

Astronomy 405

Solar System and ISM

Lecture 5

Mercury

January 25, 2013

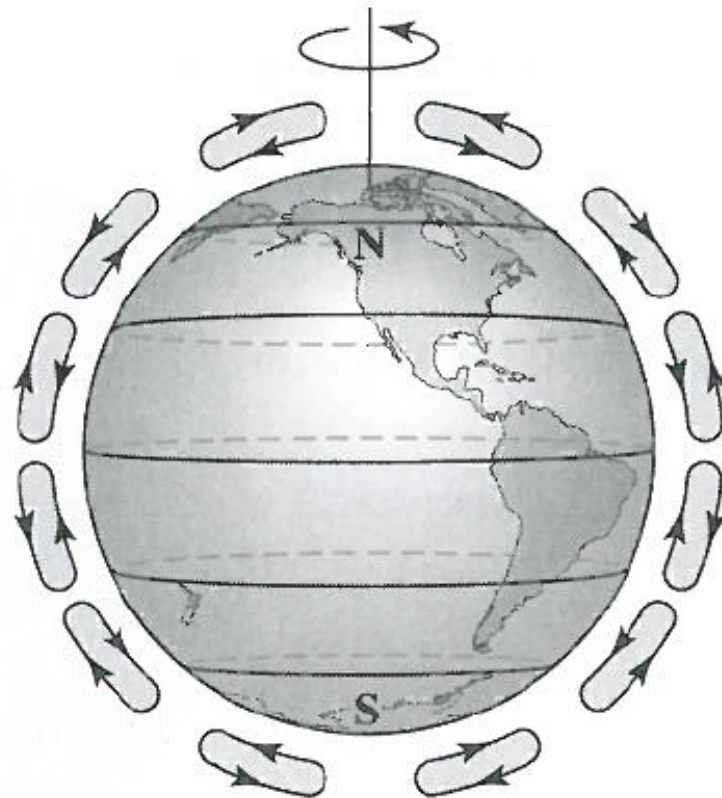
Photodissociation

Gravitational separation

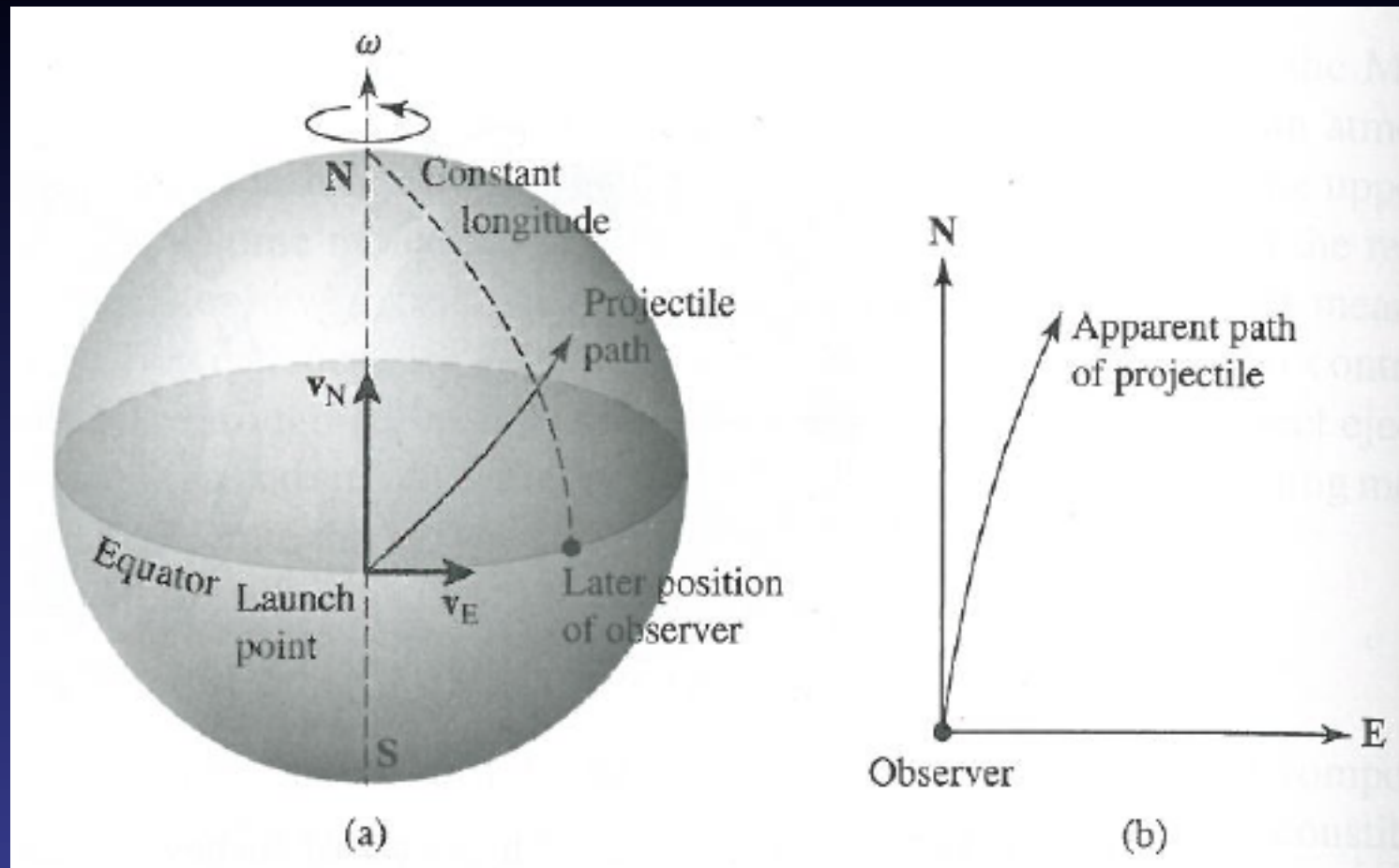
Hadley circulation



(a)



(b)

