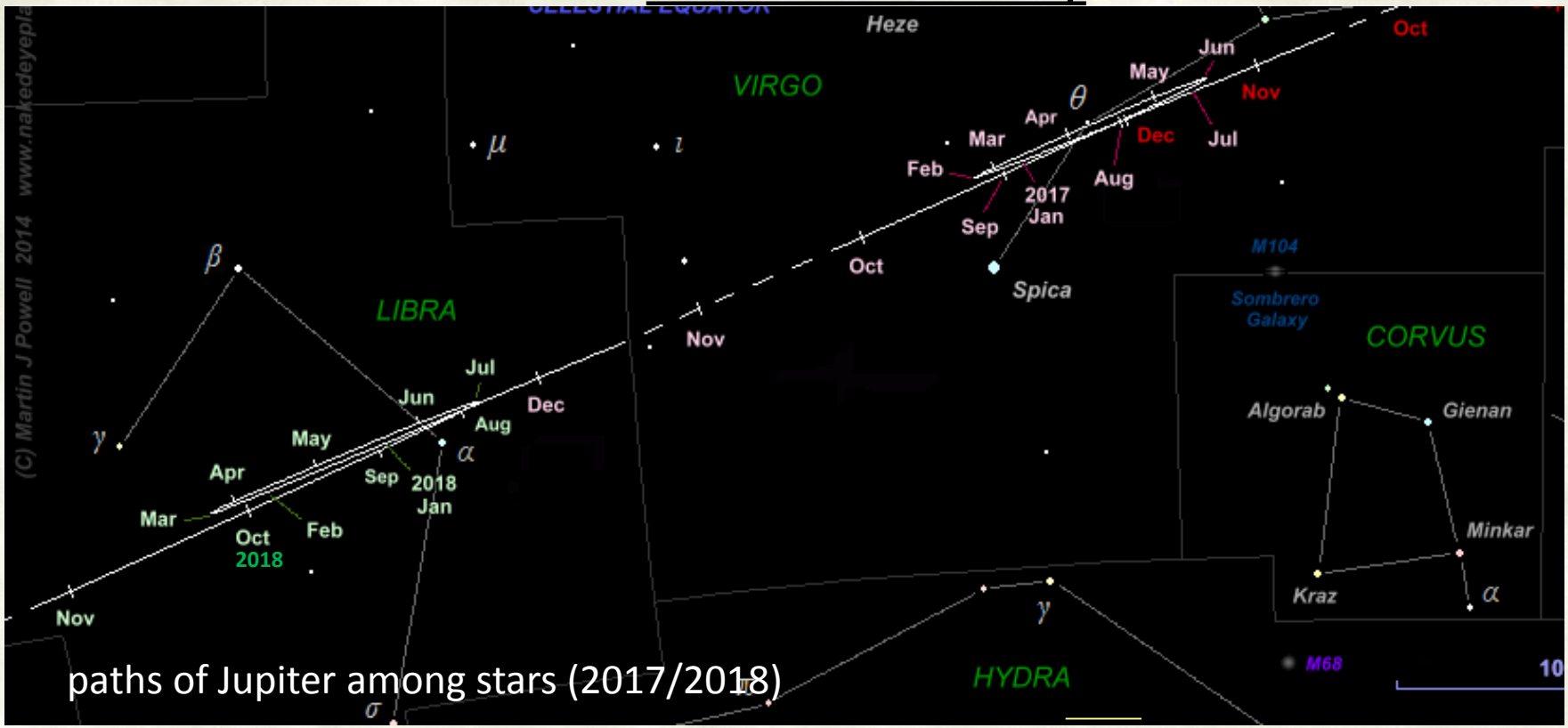
Planets in the Sky

ASTR 101

9/19/2018

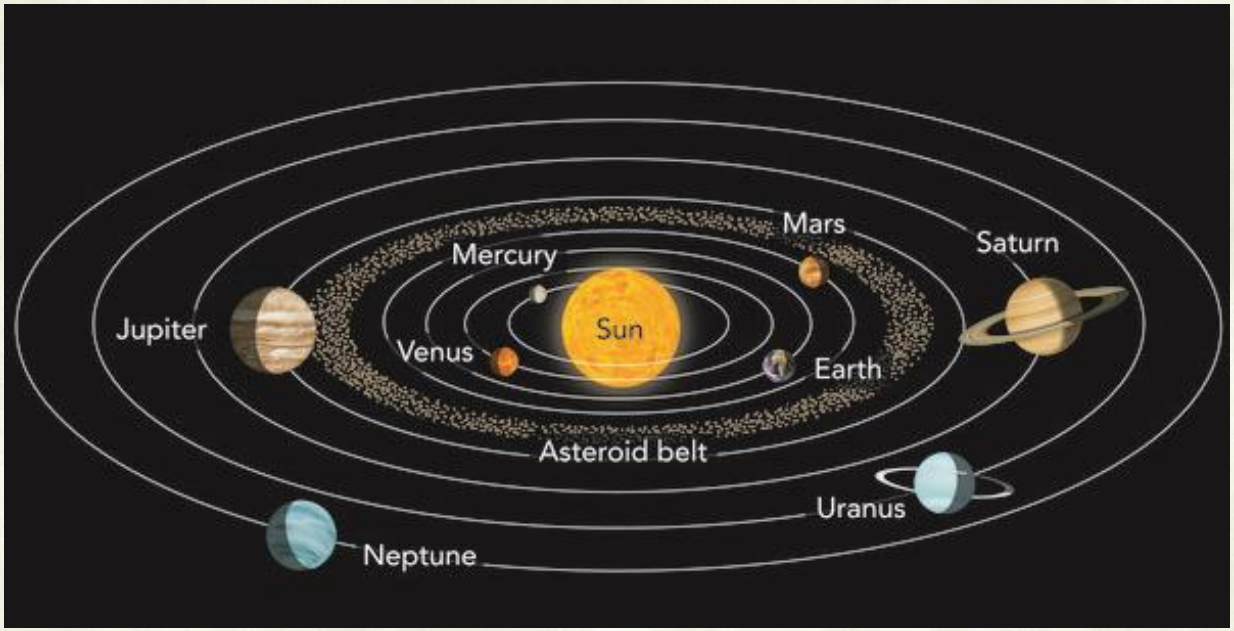
Planets in the Sky



paths of Jupiter among stars (2017/2018)

