

# Today's Topics

Friday, October 2, 2020 (Week 6, lecture 19) – Chapters 9 & 10.

A. The Moon

B. Mercury

C. Venus

D. Mars

# The Moon



[NASA]

*This image shows the far side of the moon, illuminated by the sun, as it crosses between the DSCOVR spacecraft's Earth Polychromatic Imaging Camera (EPIC) camera and telescope, and the Earth - one million miles away.*

# The Moon

Earth side



Gravity:

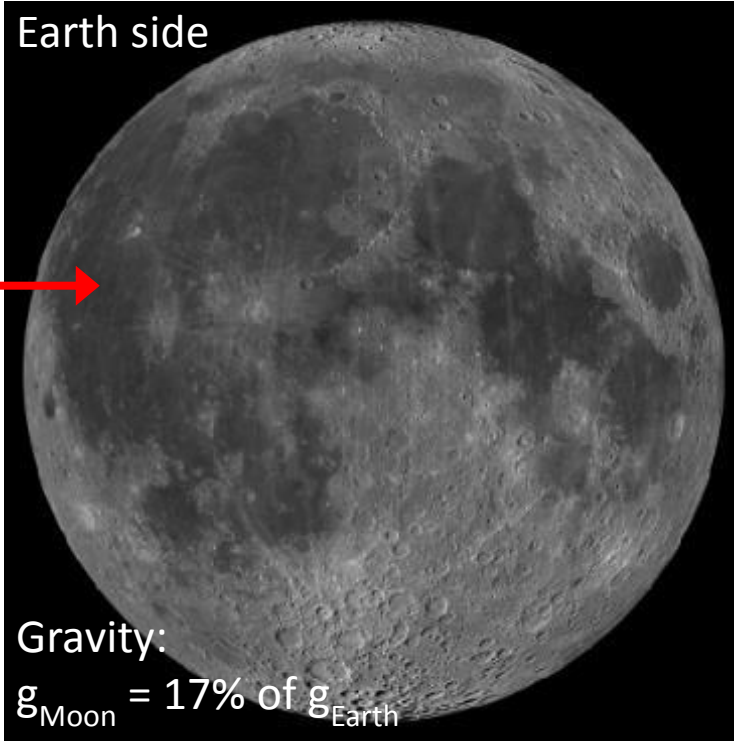
$$g_{\text{Moon}} = 17\% \text{ of } g_{\text{Earth}}$$

Far side



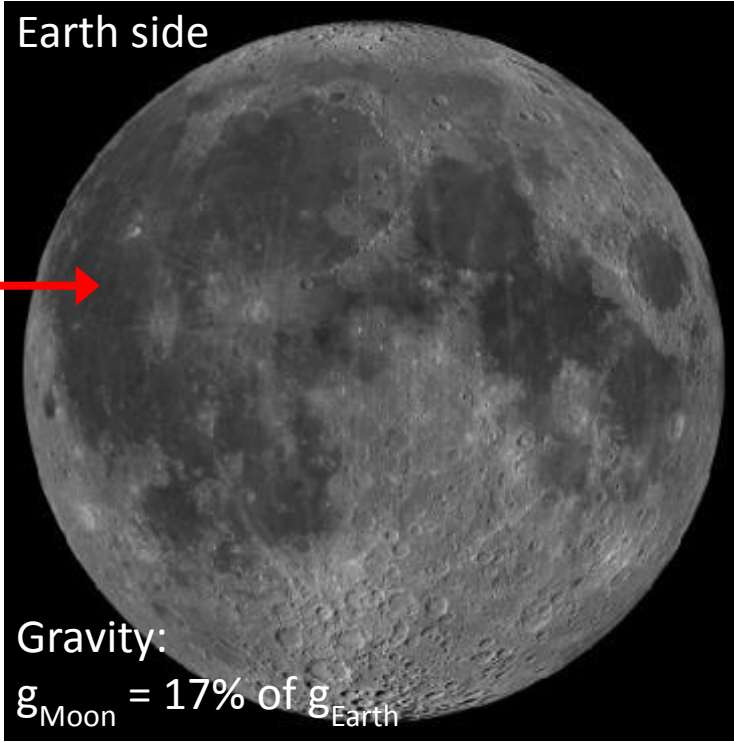
[OpenStax; NASA]

# The Moon



- Mass = 1.2% of Earth's, radius = 27% of Earth's, relatively circular orbit ( $\epsilon=0.05$ ).
- Geologically inactive (very old craters) with small iron core.
- Same side always faces Earth: **tidal locking**.
- Age of Moon rocks (Apollo): 3.3 - 4.4 billions years old.
- Rocks are mostly **silicates**.
- Average density of Moon: 3.3 g/cm<sup>3</sup>
- Water ice in craters is probably due to comets, meteorites.

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*very similar to  
Earth's mantle*