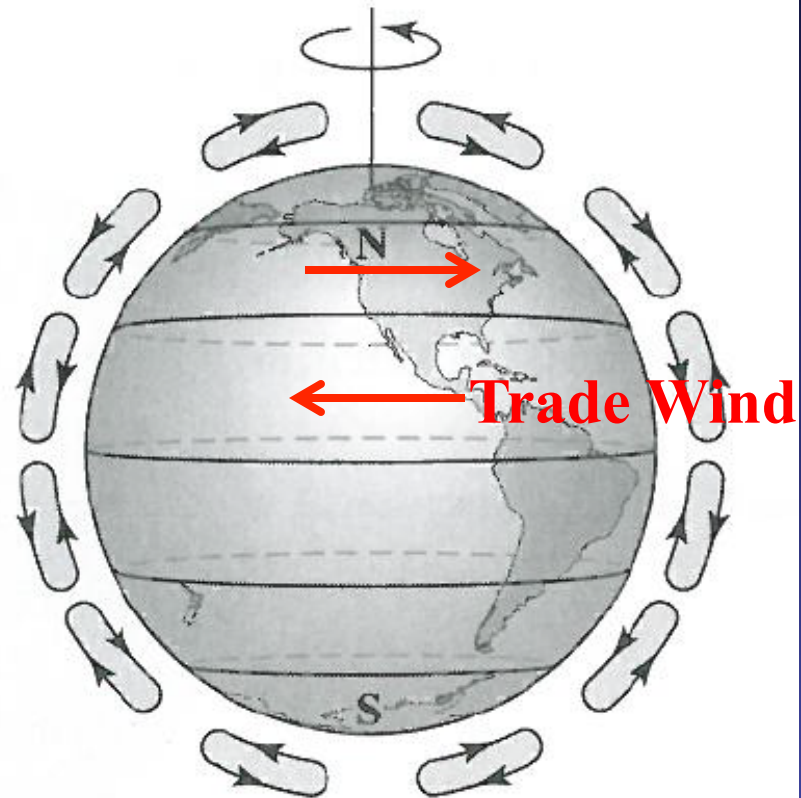


“Coriolis force”

Photodissociation
Gravitational separation
Hadley circulation



(a)



(b)