- Unlike stars which have fixed positions in the sky (celestial sphere), planets seem to move with respect to stars in a rather irregular manner.

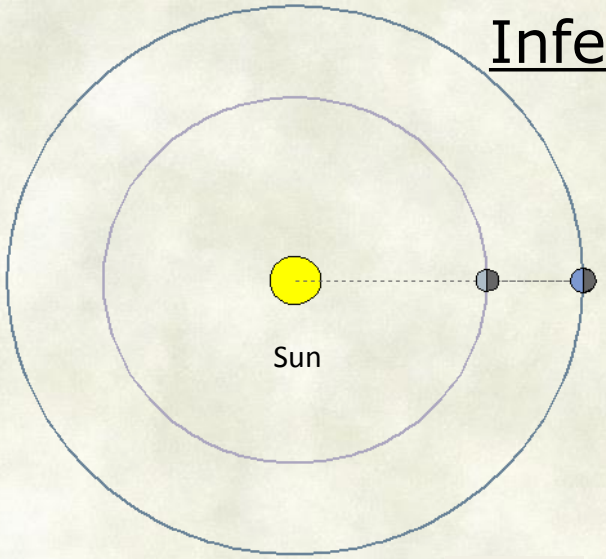
  (planet: from the ancient Greek word *asters planetai* "wandering star")

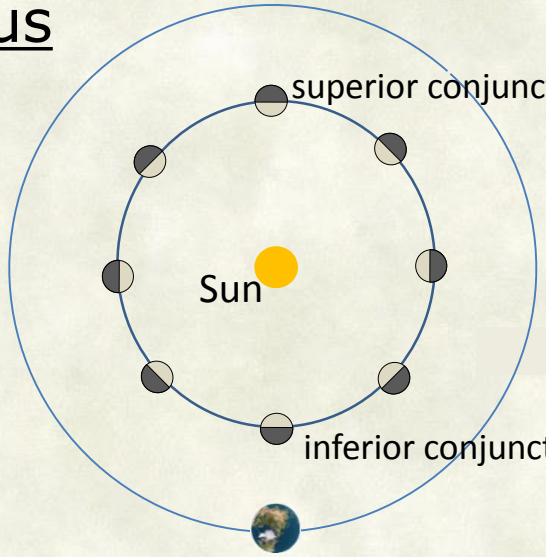


- **Inferior planets**: Orbiting inside the Earth's orbit. (Mercury, Venus).

- **Superior planets**: Orbiting outside the Earth orbit. (Mars, Jupiter, Saturn, Uranus, Neptune).

Inferior Planets: Venus



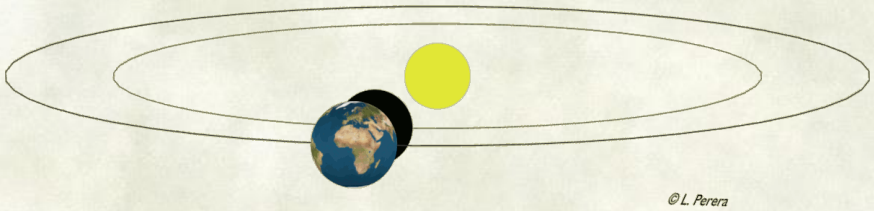


Orbits of the Earth and Venus

(animation: www.phy.olemiss.edu/~perera/animations/venus_l.gif)

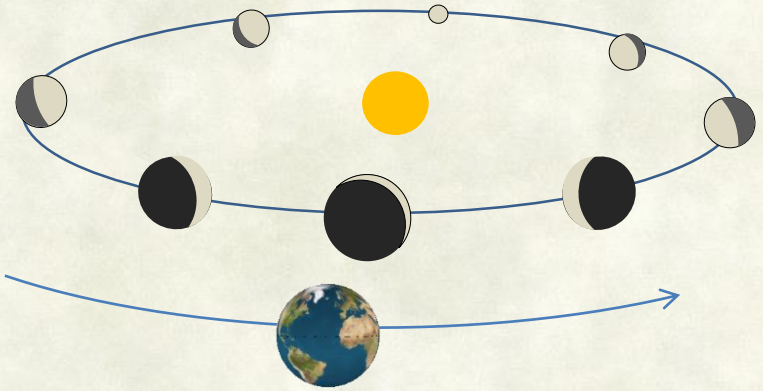
- Venus is the brightest object in the night sky after the Moon.
  - magnitude -3.7 even when it is dimmest
- In addition to being close to the Earth and the Sun, it has a high albedo = 70%.
- Venus: distance from sun 0.7 AU, Orbital period 225 days.
  - Venus completes one revolution around the Sun in 225 days
  - Earth completes one revolution around the Sun in 365 days
  - Venus "overtakes" the Earth (at the inferior conjunction) every 584 days
- Depending on the position of Venus relative to the Earth we see different amounts of the day side of Venus, resulting phases like for the Moon.
  - Length of the Venus phase cycle is 584 days.