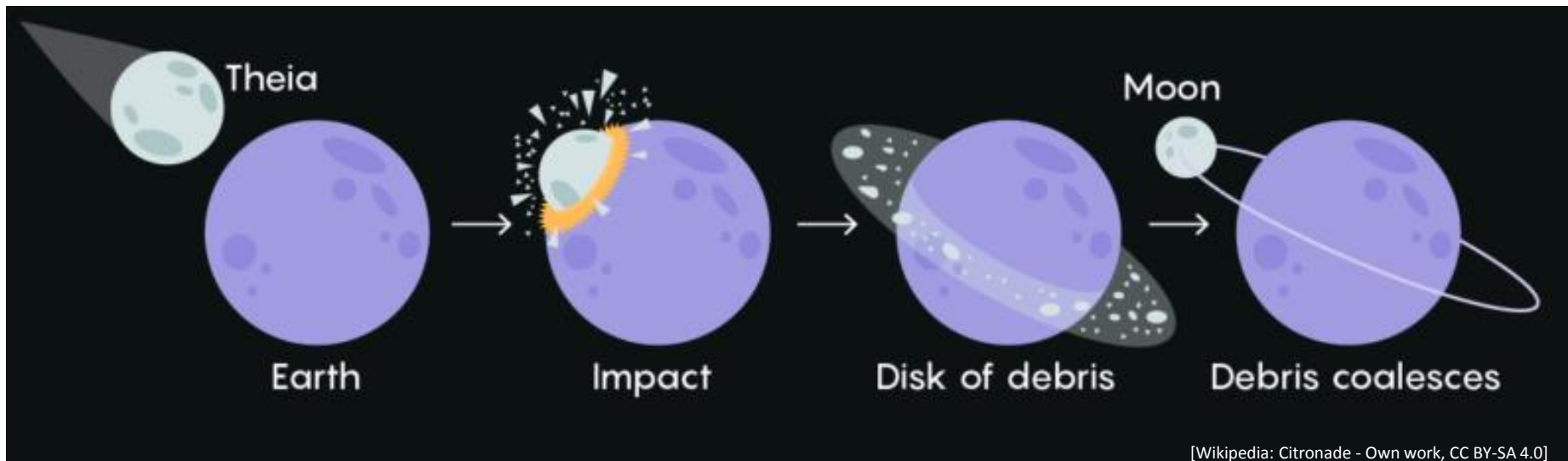
# Giant Impact Hypothesis

- Earth cannot do an orbital capture of an external moon  
→ *prevented by 2-body physics.*
- Similarities between Moon and Earth's mantle suggest a common origin.



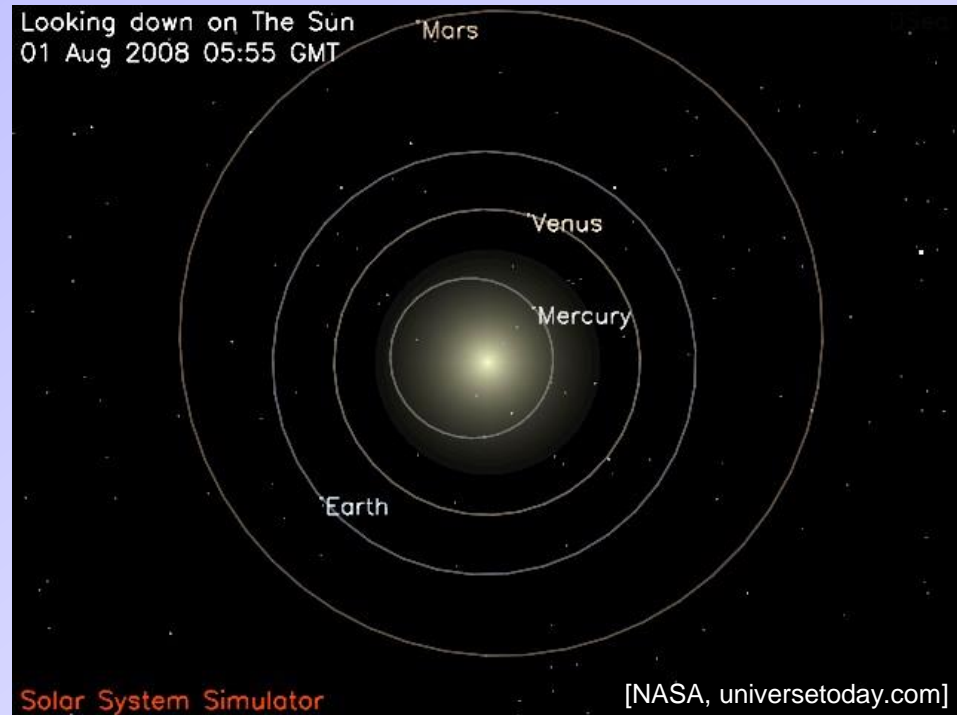
# Giant Impact Hypothesis

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- Giant impact hypothesis
  1. External Mars-sized proto-planet (Theia) smashed into Earth about 4.5 billion years ago.
  2. Debris disk from impact forms around Earth (*some debris escapes the Earth forever*).
  3. Debris disk coalesces into Moon.



# Mercury

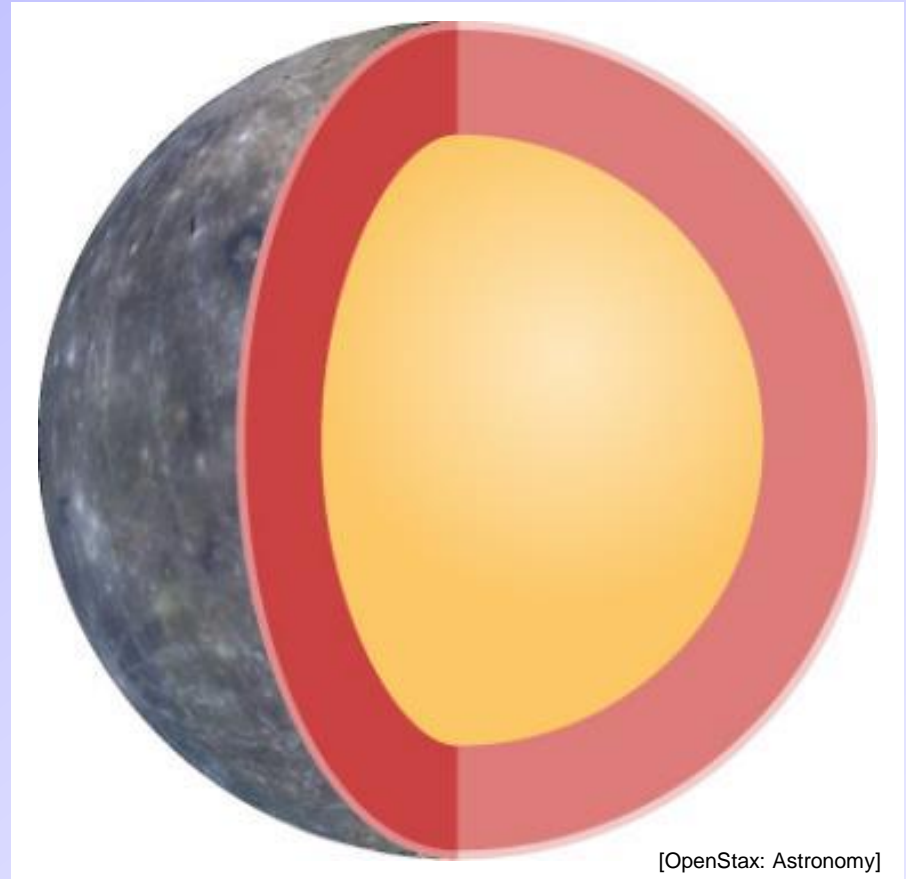
- Inner most planet, closest to Sun.  
→ 88 day orbit.
- Comparable density to Earth's.  
→  $5.4 \text{ g/cm}^3$ .
- Smallest planet.  
→  $R_{\text{mercury}} = 38\%$  of Earth's.  
→  $g_{\text{Mercury}} = 38\%$  of Earth's.
- Most eccentric orbit:  $\varepsilon = 0.206$
- Vast surface temperature variations:  
→ Max: 700 K ( $\sim 420^\circ \text{ C}$ ).  
→ Min: 100 K ( $-170^\circ \text{ C}$ ).  
→ At poles: 180 K (water ice in crater shadows).