Mercury - The Smallest Planet



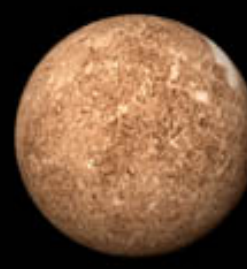
Ganymede

5262 km



Titan

5150 km



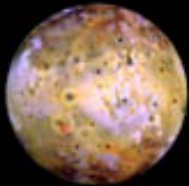
Mercury

4880 km



Callisto

4806 km



Io

3642 km



Moon

3476 km



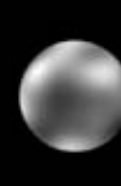
Europa

3138 km



Triton

2706 km



Pluto

2300 km

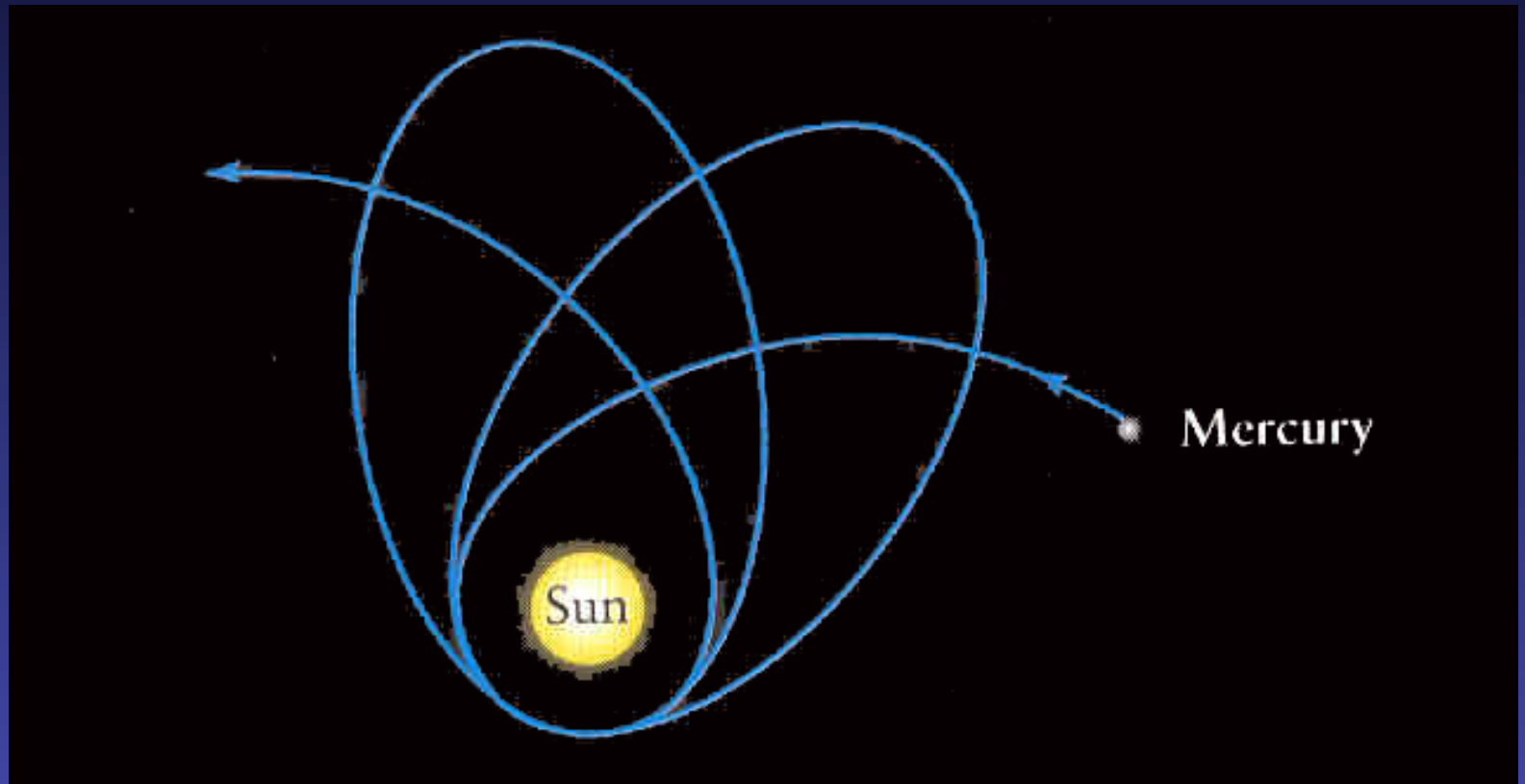


Titania

1580 km

Mercury's Orbit

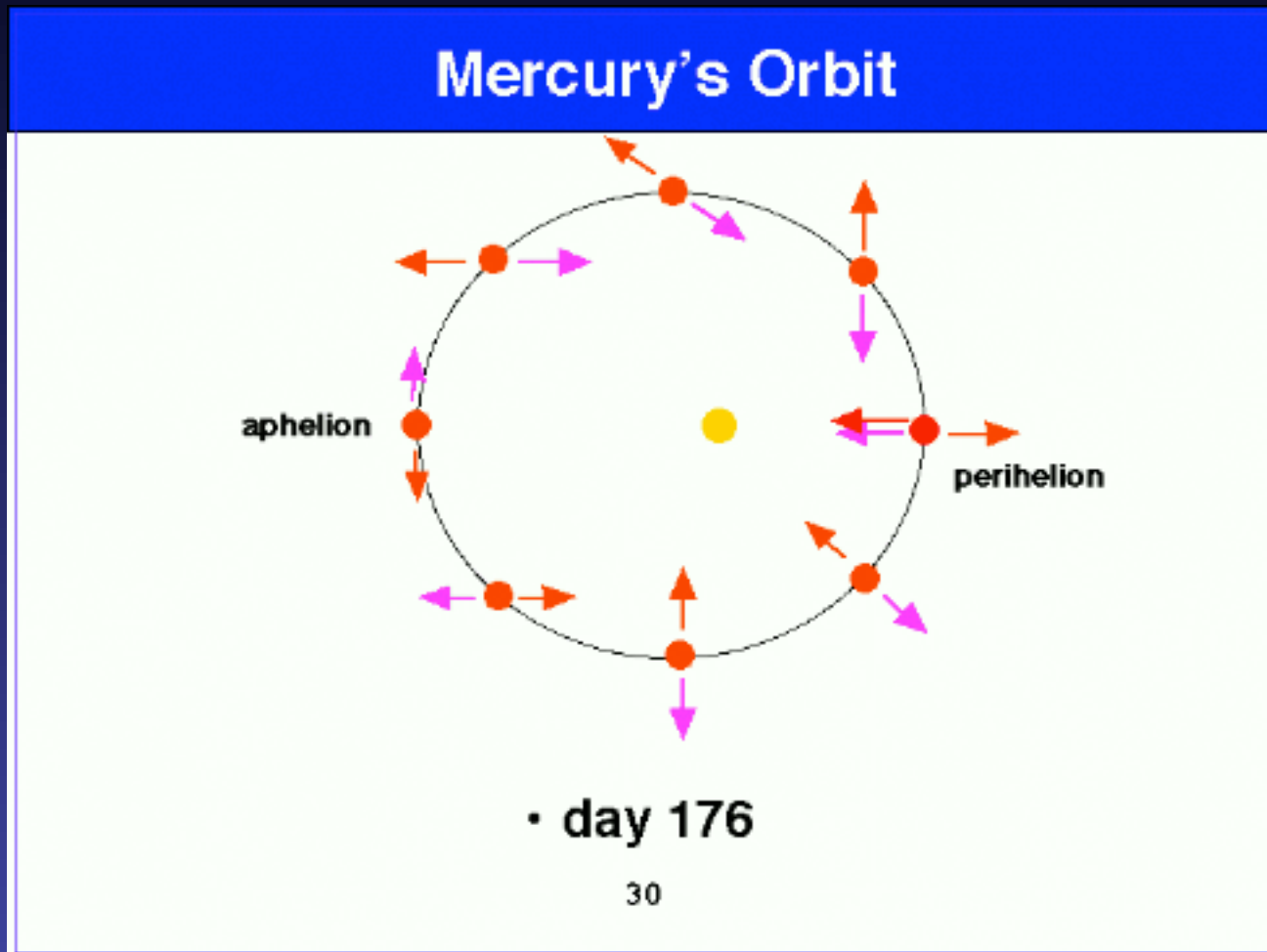
- eccentric orbit ($e = 0.2056$)
- orbit precesses by $574''$ per 100 yr
- needs general theory of relativity



3-to-2 Spin-Orbit Coupling of Mercury

rotational period = 58.64 days; orbital period = 87.95 days

Mercury's bulge always faces the Sun at perihelion



NASA's Messenger Mission to Mercury

http://www.nasa.gov/mission_pages/messenger/main/index.html

August 3, 2004 -- MESSENGER Launch

August 2005 -- Earth flyby

October 2006 -- Venus flyby

June 2007 -- Venus flyby

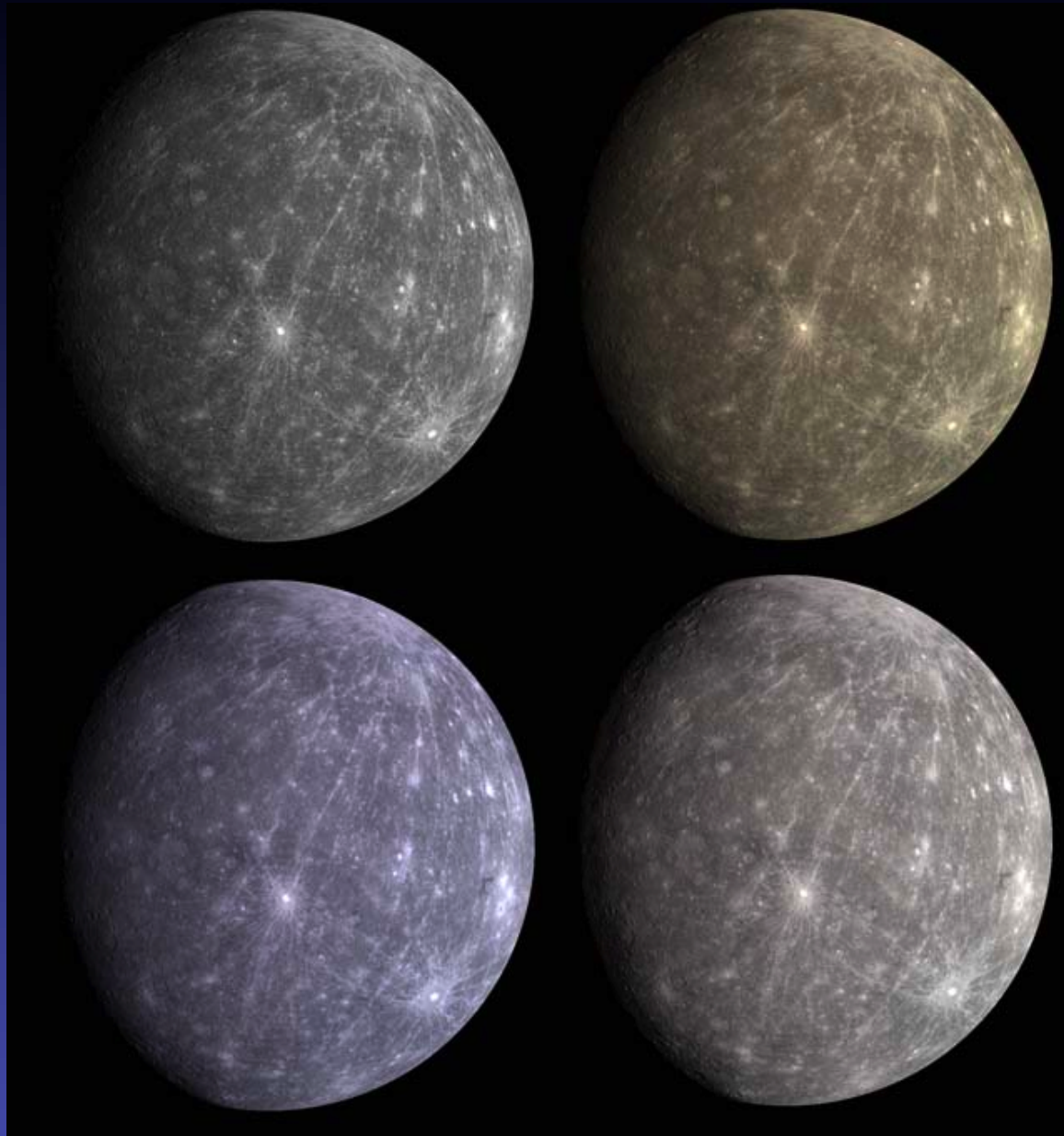
January 2008 -- Mercury flyby

October 2008 -- Mercury flyby

September 2009 -- Mercury flyby

March 2011 -- Yearlong science orbit of Mercury begins

True Color of Mercury?!

