"The Planets"

Astro/EPS C12 (CCN 17045 or 32505)

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LEC: 2 LeConte TWTh, 2:40–5:00pm
Office Hours: 419 Campbell Hall, Mon 3–4 and Tue 5–6

QUIZ 2 GRADE

QUIZ 2 grade	cutoff	N
A	8.00	16
B	6.00	11
C	4.75	13
D	0.00	23
F	0.00	0

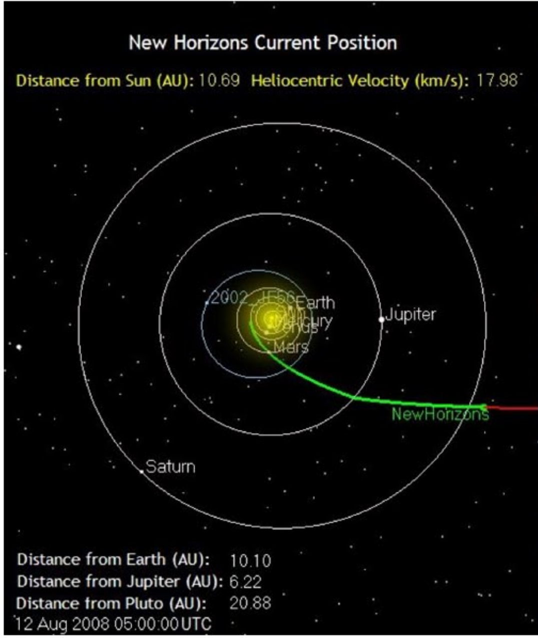
STAR PARTY

- TONIGHT !!

- attendance optional (this is just for fun)
- meet at 10pm in front of Campbell Hall
- don't be late
- my cell 510-207-2236
- may be cancelled if weather is bad

NEW HORIZONS CALENDAR

- launch: Jan 2006
- Jupiter encounter: Feb 2007
- Pluto closest approach: July 2015

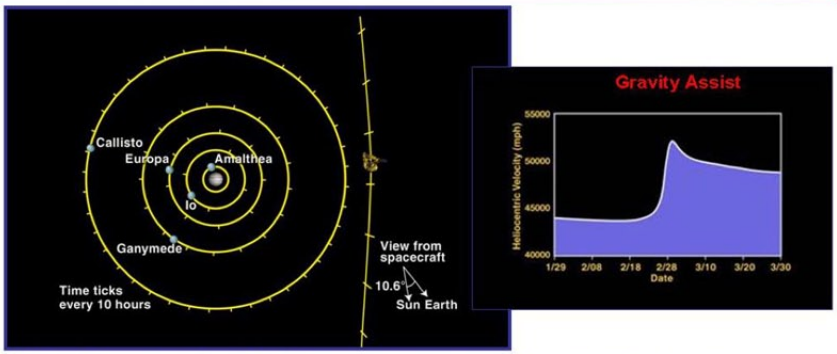


NEW HORIZONS LAST NIGHT

New Horizons Full Trajectory - Side View

Distance from Earth (AU): 10.10
Distance from Sun (AU): 10.69
Distance from Pluto (AU): 20.88
12 Aug 2008 05:00:00 UTC

JUPITER ENCOUNTER



NH Jupiter encounter objectives:

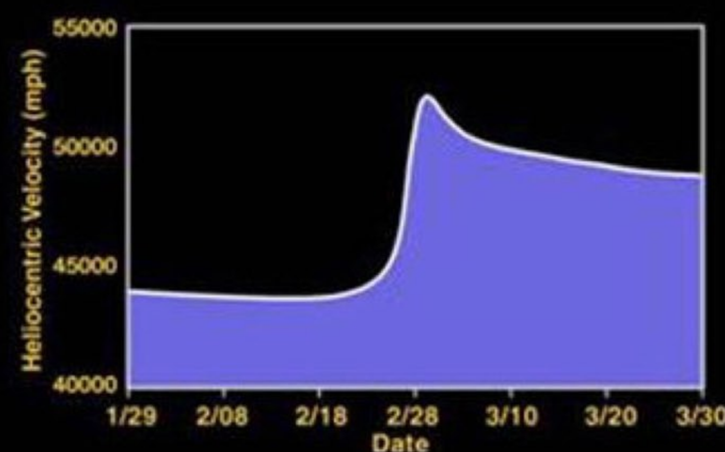
1. Gravity Assist
2. Stress test for Ops Team
3. Calibration Observations
4. Jovian system science