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**Mercury's Internal Structure.** The interior is dominated by a metallic core about the same size as our Moon.

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*Mercury is grey !*



*No atmosphere !*

[NASA: MESSENGER probe]

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## Mercury's strange rotation

- Mercury rotates 3 times (with respect to stars) for every 2 orbits around the Sun.
- Example of **tidal locking** (called a “3:2 spin-orbit resonance”).
- Mercury's experiences “**tides**” (deformation from Sun's gravity gradient).  
→ to be measured by BepiColombo probe (ESA & JAXA).

*Mercury is grey !*

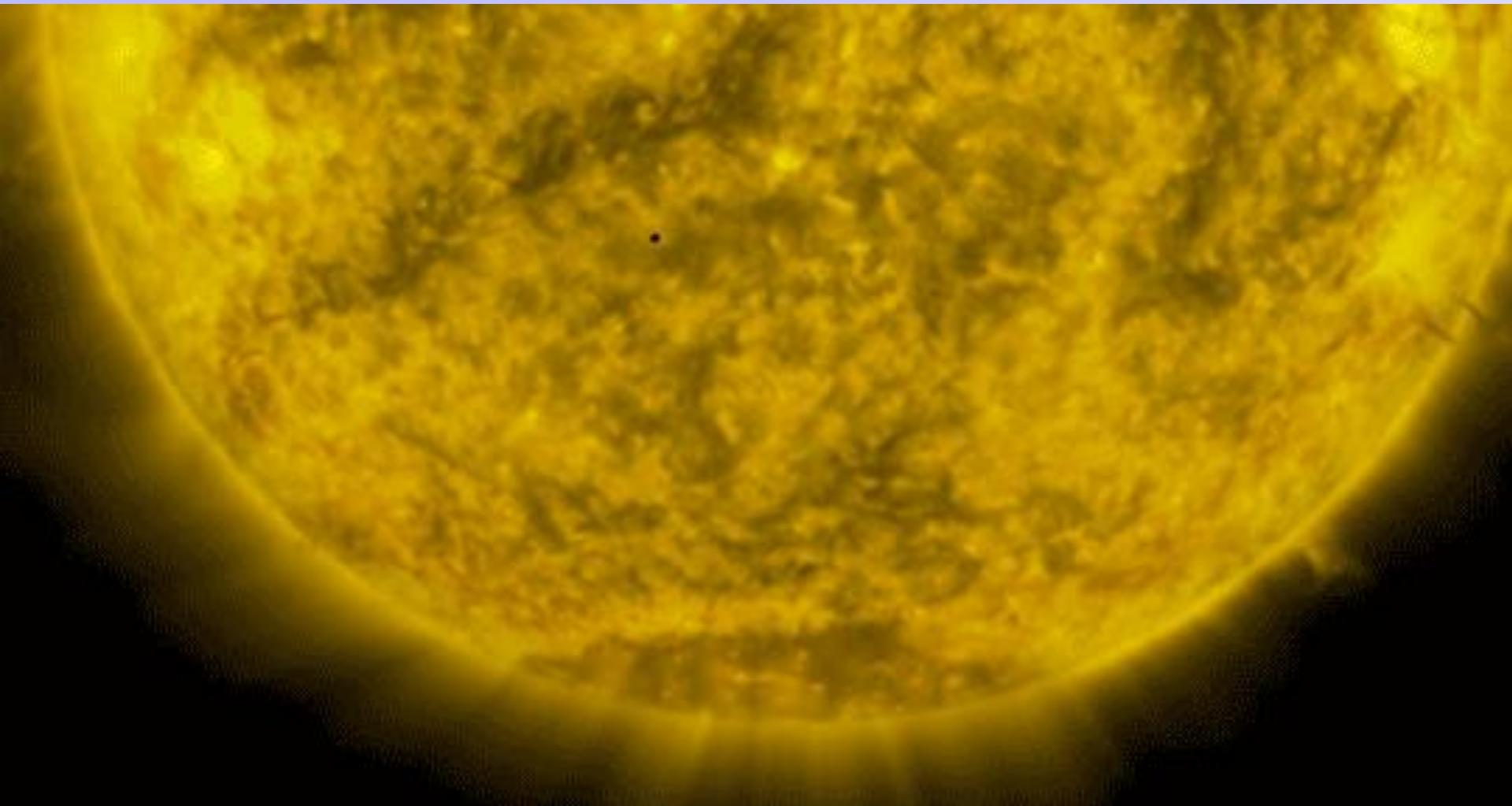


*No atmosphere !*

[NASA: MESSENGER probe]



