ASTR-1010: Astronomy I
Course Notes
Section IX

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Abstract

These class notes are designed for use of the instructor and students of the course ASTR-1010: Astronomy I taught by Dr. Donald G. Luttermoser at East Tennessee State University.

IX. The Terrestrial Planets

A. Mercury

1. Mercury is the closest planet to the Sun. As such, it always appears close to the Sun in the sky (seen just after sunset or just before sunrise).

a) When Mercury is at perihelion, the **greatest elongation** Mercury can have is 18°.

b) When Mercury is at aphelion, the **greatest elongation** Mercury can have is 28°.

2. Tides raised on Mercury from the Sun as caused it to *almost* have a synchronous rotation rate $\Longrightarrow P_{\rm rot} = \frac{2}{3} P_{\rm orbit}$.

3. **Mariner 10** has been the only spacecraft that has visited the planet (in 1974).

a) Discovered the surface is much like the Moon's. Heavily cratered but no maria (although the Caloris Basin is somewhat similar).

b) Numerous long cliffs discovered called **scarps**.

c) Numerous ridges and wrinkles found, however, these resulted from the planet's rapid cool down from formation and not from plate tectonics like on Earth.

d) The **Caloris Basin** is the largest impact feature on Mercury. It has a smooth floor with relatively few craters.

4. Mercury's interior structure is similar to Earth's, except the iron core is very large in comparison to its solid mantle.

5. Mercury has a magnetic field which suggests that its iron core has a liquid outer core and a solid inner core like the Earth's.

B. Venus

1. Venus is the second closest planet to the Sun (just inside the Earth's orbit), however, since it is farther out than Mercury its greatest elongation can reach as high as 47°.

2. Venus has 81% of Earth's mass and is at 95% of Earth's diameter $\Longrightarrow$ it is Earth's *twin*.

3. Venus' rotation rate is very slow (243 days) and it rotates backwards (*i.e.*, **retrograde rotation**).

4. Venus has 100% cloud coverage which gives it a high albedo (0.76) — the clouds are composed of sulfuric acid droplets.

5. Its CO_2 atmosphere has a surface pressure 100 times that of Earth and is at an average temperature of 480° C = 900° F = 750 K.

a) In early 1970's, the Soviets landed two spacecraft on Venus (*e.g.*, the **Venera spacecrafts**) which measured the atmospheric surface conditions.

b) Dr. Carl Sagan was the first person to predict Venus' high surface temperatures and pressures and the reason for them.

c) Venus has experienced a **runaway greenhouse effect** which accounts for the high temperatures.

i) Due to its proximity to the Sun, either water didn't condense out of its initial atmosphere or the initial ocean that formed quickly evaporated away.

ii) The additional H_2O in the atmosphere added to the effect CO_2 had in the tremendous increase in the surface temperature $\Longrightarrow$ H_2O is also a greenhouse gas.

d) Life was unable to get started due to the lack of liquid water $\Longrightarrow$ no lifeforms to produce O_2.

e) As such, no O_2 means no O_3 $\Longrightarrow$ solar UV light able to photodissociate H_2O into free H, which quickly escaped out due to its high gas velocity (remember $v_{\rm esc}$ vs. $v_{\rm gas}$).

f) The free O combined with the sulfur (S) produced by the early volcanism $\Longrightarrow$ SO_2 clouds!

6. Today Venus has a dry, dense atmosphere.

7. Venus has volcanism but no obvious plate tectonics.

a) The volcanos are **shield volcanos**.

b) It has two large continent-sized highlands:

i) **Istar Terra** in the northern hemisphere. **Maxwell Mons** located here and is the highest mountain on Venus.

ii) **Aphrodite Terra** in the southern hemisphere and contains many volcanos.

c) The **Magellan** spacecraft has mapped the entire surface of Venus in the 1990s from orbit with high-resolution radar imaging.

C. Mars

1. Mars is the fourth planet from the Sun. It has 11% of Earth's mass and is at 53% of Earth's diameter. Mars has 2 small moons, **Phobos** and **Deimos**, which are probably captured asteroids.

2. Because of Mars' small size, it never obtains a very large angular size as observed from Earth.

a) Because of this, some early observers claimed to see surface features that really didn't exist.

b) In 1877, an Italian astronomer, Schiaparelli, claimed to seen several straight dark features on Mars' surface $\Longrightarrow$ **canali**, which was later was mistranslated to *canals* in English.

c) In the late 1800's, a rich amateur astronomer, Percival Lowell, built a telescope in Flagstaff, Arizona to study the *Martian canals*. Lowell claimed to see a large number of these canals and claimed that they were artificial waterways constructed by intelligent Martians.

d) However, professional astronomers, like Barnard, never saw such features and these canals were never accepted by the scientific community. However, the media reported Lowell's observations as being real (and never reporting Bernard's observations), which lead the public to believe

that Mars' supported an intelligent civilization.

3. **Mariner 9** went into orbit around Mars in 1971 and took high resolution images of Mars' surface. It found a dry, cratered surface $\Longrightarrow$ Lowell's canals were finally put to rest.

a) Mariner 9 found that Mars possesses the largest volcanic mountain in the solar system, **Olympus Mons**.

b) It found that Mars' polar ice caps result primarily from frozen CO_2 — frozen water is only a minor component of the ice caps.

c) It also discovered the biggest canyon in the solar system, **Valles Marineris**, which is over 3000 km long and parallels the equator of the planet.

4. In 1976, NASA sent 2 probes to Mars called **Viking 1** and **Viking 2**. Each contained an orbiter and a soft lander.

a) The landers measured surface atmospheric conditions and searched for microbial life in the soil.

i) At first the experiments suggested that life might be present in the soil.

ii) However, further analysis showed that the reactions that were being observed resulted from hydrogen peroxide in the soil interacting with the nutrients in the experiment $\Longrightarrow$ **no life was found on Mars**.

b) The orbiters saw evidence that long in the past (billions of years), liquid water once flowed on its surface $\Longrightarrow$ dried up river beds.

5. In 1997, the **Mars Pathfinder** mission landed on Mars. Besides the lander, a rover by the name of **Sojourner** was part of the mission. This mission made detailed measurements of Mars' atmosphere and the chemical composition of the soil and rocks in the area of the landing site.