Inferior Planets: Venus

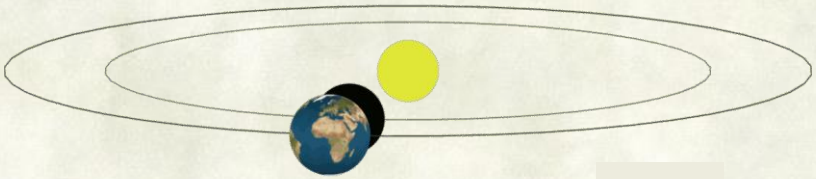


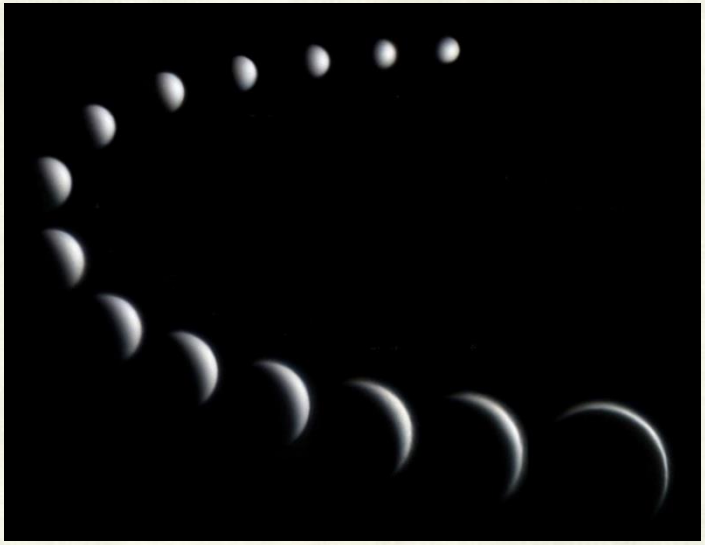
Phases of Venus

Animation: www.phy.olemiss.edu/~perera/animations/venus_h.gif



- Depending on the position of Venus relative to the Earth we see different amounts of the day side of Venus, resulting phases like for the Moon.
- But unlike for the Moon, distance between the Earth and Venus changes considerably:
  - At the inferior conjunction : 40 million km (~0.3 AU)
  - At superior conjunction : 260 million km (~1.7 AU)
- So in between conjunctions, the actual visual size of Venus varies considerably(10" to 63" - a factor of 6)
- Fully illuminated side of Venus faces us when it is near the superior conjunction
  - farthest from Earth ⇒ visual size is smallest, so not the brightest Venus.