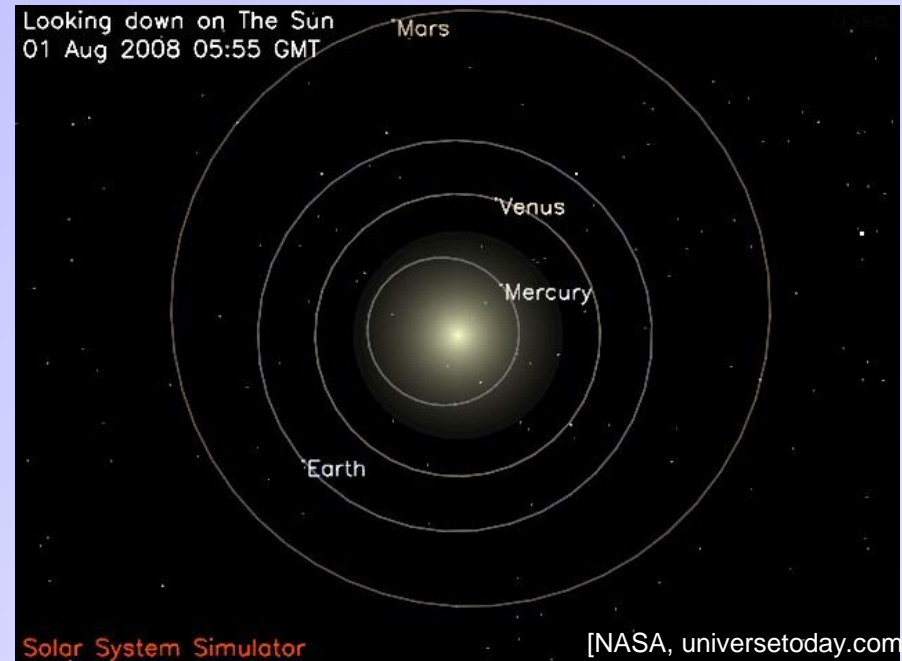
# Transit of Mercury



[NASA: Solar Dynamics Observatory, May 9, 2016]

# Venus

- Second planet from Sun.
- 224 day orbit, low eccentricity  $\varepsilon = 0.007$
- **Earth-like features:**
  - $R_{\text{Venus}} = 95\%$  of Earth's.
  - $M_{\text{Venus}} = 82\%$  of Earth's.
  - $g_{\text{Mercury}} = 90\%$  of Earth's.
  - Density:  $5.24 \text{ g/cm}^3$ .