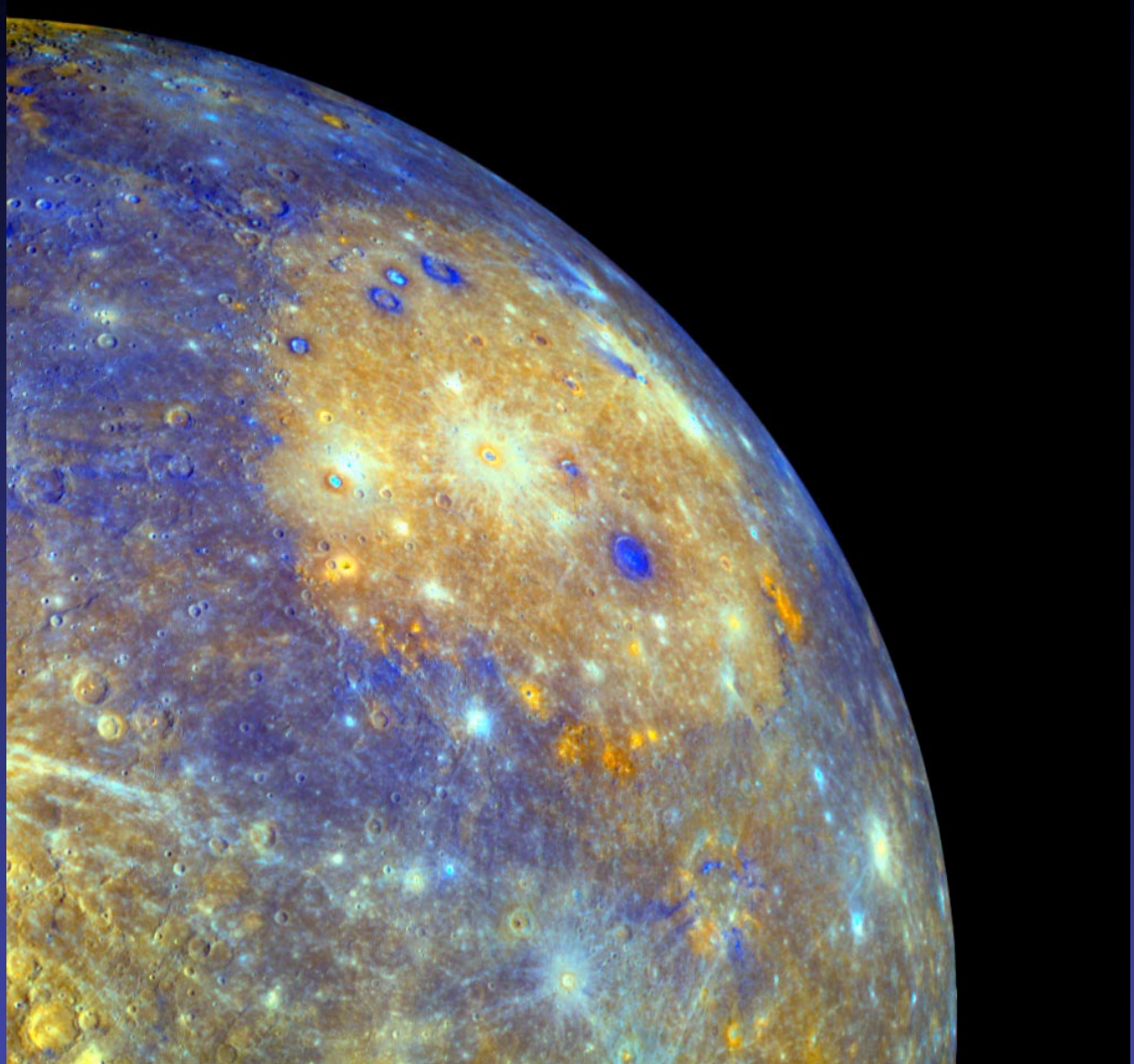


Surface of Mercury

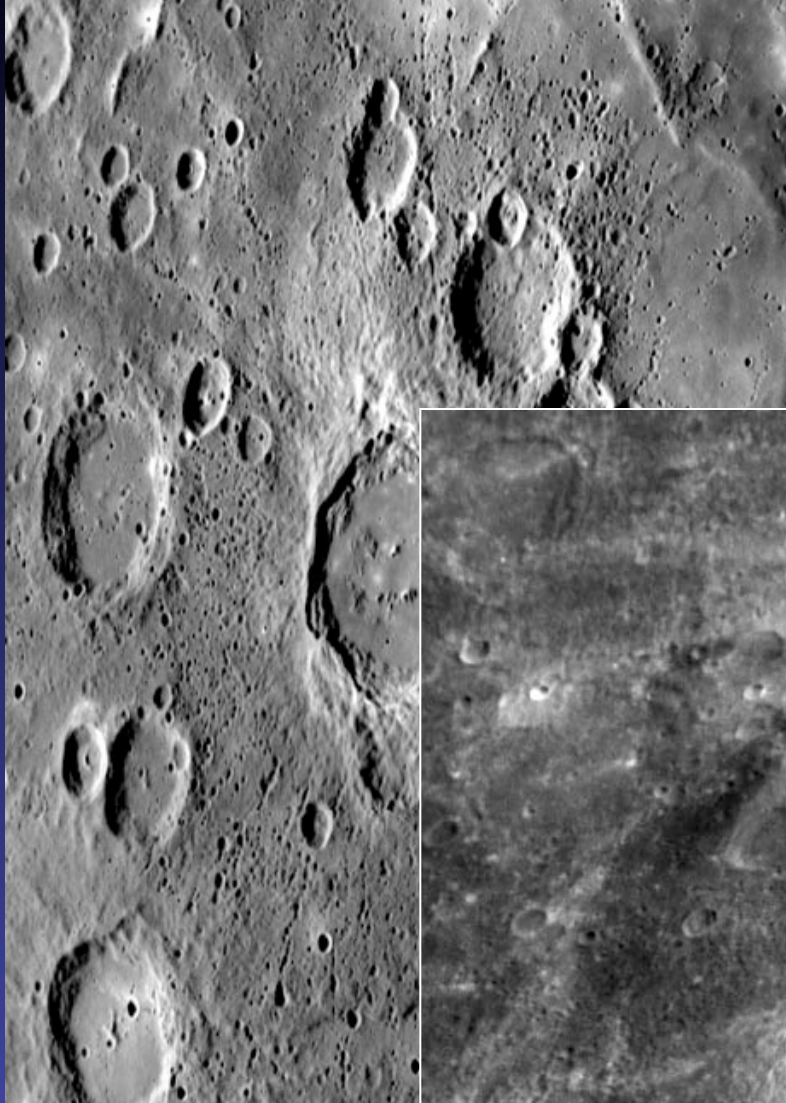
Caloris Basin

Largest impact crater

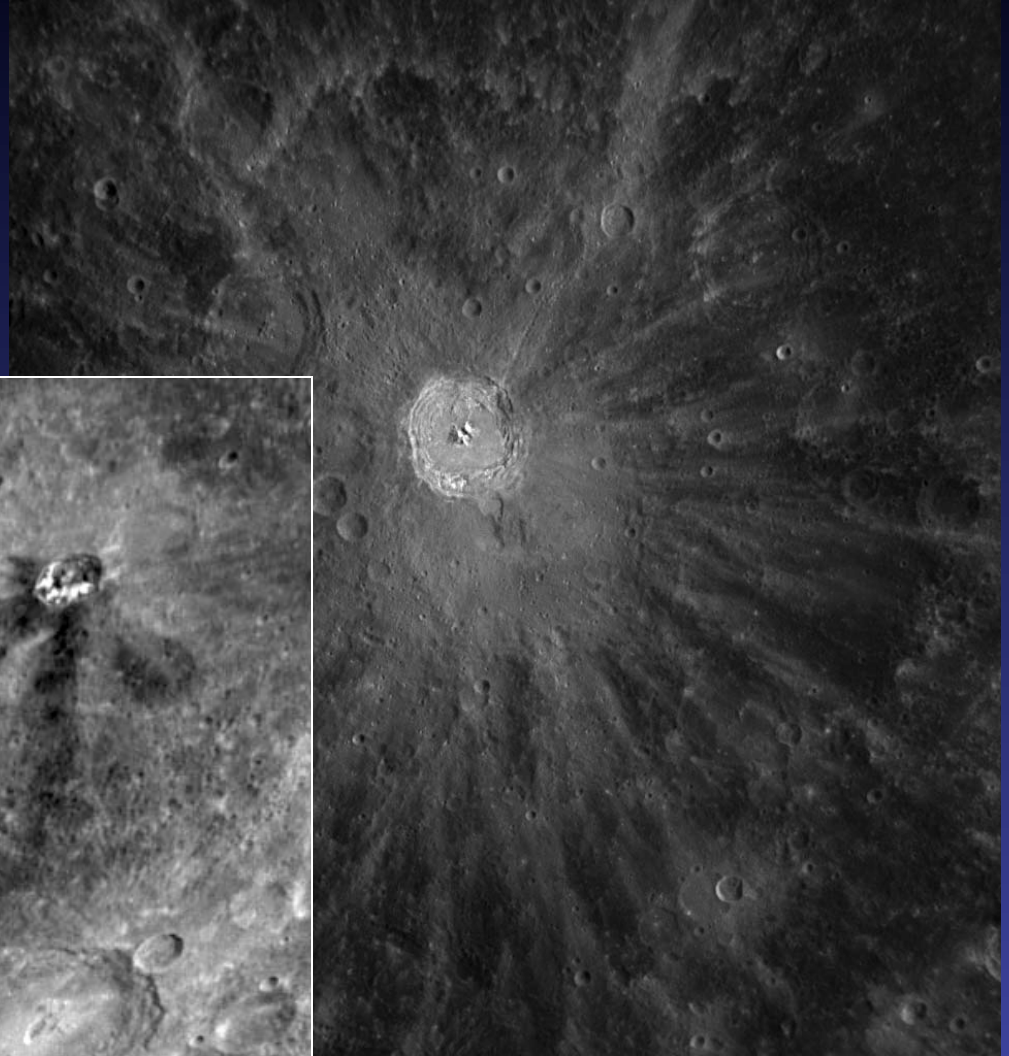