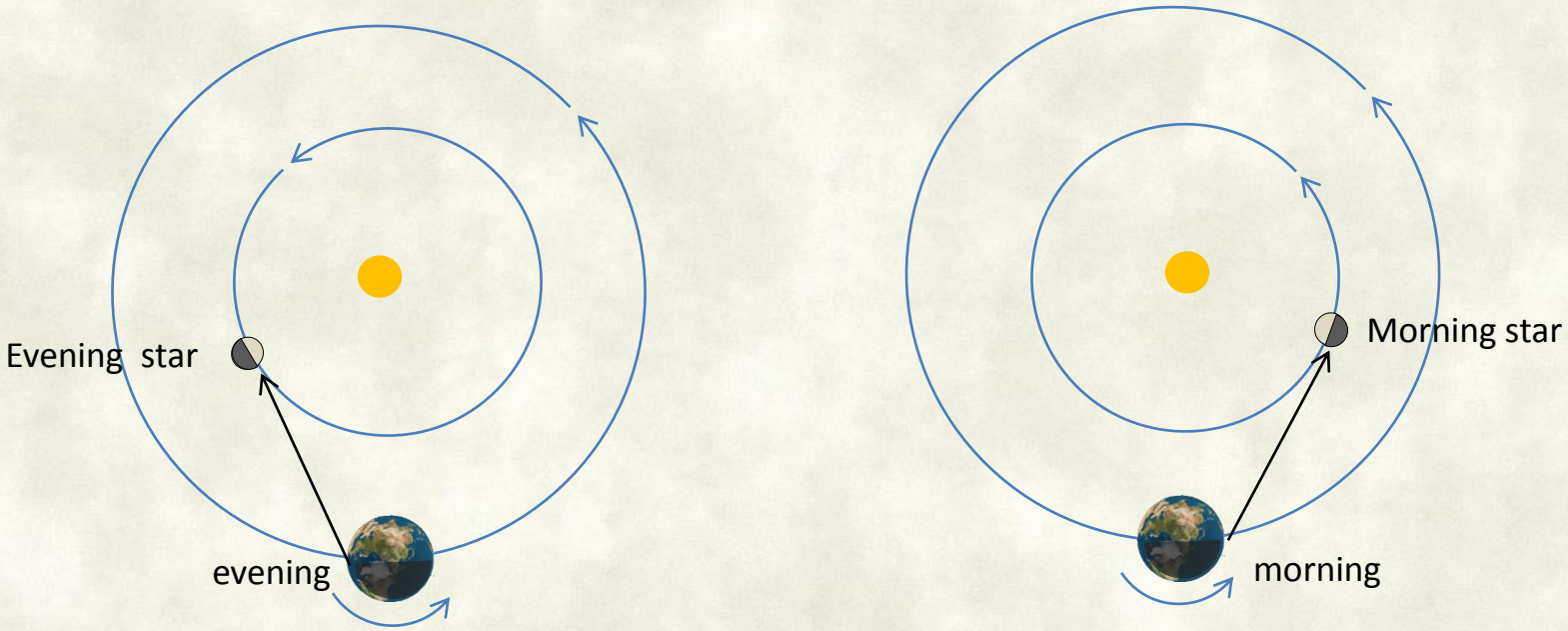




Phases of Venus

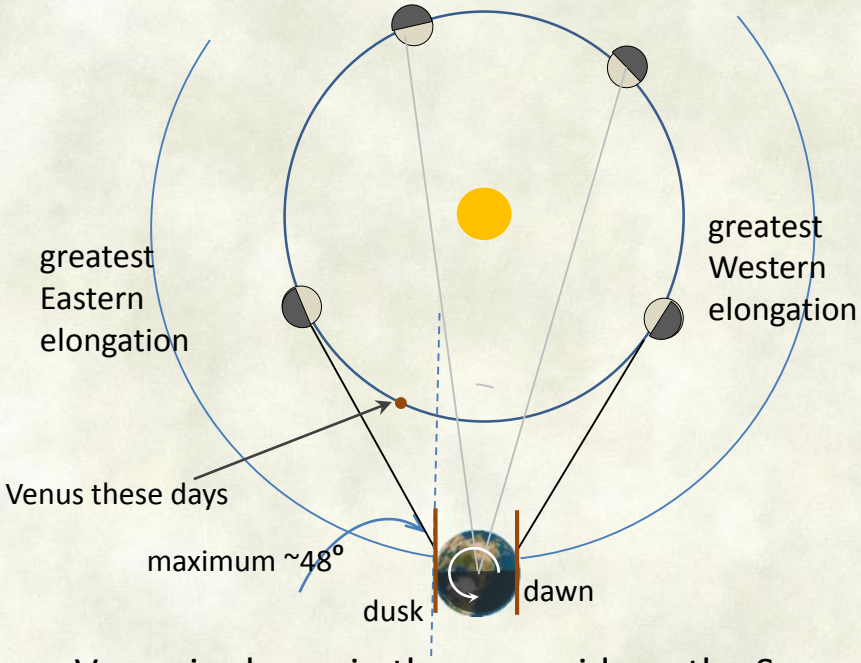
- Venus is brightest (mag. -4.5) when it is in crescent phase (about 25% of the lit side).

Venus: the Evening and Morning star

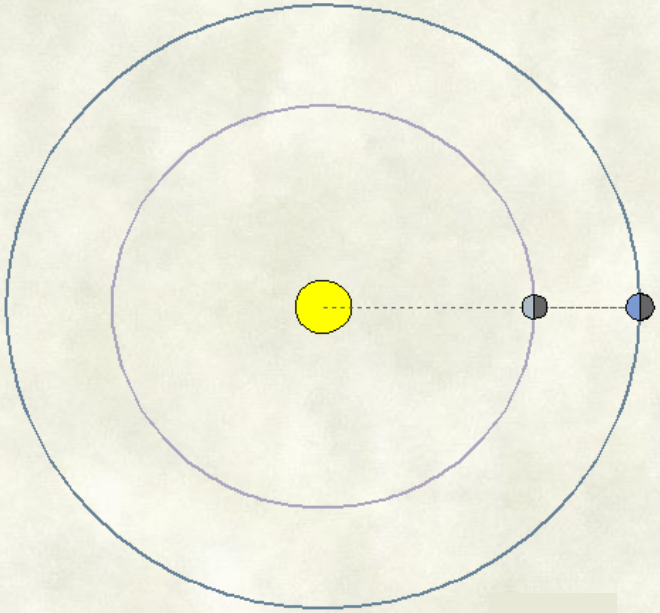


- When Venus is behind the Earth on its orbit.
  - Venus is visible after sunset in the western sky (***Evening star***)
- When Venus is ahead of the Earth on its orbit.
  - Venus is visible before sunrise in the eastern sky (***Morning star***)
- As Venus "overtakes" the Earth (at the inferior conjunction) it changes from the "Evening Star" to the "Morning Star"
  - This happens on March 25th for the current cycle

Venus is always in the vicinity of the Sun



Venus is always in the same side as the Sun



Angular separation between the Sun and Venus

animation: www.phy.olemiss.edu/~perera/animations/venus_l.gif

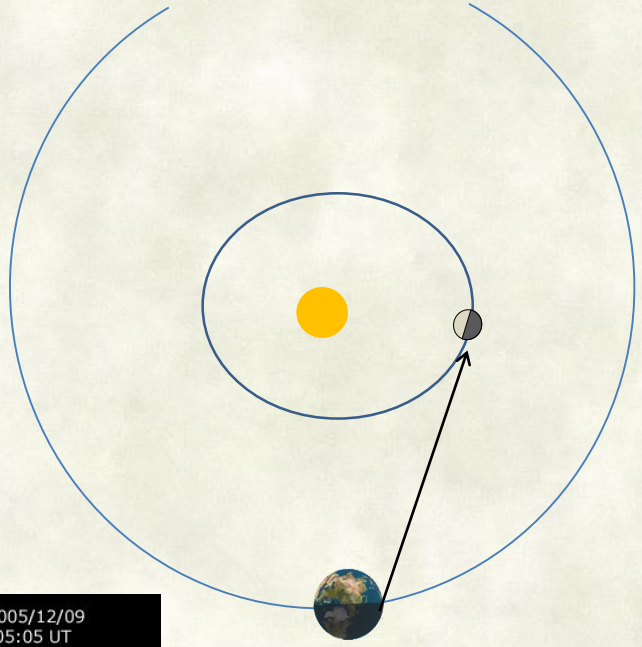
- Since Venus orbit is inside the Earth orbit, Venus is always in the same side as the Sun as seen from the Earth. Never in the opposite side to the sun.
  - Angular separation between Sun and Venus (**elongation**) has a maximum value of about 48**°**.
  - So Venus is always visible less than 48° from the Sun in the morning or evening sky.
  - Venus is never visible around the zenith or at midnight.