International Observing Campaign:

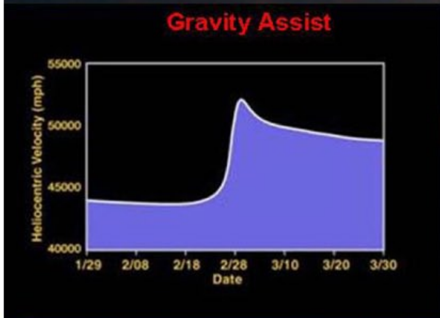
- Hubble, Chandra, XMM
- Rosetta, MRO (HIRISE)
- IRTF, Gemini, Subaru, KPNO, VLT,AAT
- Amateurs

A. Stern

Gravity Assist



GRAVITY AND VELOCITY



- velocity continually decreasing with time, due to Sun's pull
- velocity would go to zero if initial velocity less than escape velocity
- big "kick" from Jupiter similar to what happened to many planetesimals

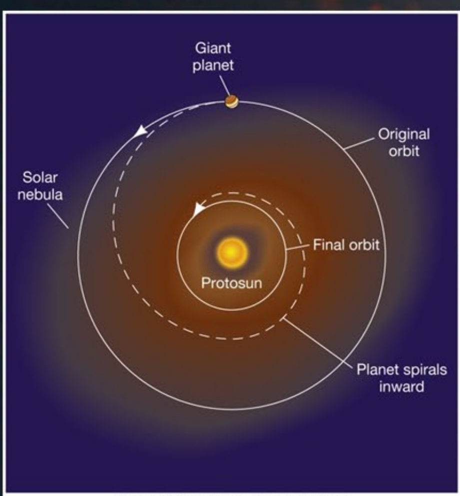
MAINTAINING AN ATMOSPHERE

$$v_{\text{esc.}} = \sqrt{2\ g\ r} = \sqrt{\frac{2Gm_{\text{planet}}}{r}}$$

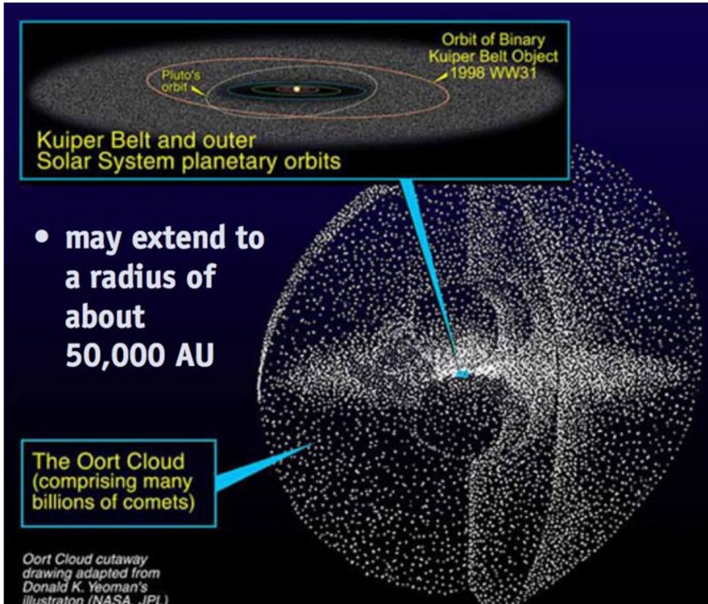
$$\bar{v} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8RT}{\pi \mu M_{\text{u}}}}$$

- v_{esc} = escape velocity from planet
- $\bar{v}$ = average thermal velocity of a molecule
- if $6\ \bar{v} > v_{esc}$, then the atmosphere is escaping the planet !!