Diameter = 1,550 km



Surface of Mercury

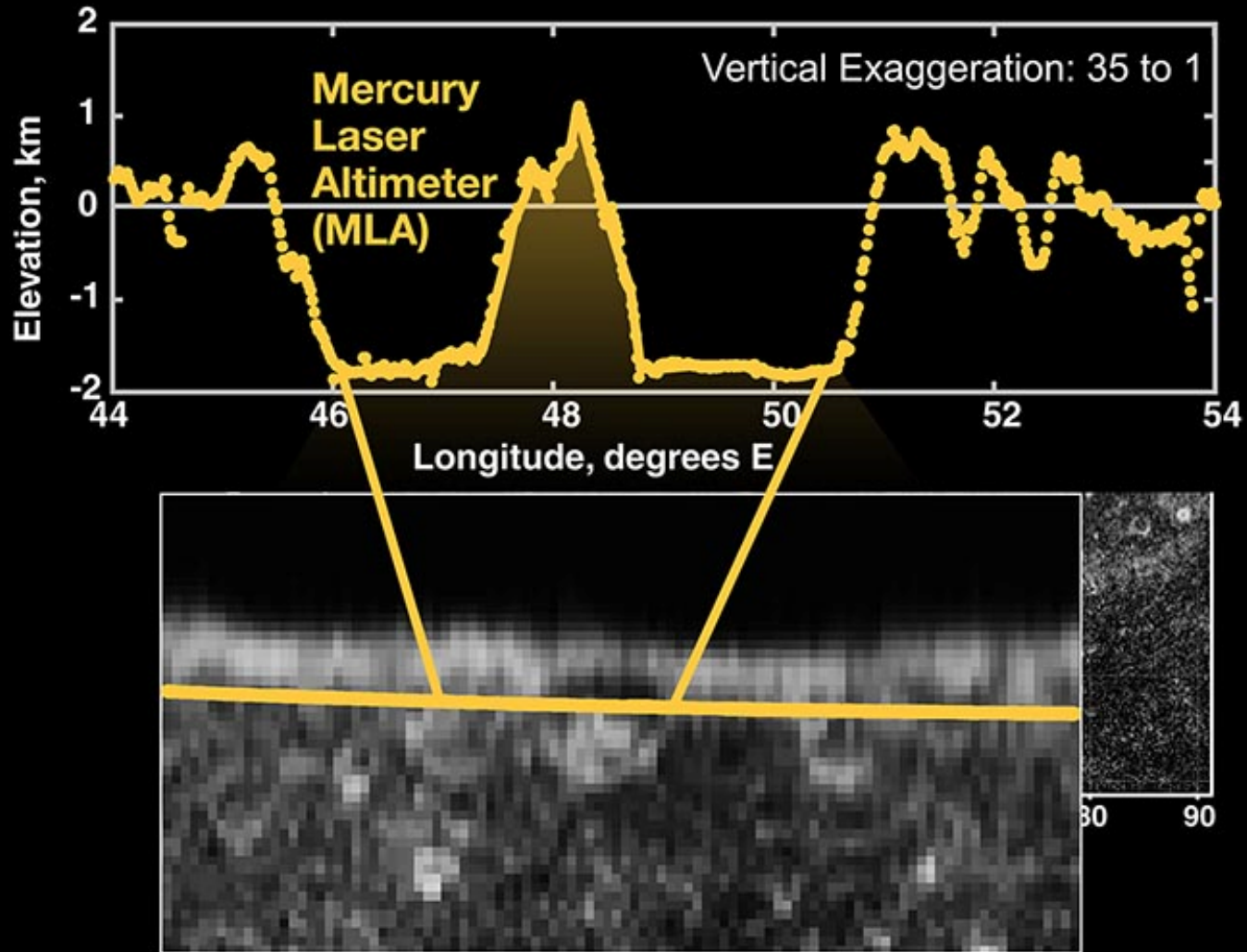


Crater ejecta, chains of secondary impacts



Ejecta rays

How tall are those crater walls?



