

A Survey of the Planets

[Slides]

Mercury

Difficult to observe - never more than
28 degree angle from the Sun.

Mariner 10 flyby (1974)

Found cratered terrain.

Messenger Orbiter (Launch 2004; Orbit 2009)

Rotation is 59 days (discovered by MIT)

Thin sodium (Na) atmosphere - recent discovery

No Moons.

Venus

A near twin to Earth in size and mass

Dense CO₂ atmosphere

Surface pressure ~90 bars (earth atm = 1 bar)

Surface temperature ~750 K (0 K = -273 C)

Retrograde rotation, 243 days

(Prograde rotation is West -> East)

(Retrograde rotation is East -> West)

Surface volcanic features, vast resurfacing
of entire planet about 1 billion years ago.

No Moons.

Mariner, Pioneer, Venera:

Flybys, orbiters, landers (1960s, 1970s)

Magellan Mission 1989 - Radar mapping to
100m resolution (headed by MIT).

Earth

N₂, O₂, H₂O atmosphere

Surface area 71% H₂O

Prograde rotation 23hr 56min 04.1sec

=>Why do we use a 24 hour clock?

Weathered, tectonic, volcanic,
and cratered surface.

One satellite (large relative to its primary).

Moon

Cratered surface - formed by impacts

Mare - ("seas") formed by lava flows

Regolith - soil

Age: 4.5 Gy - same as rest of solar system

(Gy = 10⁹ years)

0 - 0.5 Gy - heavy bombardment

1.0 - 2.5 Gy - lava flows forming Mare

2.5-4.5 Gy - less frequent bombardment

Origin of the Moon?

Mars

Thin CO₂ atmosphere

Surface Pressure ~6 mbar (0.6% of Earth)

Surface Temperature: 190 to 240 K (-83 C to -33 C)

Rotation is 24.5 hours, prograde

Cratered surface, volcanoes, chasms

Evidence for water flow! (Where is it now?)

Polar caps - CO₂ and H₂O

Missions:

Mariner 9 (1971) - first orbiter

Viking 1+2 orbiters and landers (1976)

No evidence for life

Mars Meteorites (1996): Evidence for life? Not.

Mars Observer (lost in 1993).

Mars Pathfinder (1997).

Mars Global Surveyor (1997).

Mars Climate Orbiter (lost in 1999).

Mars Polar Lander (lost in 1999).

Mars Odyssey (2001)

Mars Express (Europe, 2003)

Mars Exploration Rovers – landing 2004.
(Spirit & Opportunity)

Mars Reconnaissance Orbiter (arrive 2006)

Two small satellites, Phobos and Deimos

Asteroids

First one (Ceres) discovered in 1801

Location (2.8 AU) fit Bode's Rule

There are >10,000 known asteroids

Most orbit between Mars and Jupiter,
region called the "asteroid belt"

Sizes range from boulders - 1000 km

A Disrupted planet? <----No

Probably left-over planetesimals from
formation of the solar system.

Missions:

Flybys "Targets of opportunity"

951 Gaspra [12-km] (Galileo 1991)

243 Ida [32-km] (Galileo 1993)

253 Mathilde [52-km] (NEAR 1997)

9969 Braille [2-km] (DS-1 1999)

Orbiters:

NEAR - launch 1996; arrival 2000.

433 Eros [30-km] near-Earth asteroid.

Dawn – to Vesta and Ceres (2007)

Sample Return:

Hyabusa (MUSES-C) Japan.

Destination: 25143 Itokawa

Launch 2003, Sample 2005, Return 2007

Jupiter

Largest of the Jovian gas giant planets.

A “star” that failed.

Dynamic atmosphere: H₂, He, CH₄, NH₃

Red Spot - long lived high pressure system
(not a hurricane as often described).

Rotation 9.8 hours

Has a faint ring - discovered by Voyager.

Lots of satellites (current count is 16 or more)

Galilean satellites (discovered 1610)

Ganymede (D=5280 km)

Largest moon in the solar system
(Larger than Mercury and Pluto!)

Icy surface (H₂O), some craters.

Callisto (D=4840 km, ~Mercury)

Heavily cratered rock + ice surface.

Europa (D=3130 km, smaller than Moon)

Grooved ice terrain, few craters.

What does this imply about surface?

Evidence for subsurface ocean??