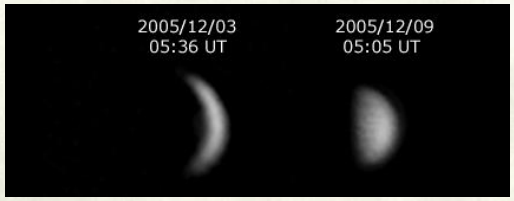
Mercury

distance to Sun: 46Mkm- 70Mkm
(0.3AU- 0.47AU)
orbital period: 88 days (0.24 y)

phase cycle : 116 days

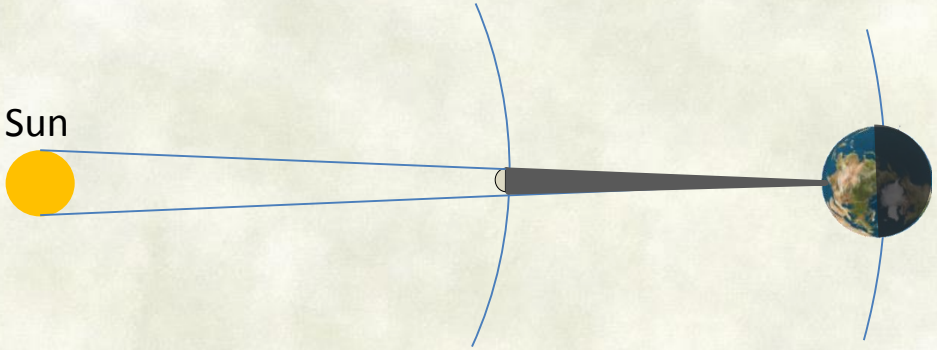
diameter : 4880km
albedo : 14%

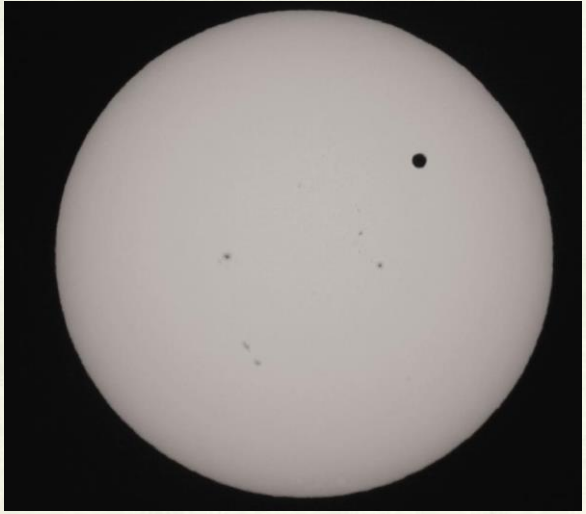




- Mercury shows similar behavior as Venus in the sky.
- But since it is closer to the Sun, its greatest elongation is 18° to 27° depending on the location on its very elliptic orbit
- It does not strays too far from the vicinity of the Sun.
- Mercury is visible only just after sunset or before sunrise, closer to horizon.
  - A challenging object to see.

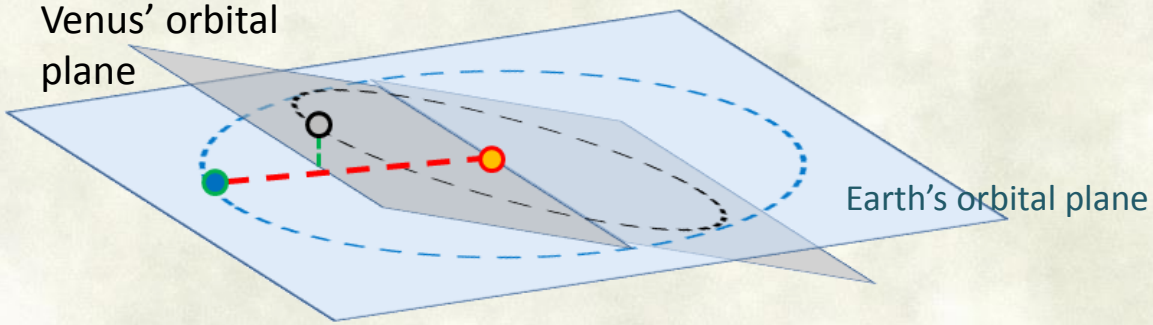
Transits of Mercury and Venus

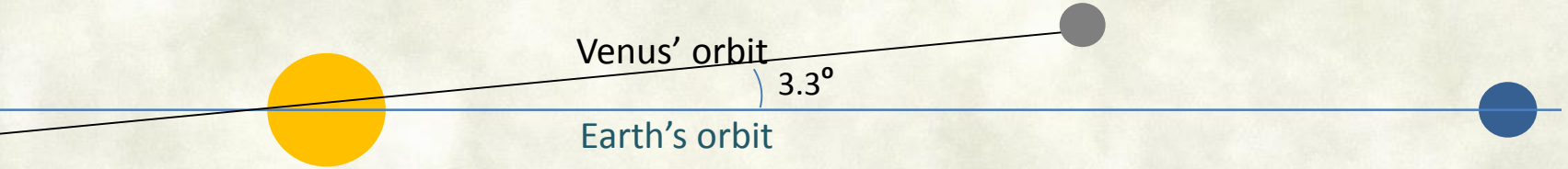




Transit of Venus, June 2012

- Mercury and Venus can come directly in between the Earth and the Sun at the inferior conjunction, eclipsing the Sun.
- Since orbital planes of Mercury and Venus are inclined to the Earth's orbital plane (Venus 3.3°, Mercury 7°), transits won't occur at every inferior conjunction.