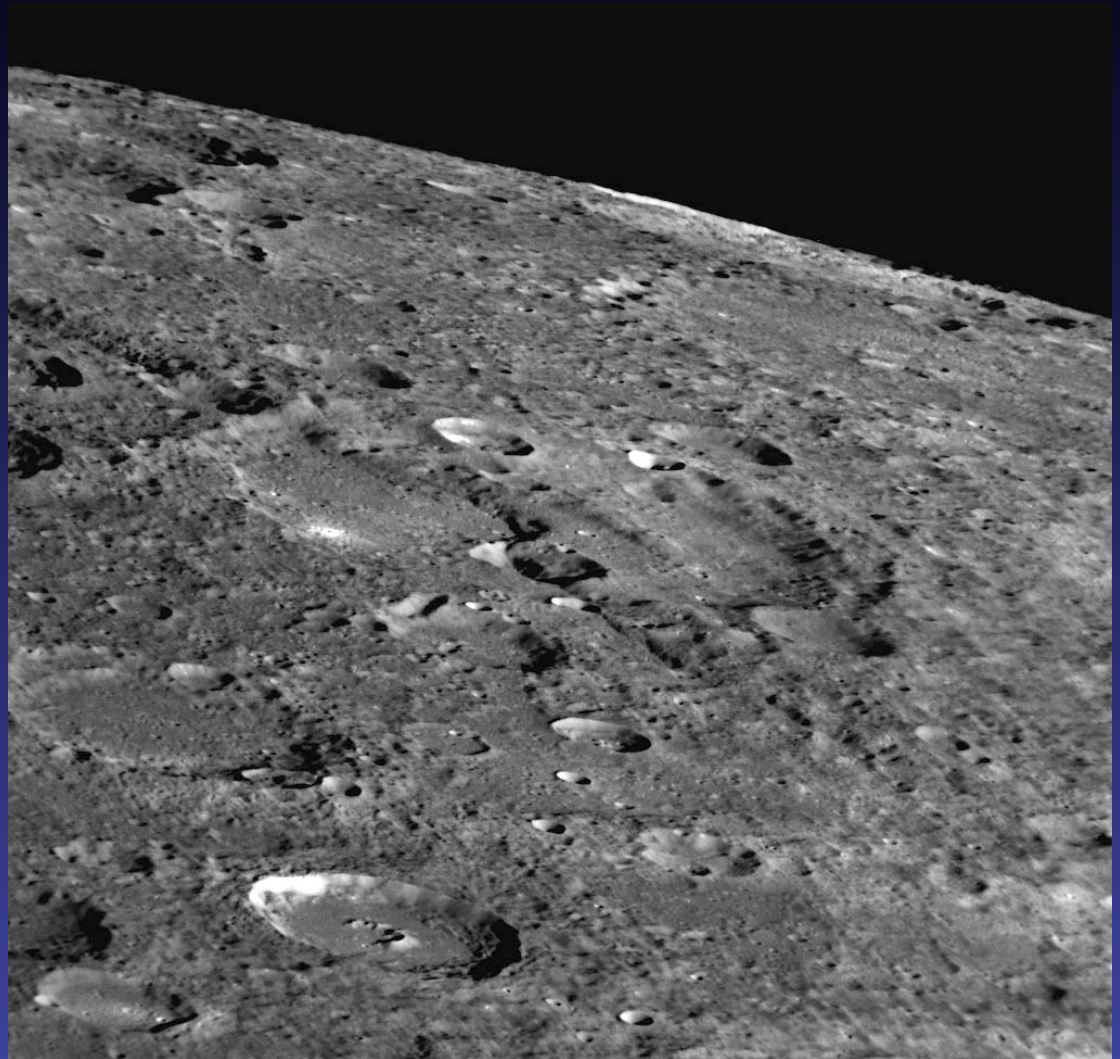
Crater diameters: 107 km (left) and 122 km (right).
The rms roughness of the floor ~ 35 m.

Scarp = Fault = Crack

When Mercury cooled, its surface shrank and cracked.



Mariner



MESSENGER

Mercury is heavily cratered.

Comparisons with the Moon:

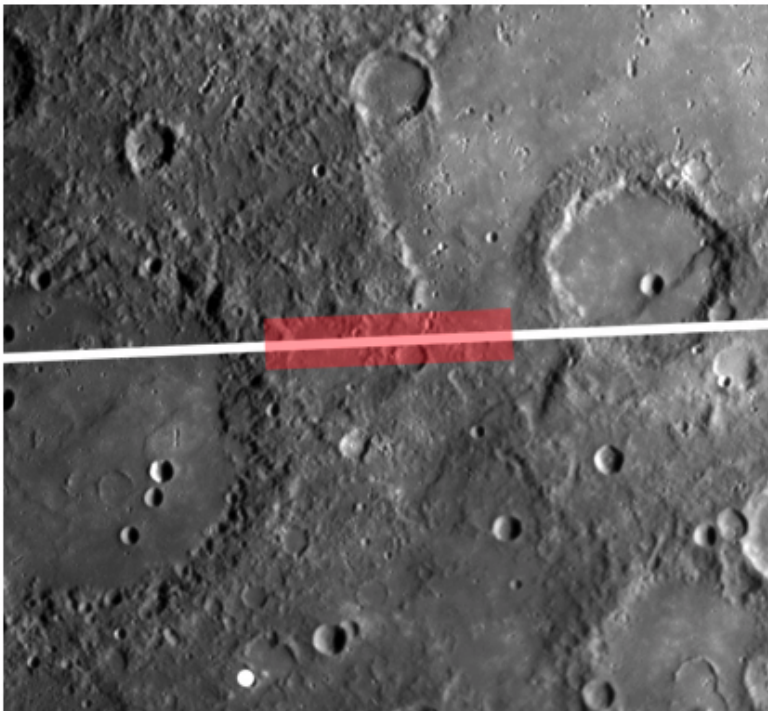
- Mercury's craters have shorter crater walls because of higher gravity.
- Mercury's craters are separated by regions without significant cratering => surface has been refreshed

Mercury is closer to the Sun and hotter than the Moon, so it remained hot longer and molten material can reach the surface and cover older impact sites