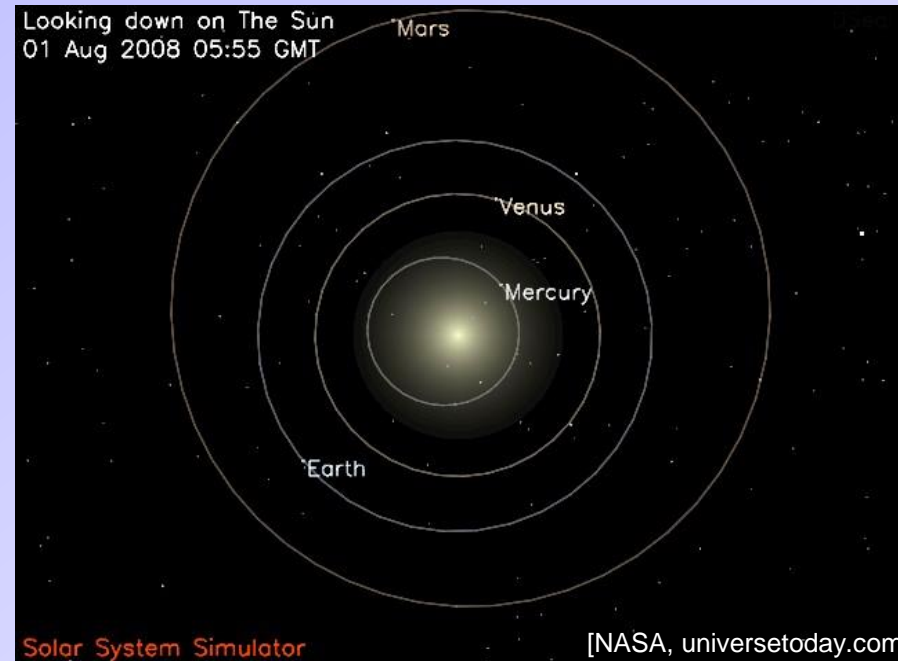


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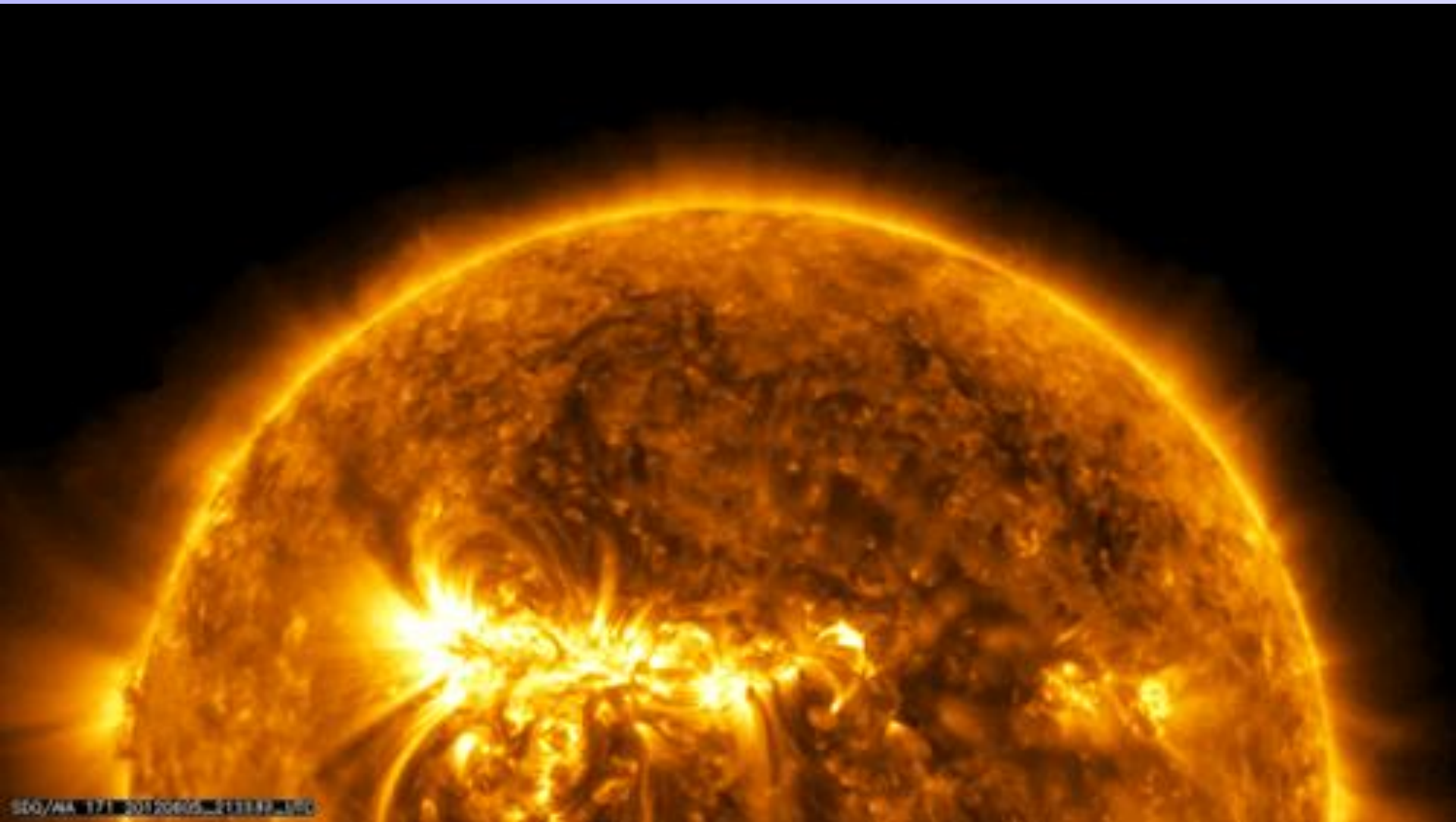
## Very non-Earth features

- Planet **rotates backwards** (opposite Earth's).
- Planet **rotates very slowly**: 1 Venus rotation = -243 Earth days.
- **Very hot** → Surface temperature:  $T = 730 \text{ K} = 460^\circ \text{ C}$  (*hotter than Mercury*).
- High pressure **atmosphere: 90 times Earth's**.
  - mostly  $\text{CO}_2$  with a little  $\text{N}_2$ , and **no water**.
- Very weak magnetic field.





# Transit of Venus

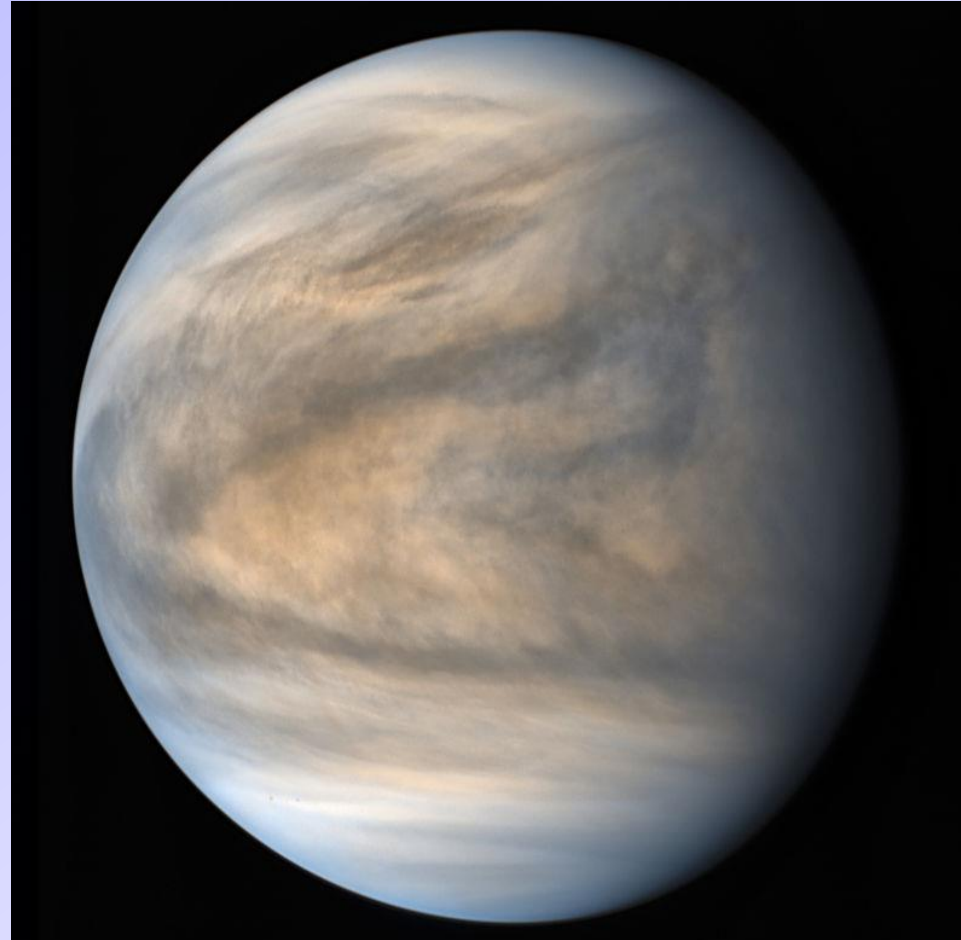


[NASA: Solar Dynamics Observatory, June 5, 2012]