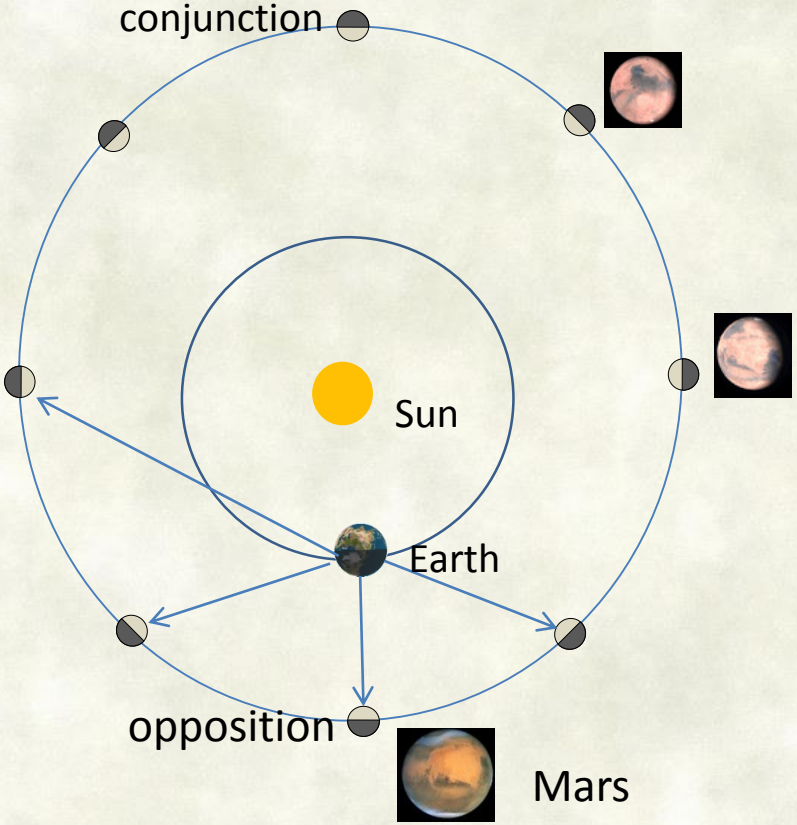


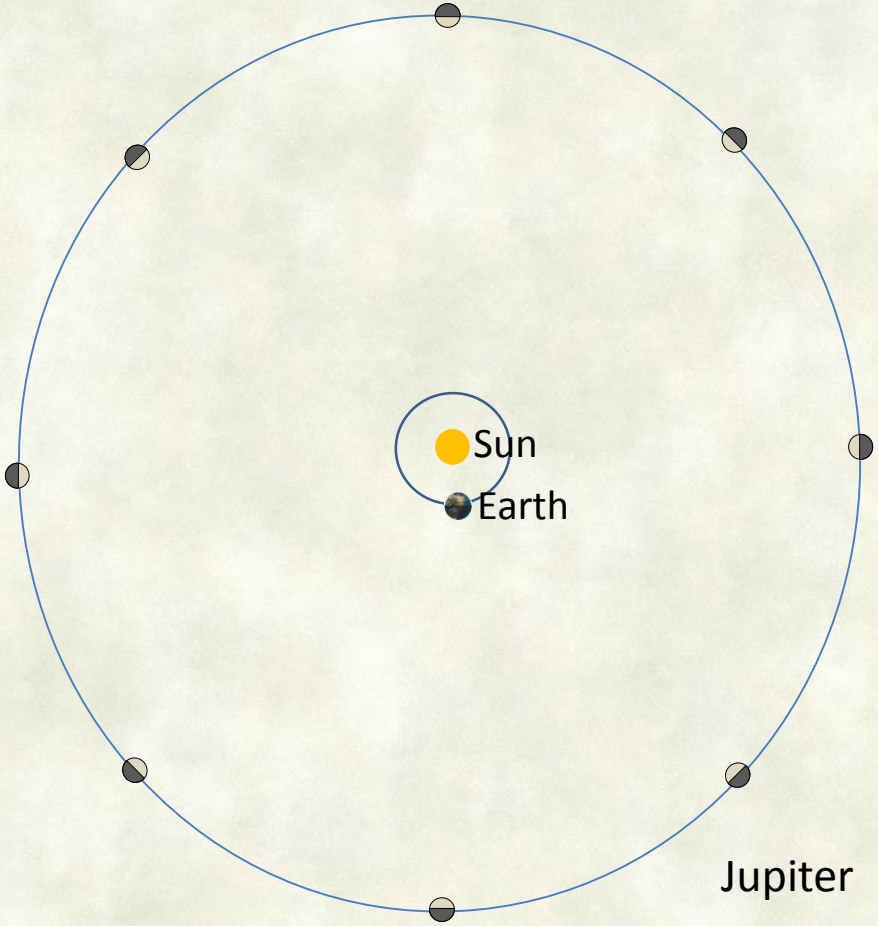


Transit of Venus, June 2012

- Angular sizes of planets are much smaller than the Sun
  - Sun: 32 arc minute Venus: 1.1 arc minute Mercury 0.2 arc minute
- So unlike during a lunar eclipse, there is no apparent change in Sun's brightness.
- Only visible through a telescope.
- Past and upcoming transits :
  - **Venus:** 1874 Dec 9, 1882 Dec 6, 2004 Jun 8, 2012 Jun 6, 2117 Dec 11, 2125 Dec 8
  - **Mercury:**2003 May 7, 2006 Nov 8, **2016 May 9, 2019 Nov 11**, 2032 Nov 13, 2039 Nov 07, 2049 May 07