Io (D=3460 km, same as Moon)

Most active volcanoes in the solar system. Induced by tidal stresses.

Pioneer 10, 11, Voyager 1, 2 flybys (1970s)

Galileo Orbiter / Probe (1995-2003).

Extensive Galilean satellite tour.

Saturn

Gas planet, H₂, He, CH₄, NH₃ atmosphere

Density < 1 gm / cm³

Complex Ring System

Lots of satellites (current count is 18 or more)

Titan (D=5120 km, second largest)

Has a substantial atmosphere!

Composition N₂, CH₄

Pressure ~1.6 bar

Iapetus (D=1440 km)

Half-light, half-dark hemispheres

How did this occur?

Hyperion (D=150 km)

Chaotic rotation - it “tumbles” along in its orbit. (Discovered by MIT)

Pioneer 11, Voyager 1,2 flybys (1970s, 1980s)

Cassini Orbiter Mission -

Launch 1997

Saturn orbit 2004. (Four year mission.)

Huygens Titan Probe

Extensive satellite tour.

Uranus

Discovered 1781 by Herschel

Gas planet, H₂, CH₄ atmosphere

[Obliquity - angle between rotation axis and the orbit plane.]

Obliquity of Uranus is 98 degrees -
the planet “lies on its side” in the orbit plane.

Ring system discovered 1977 by MIT.

(Current count is 11 rings or more.)

Lots of satellites (current count is 17 or more)

Miranda (D=235 km)

Very strange body - once disrupted
and then recombined?

Voyager 2 (flyby 1986)

Neptune

Existence first suspected based on
perturbations to Uranus’ orbit.

Discovered near predicted position (1846)

A triumph for celestial mechanics.

Gas planet, H₂, CH₄ atmosphere.

Ring “arcs” first suspected 1984.

Complete ring system confirmed
by Voyager 2 (1989). (Five rings known.)

Satellites -- current known total is 8

Two prior to Voyager (Nereid, Triton)

Voyager discovered six

Triton (D=2700 km)

In a retrograde orbit! (Captured?)

Thin N₂, CH₄ atmosphere

Bright icy (N₂, CH₄) surface

Geyser-like eruptions?

Voyager 2 flyby, 1989.

Neptune Orbiter Mission-

Concept studies underway.

Pluto

Existence suspected based on possible perturbations to Neptune's orbit.

Discovered by Tombaugh (1930)

Eccentric orbit - crosses that of Neptune

Closer to sun than Neptune 1979-1999

Orbital period is 248 years

Diameter (2300 km) too small and distance too far to see surface.

Mass too low to have perturbed Neptune

Is there a tenth planet?

Probable composition -- rock + ice (CH₄, H₂O)

Rotation 6.4 days

Large Satellite, Charon (1978, Christy)

D=1200 km (more than one-half Pluto!)

Synchronous orbit

Once-per-century series of eclipses

First detected 1985 by RPB

Solving for diameters, densities, and mapping Pluto's surface

Thin atmosphere - discovered by MIT (1988)

Composition CH₄, N₂, CO.

Multiple missions proposed/approved/cancelled

PLUTO NEW HORIZONS - launched 2006

Arrival: 14 July 2015

Comets

Small icy, rocky bodies (D<5 km) in highly eccentric orbits.

Made of H₂O, CH₄, NH₃ ice?

Probably remnant planetesimals stored in the outer regions of the solar system.

Called the "Oort cloud" at 10,000 AU.

Also the "Kuiper Belt" > 30 AU.

Occasionally perturbed into the inner solar system. Orbits altered by Jupiter.

Comet Shoemaker-Levy 9 (impact 1994).

Display bright heads, long tails due to evaporation of ice when near sun.

Example: Comet Halley. 76 year orbit.

Last Earth passage 1986. Next return 2062.

Recent Bright Comets:

Hyukatake (1996)

Hale-Bopp (1997)

Vega / Giotto flybys of Halley (1986)

CONTOUR - multiple flybys (launch failure 2002)

Stardust - sample return from comet tail.

Launch 1999; Wild 2 sample 2004; Return 2006

Deep Impact - Impact probe, test interiors.

Launch 2002; Impact comet Tempel 1 2005.

Comet Nucleus Sample Return - (2010-2020?)

{Hartmann Figure 2-34}