The Solar System
Contents

Sun
Jupiter
Saturn
Uranus
Neptune
Venus
Earth
Mars
Mercury
Kuiper belt
Asteroids
Oort Cloud
The Sun

• A G2V star
• Stable over geological time
• 4.6 billion years old
• 24,000 light years from the galactic center
• 99% of the mass of the Solar System
Jupiter

• The largest of the Sun’s planets
• 5.2 AU from the Sun; 12 year period
• $0.001 \, M_\odot$
• Most of the angular momentum
• Close to Solar composition
• Density = 1.32 gm/cm$^3$
What density tells us

Density is mass/volume

The mean density of an object indicates its bulk composition.

• Ices have densities near 1 gm/cm$^3$
• Rock has densities near 3 gm/cm$^3$
• Metals have densities near 5 gm/cm$^3$

Densities go up when matter is compressed, as in planetary cores.
Planetary Distances

Kepler’s laws:
• Planetary orbits are ellipses, with the Sun at one focus
• Equal areas are swept out in equal times
• $P^2 \sim d^3$

These are empirical laws, based on observations of planets.
Aside: Planetary distances

Newton’s laws:

- Inertia
- F=ma
- Equal and opposite reactions

These are physical laws, based upon observation, but with interpretation.

Gravity:

\[ F_G = \frac{GMm}{d^2} \]
Aside: Planetary distances

Using Newton’s laws, one can derive Kepler’s laws.

\[ F_G = \frac{GMm}{d^2} = ma \]

In a circular orbit, \( a = \frac{v^2}{d} \)

\[ P = \frac{2\pi d}{V} \quad \text{(time to go once around the orbit)} \]

Plugging in, and cancelling the \( m \):

\[ \frac{GM}{d^2} = \left( \frac{2\pi d}{P} \right)^2 / d = 4\pi^2 d / P^2 \]

\[ P^2 = \left( \frac{4\pi^2}{GM} \right) d^3 \]
Aside: Planetary distances

What is $4\pi^2/GM$?

It is 1 where the period is in years and the distance is in AU.

We can measure periods easily; distances are harder.

We know that Venus is 0.72 AU from the Sun, so it is 0.28 AU from Earth at inferior conjunction.

Solution: use parallax during a transit to get 0.28 AU in km.
Transits of Venus
Australia
The Astronomical Unit

The parallax of Venus as first measured in 1761 and 1769, in transits observed from Paris and Tahiti.

The AU is $1.5 \times 10^8$ km.

This sets the scale of the Solar system

There was a transit of Venus in 2004, the next is in 2012 (they come in pairs about every 120 years).
Don’t miss it!
The Astronomical Unit

How far is one AU?

93 million miles

At 60 mph, it would take you 1.55 million hours to drive this far. That’s 177 years.

Jupiter is 5.2 AU from the Sun (as close as 4.2 AU to Earth)

Pluto is 40 AU out

The Kuiper Belt extends out to about 100 AU.

The Oort cloud extends about 20,000 AU
An abode for life?
- mostly atmosphere
- H and He
- T = 124K
- High radiation environment

Probably not.

But there are 4 large moons
The Galilean Moons

Io, Europa, Ganymede, and Callisto

- Icy moons
- Tides generate internal heat
- Io is essentially molten
- Liquid water is possible in Europa and Ganymede

Habitable zones are not set solely by solar insolation
Saturn

M: 95 \( M_\oplus \)
D: 9.5 AU
P: 29 year
Composition: 20-30 \( M_\oplus \)
    core + H,He
Ring
Uranus

Discovered in 1781 by Wm Herschel
Axis inclined 98°
Neptune

Predicted using Newton’s Laws, based on deviations in Uranus’ orbit

Discovered in 1840s

Large moon:
Triton