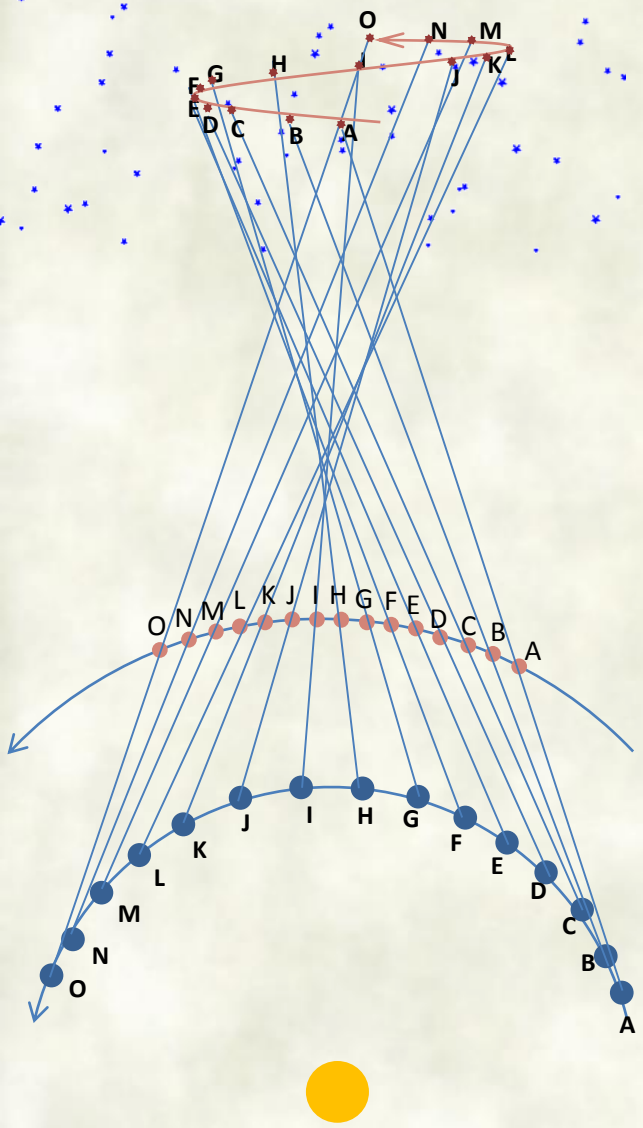
Superior Planets



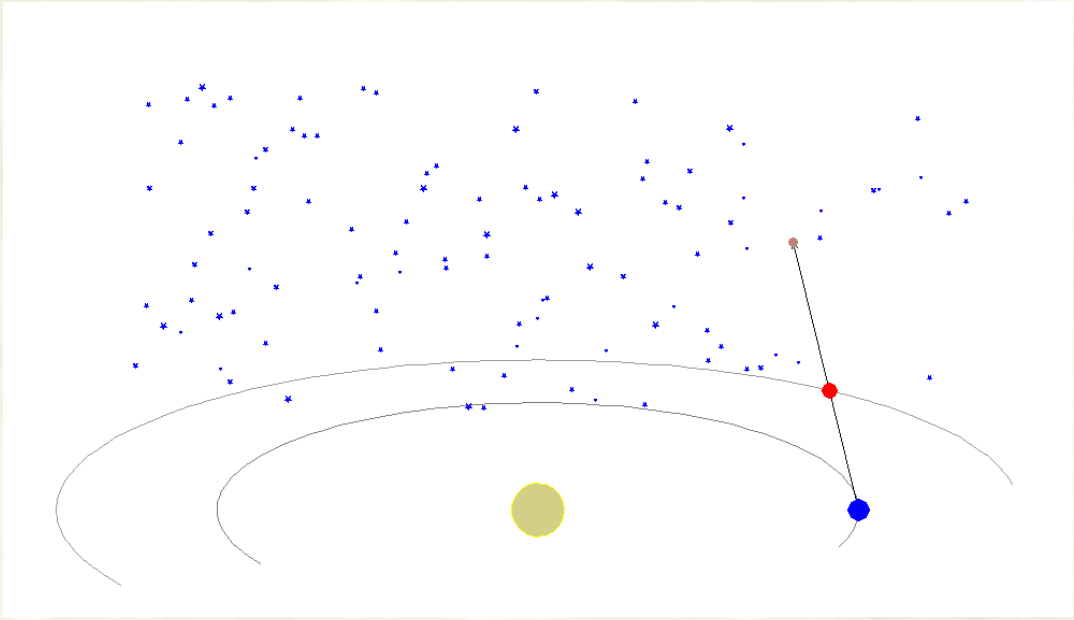


- Superior Planets can be visible at any altitude, any time in the night sky.
- They do not show a full cycle of phases:
  - Mars is the only superior planet ever shows a visible phase.
  - As the distance to a superior planet from the Sun increases, less and less of the unlit side becomes visible from Earth.