# Venus



*Visible light image (by Mariner 10, 1974).*



[Source: JAXA, ISAS, DARTS, Damia Bouic]

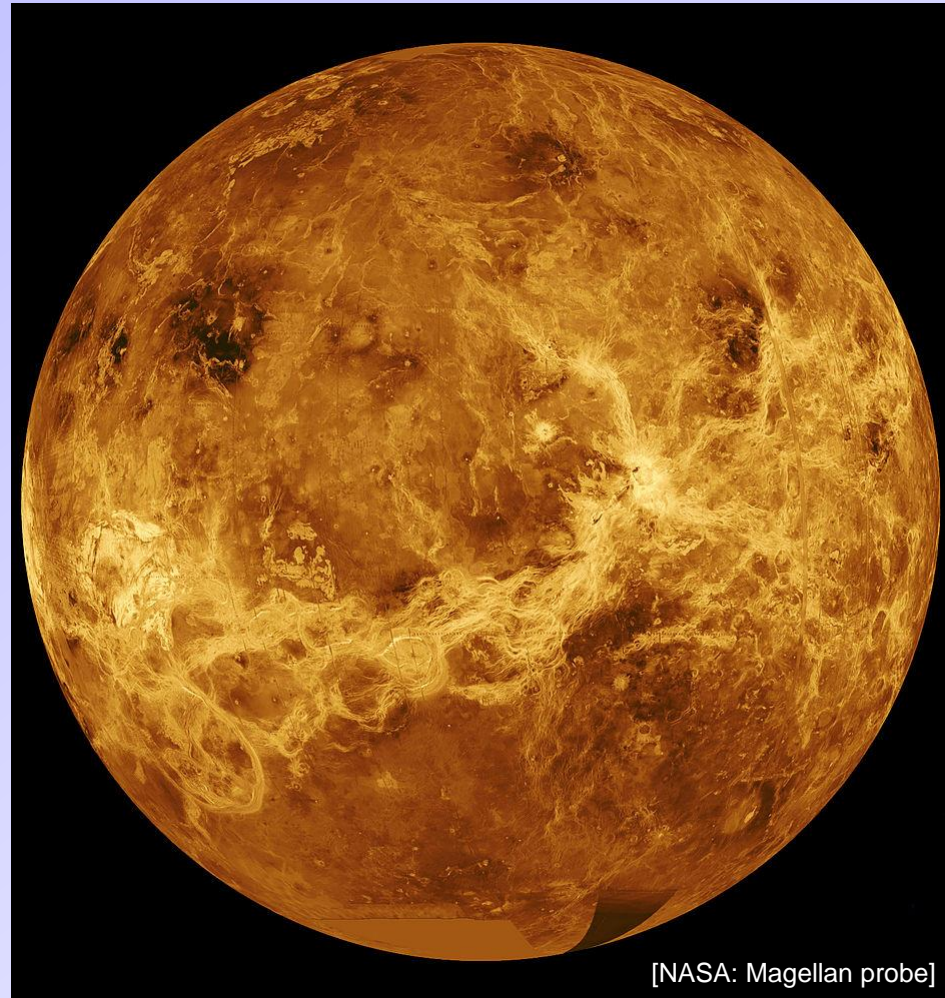
*False color UV image (by Akatsuki probe, 2016).*

The surface is completely obscured by **sulfuric acid clouds !!!**

# Venus with Radar Imaging

## Radar Imaging/mapping

Radar images are collected by directing microwaves at 2.4 GHz onto surface (through clouds) and imaging the scattered return waves.



[NASA: Magellan probe]

Radar image map of Venus  
(by Magellan probe, 1990-1994)



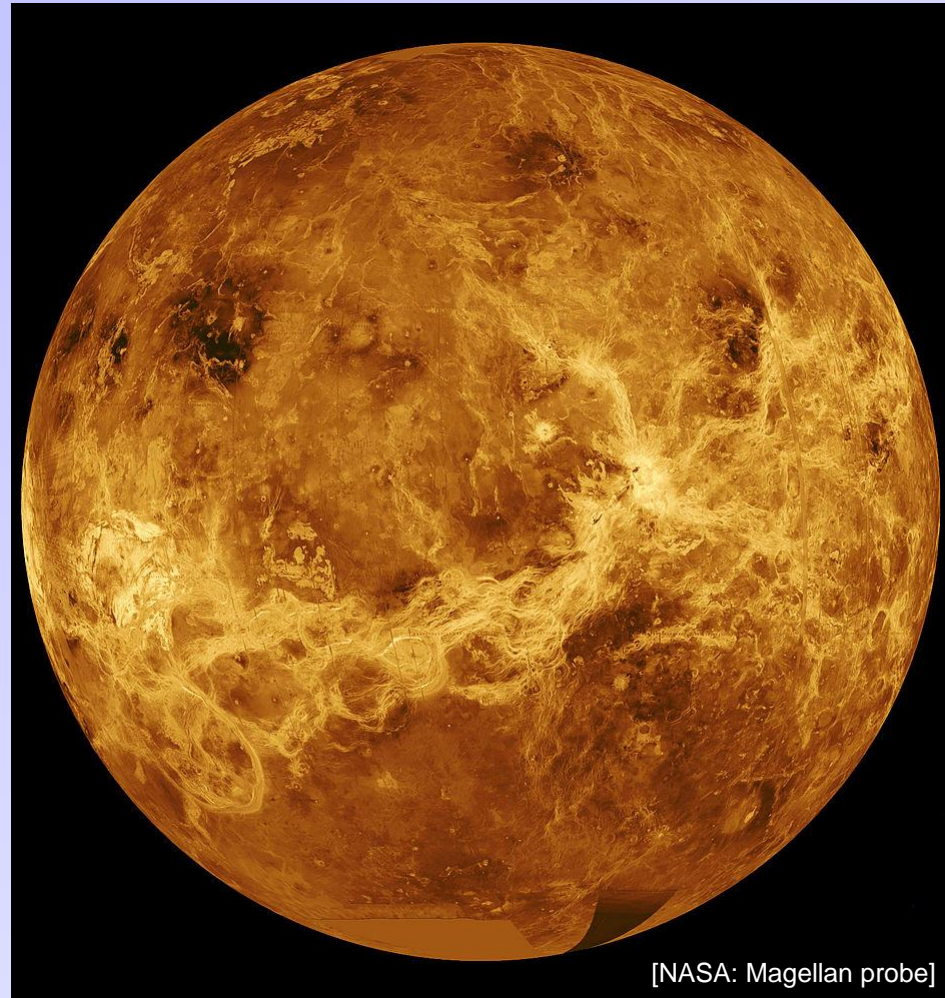
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## Many features from mapping:

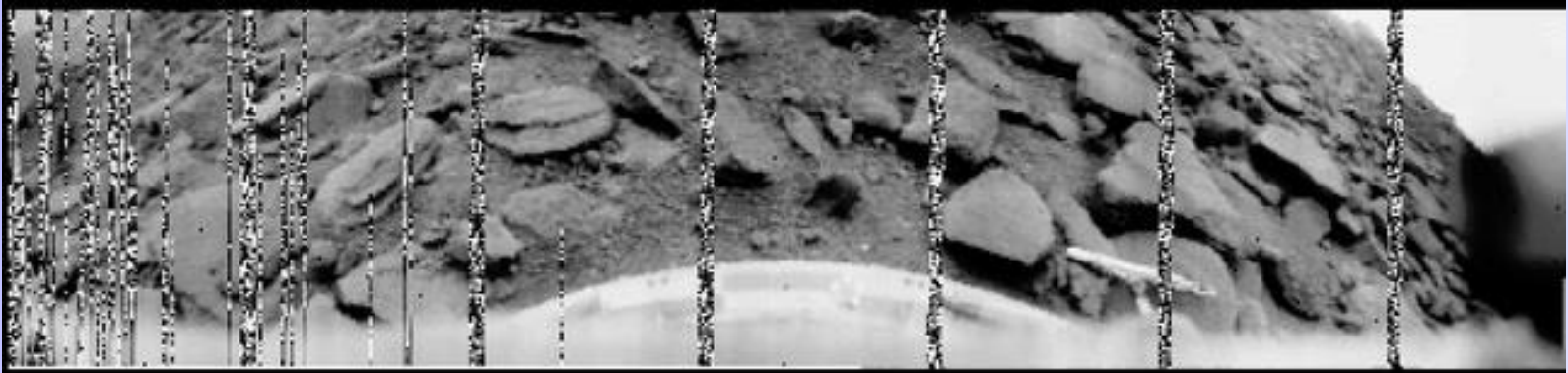
- volcanoes (dormant).
- large solid lava plains (70% of planet).
- Mountains.
- Highlands that form two “continents”.
- Craters.
- But **no** tectonic plates.
  - not much geologic activity.



Radar image map of Venus  
(by Magellan probe, 1990-1994)

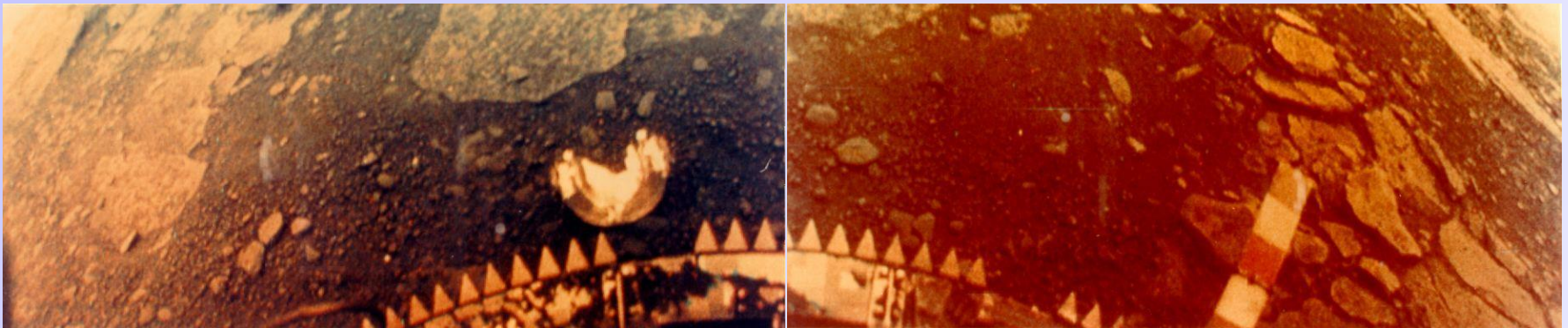
# Venusian Surface

Venera 9 probe (1975)



[Wikipedia: By Government of the USSR / Venera 9 mission, copyright presumably held by the Russian space agency - [www.mentallandscape.com](http://www.mentallandscape.com), website owned by Don Mitchell]

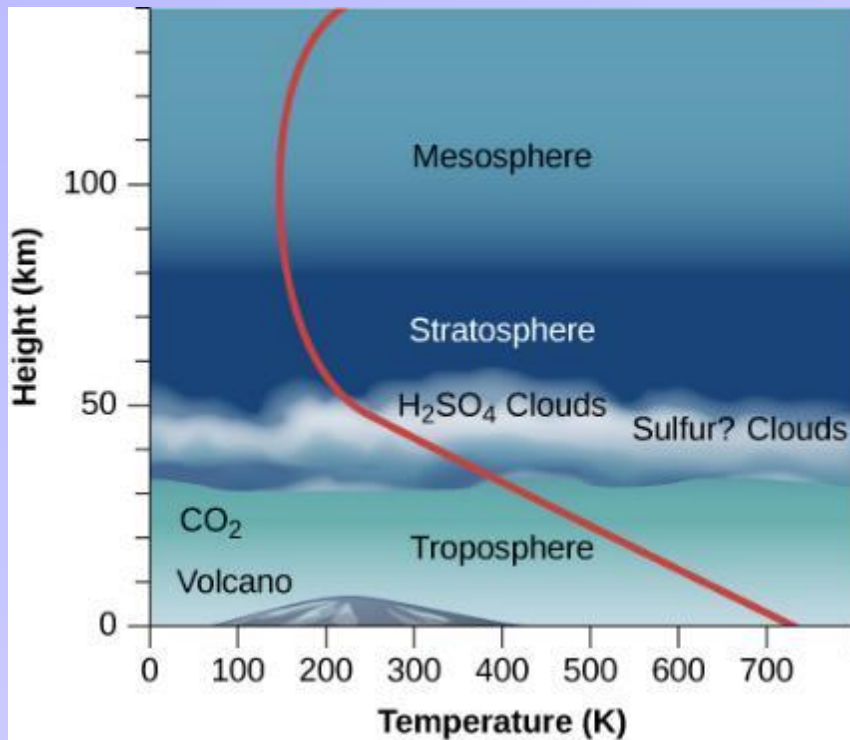
Venera 13 probe (1982)