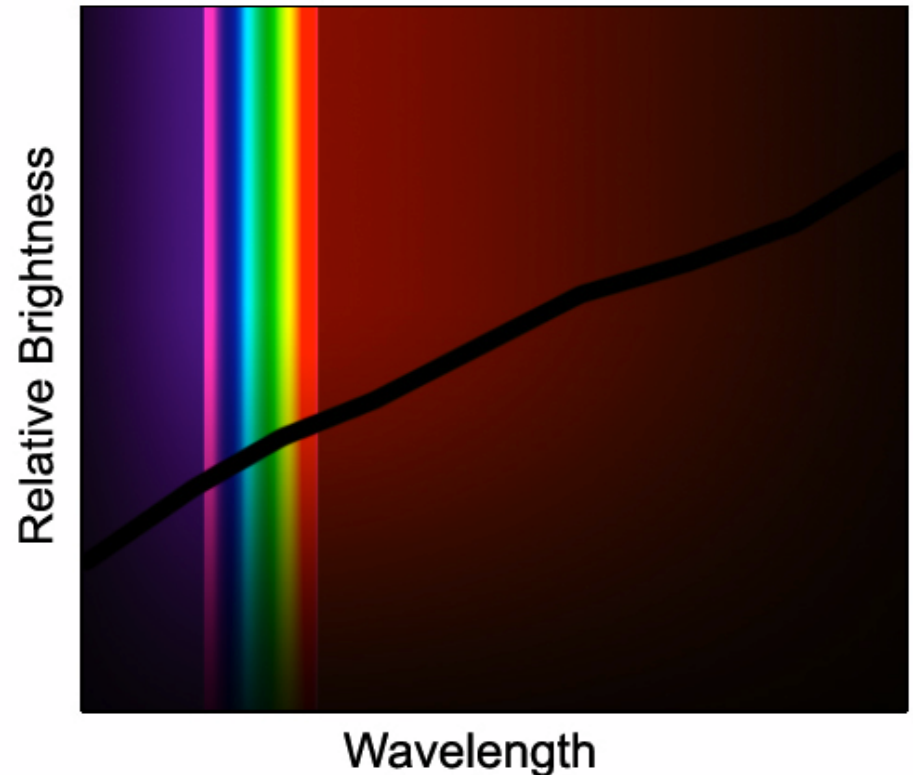
Optical-IR Spectra of Mercury

Reflected sunlight + thermal emission of Mercury

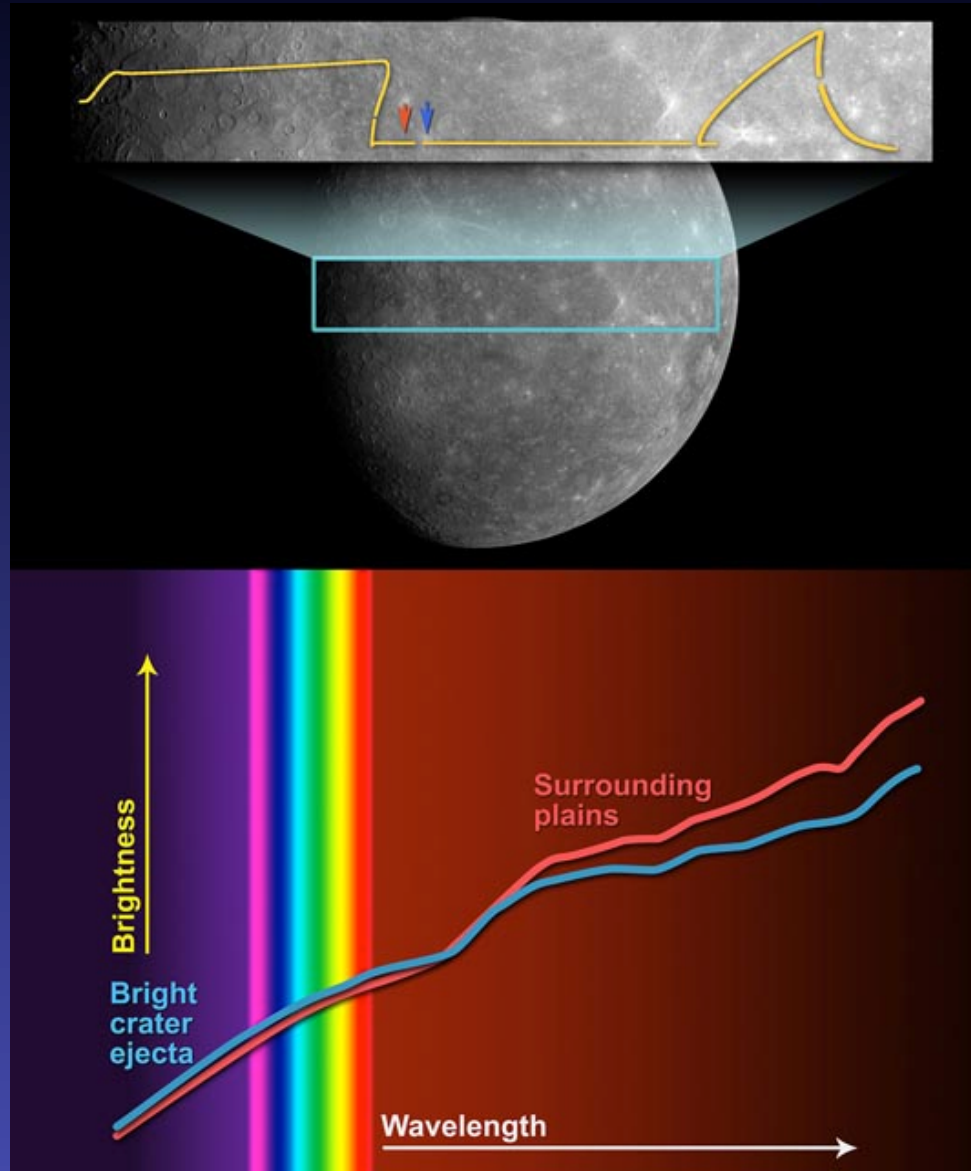
MASCS Ground Track



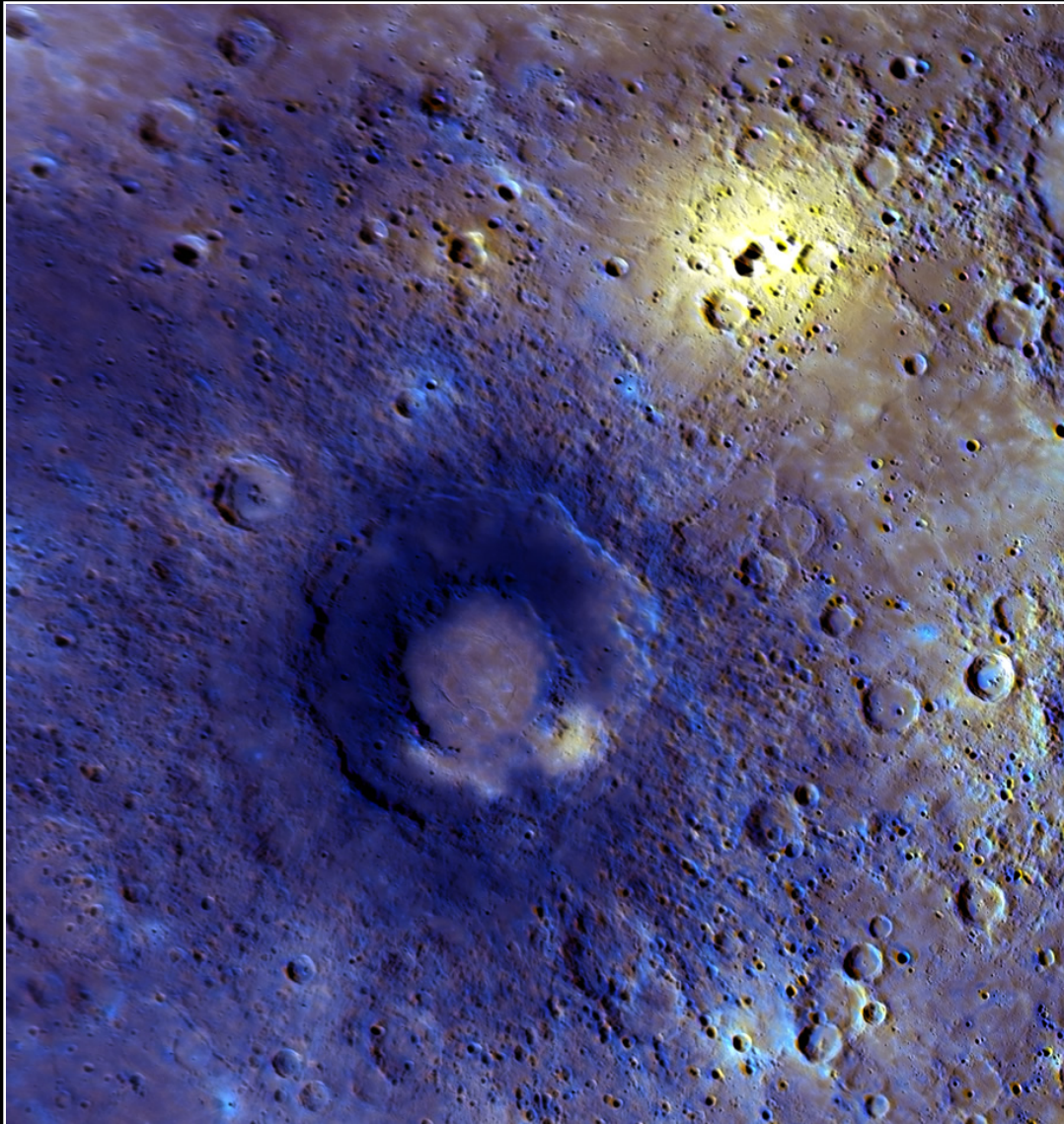
Average Spectrum



Spectral energy distribution (spectrum) depends on compositions of the surface regolith (soil)



Volcanic Activity of Mercury



Yellow area:
Rimless depression
May be an explosive
volcanic vent - based
on compositional
differences.

Temperature and Atmosphere of Mercury

Spin axis is perpendicular to the orbital plane.

Subsolar point 825 K ; polar region <167 K

Daytime average 700 K; nighttime average 88 K

The primordial atmosphere has been lost...

The current atmosphere:

- solar wind H^+ , He^+ trapped in Mercury's magnetic field
- Na, K liberated from the soil by solar wind particles or micro-meteorites

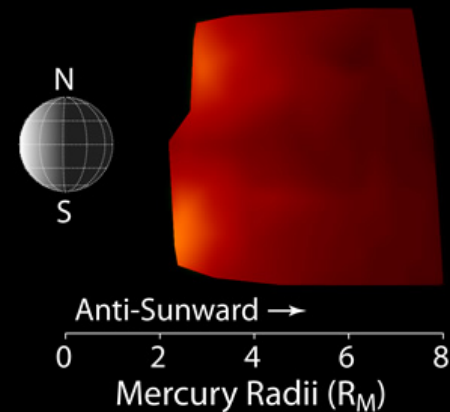
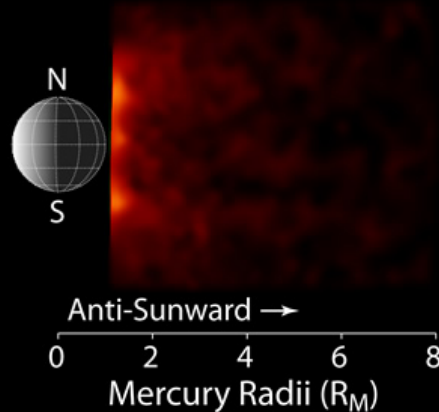