Retrograde motions



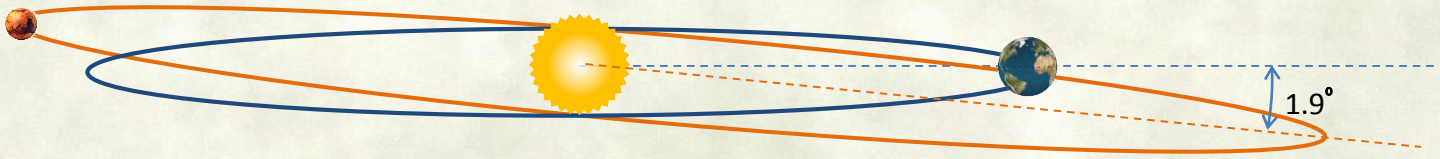
Consecutive positions of Earth and Mars on their Orbits



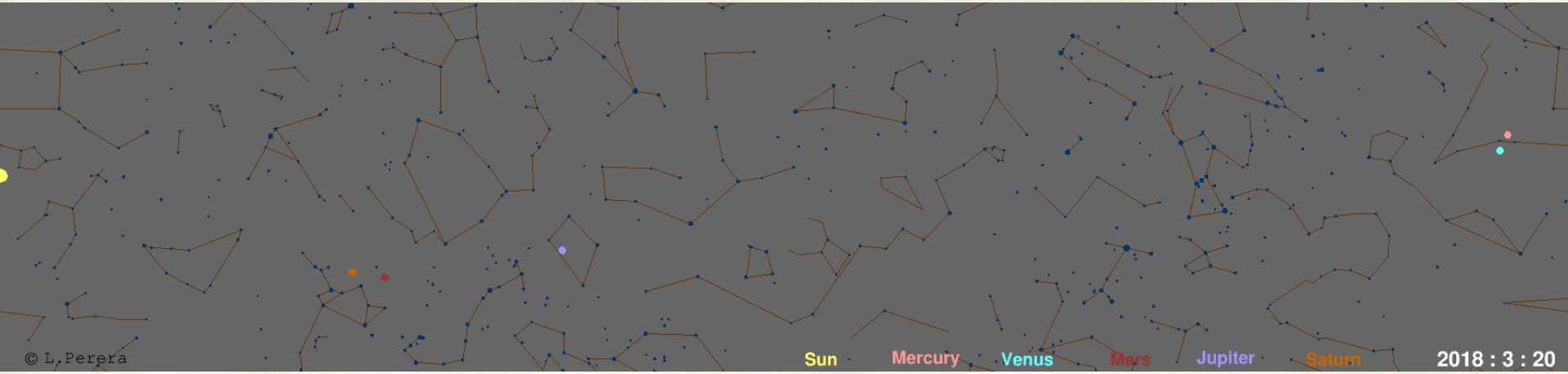
- Usually planets move from east to west with respect to stars.
- But sometimes relative motion between the Earth and a planet is such that, they appear to move west to east for a while.
- For example Mars completes one orbit in 687 days on a larger orbit (1.7 AU)
- Therefore its moves on its orbit at a slower rate than the Earth, and relative speed and direction between them changes.
- Sometimes Earth passes by the slower moving Mars resulting an apparent backward motion:

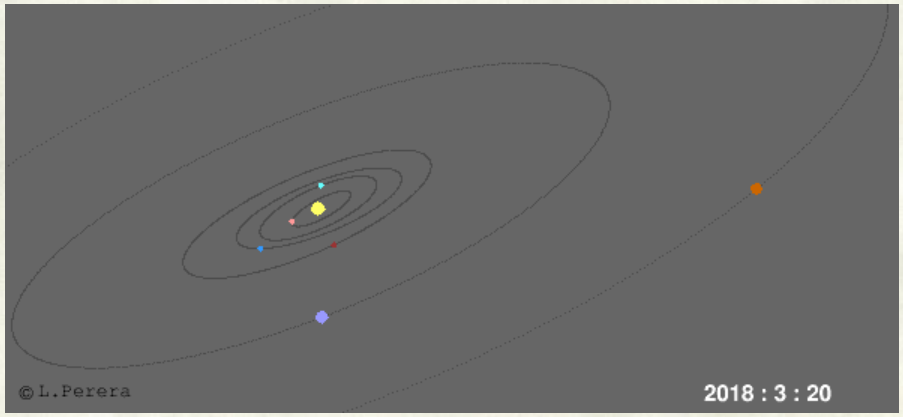
Retrograde motion - of Mars.

Path of Mars during retrograde motions



- The orbit of Mars is significantly elliptical, and its orbital plane is inclined with respect to the Earth's orbital plane (by 1.9°).
- Therefore during retrograde motion, depending on the relative positions of Mars and the Earth it can show complicated paths in the sky.
- Understanding the motion of Mars among stars was one of the most baffling problem faced by astronomers since antiquity.
- It was finally solved by Johannes Kepler in early 17th century, who discovered the elliptical nature of planetary orbits.





Paths of Planets 2018-2021

http://www.phy.olemiss.edu/~perera/animations/paths.html

Review Questions

- Which planets do show phases, and which of them show a full cycle of phases.
- Why isn't Venus ever visible overhead or around midnight?
- What is the Morning star and the Evening star?
- What makes the observing Mercury so difficult?
- What is the phase of Venus when it is brightest?
- Why isn't Venus brightest when it is in full (or near full) phase?
- What makes Venus the brightest planet visible from the Earth?
- Ancient astronomers could not properly explain why planets do retrograde motion. Why?
- What causes the retrograde motion of planets?
- Can the Moon ever be in retrograde motion?
- Which planets can transit the Sun?
- What time in the night Mars could be visible in the sky?
- Why isn't there a transit at every inferior conjunction of Venus or Mercury?