[Source: [https://nssdc.gsfc.nasa.gov/photo\\_gallery/photogallery-venus.html](https://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-venus.html)]

# Venus's Atmosphere

## *Runaway Greenhouse Effect*



Carbon dioxide (CO<sub>2</sub>): 96.5 %.  
Nitrogen (N<sub>2</sub>): 3.5 %.

- Once sunlight enters the atmosphere it is repeatedly scattered (e.g. clouds) and converted to heat at the surface.
- The surface re-radiates this energy in the infrared, which is easily retained by the CO<sub>2</sub> atmosphere.

Note: a significant fraction of the Sun's light is reflected by the clouds (90%) .

**High Wind:** The surface is relatively calm, but the clouds circulate at 300 km/h !



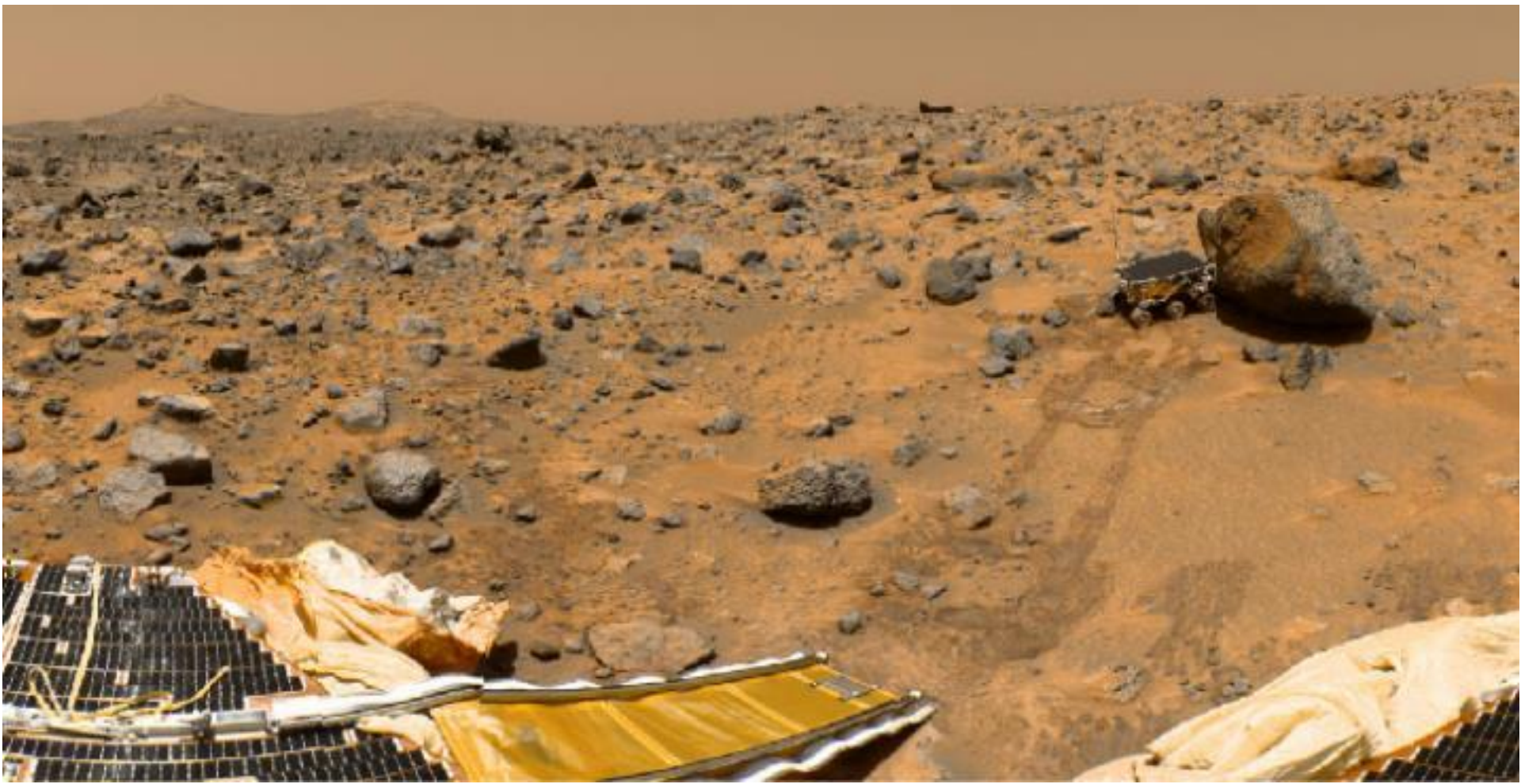
# Venus: Stratospheric Colony ?



[NASA - <http://sacd.larc.nasa.gov/branches/space-mission-analysis-branch-smab/smab-projects/havoc/>]

At an altitude of 55 km, the temperature is 20-30° C (if you can handle the wind !)

# Mars



[NASA:Pathfinder mission + sojourner]