Solar Wind Interaction with Mercury

Sodium Emission in Mercury's Tail

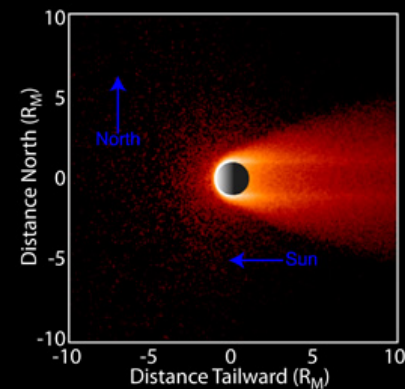
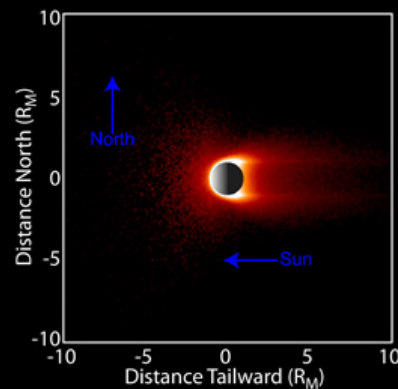
Third Flyby

Second Flyby

Third flyby scale stretched 5X



Models at flyby conditions



Mercury has a high density, 5.4 g/cm^3 , compared to the Moon's 3.4 g/cm^3 .

It must have lost the light surface material from a collision with a large planetesimal in its early history. $1/5$ Mercury's current mass, 20 km/s .

Mercury has a magnetic field of $4 \times 10^{-7} \text{ T}$ at an altitude of 330 km , ~ 100 times weaker than that of the Earth.

Liquid metallic core + rotation
 $\Rightarrow$ magnetic dynamo $\Rightarrow$ magnetic field

Current rotation is slow $\Rightarrow$ frozen-in remnant field

Is the intrinsic field dipolar?

Yes!

Has the field changed
since Mariner 10?

No.

Are there Mars-like
crustal anomalies?

**Not in the
regions sampled
at low altitude.**