GIANT PLANET FORMATION

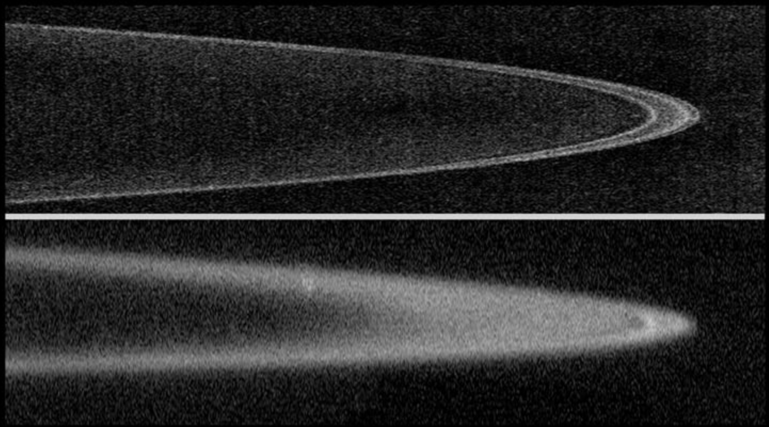


- giant planets probably migrated by interacting with the disk
- many different types of migration
  - interaction with gas --> inward migration
  - interaction with planetesimals --> outward migration

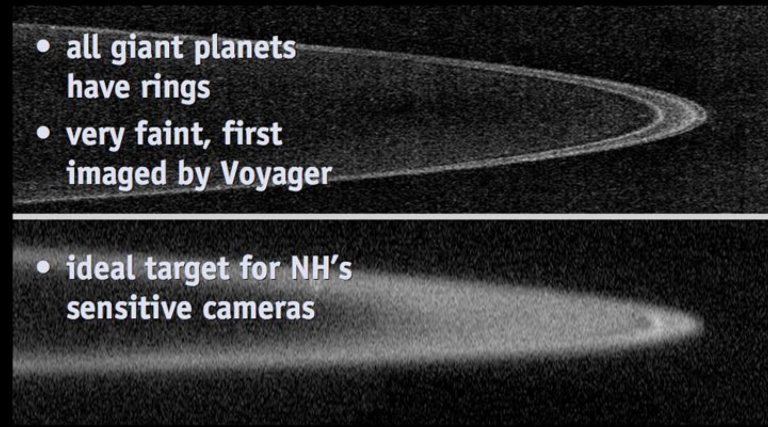


- may extend to a radius of about 50,000 AU

JUPITER'S RING

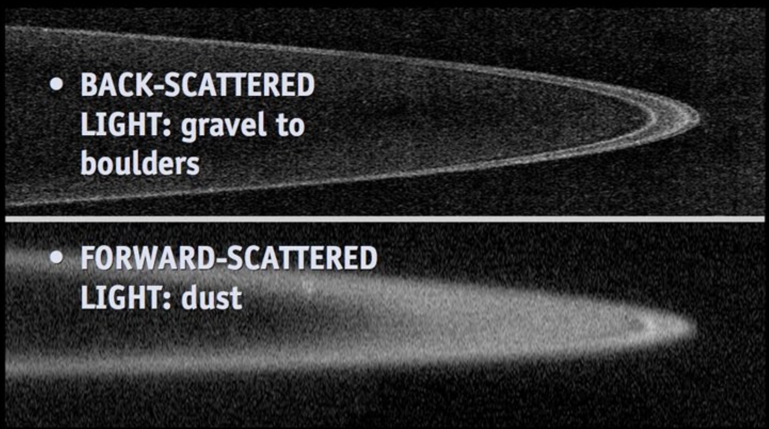


JUPITER'S RING



- all giant planets have rings
- very faint, first imaged by Voyager
- ideal target for NH's sensitive cameras

JUPITER'S RING



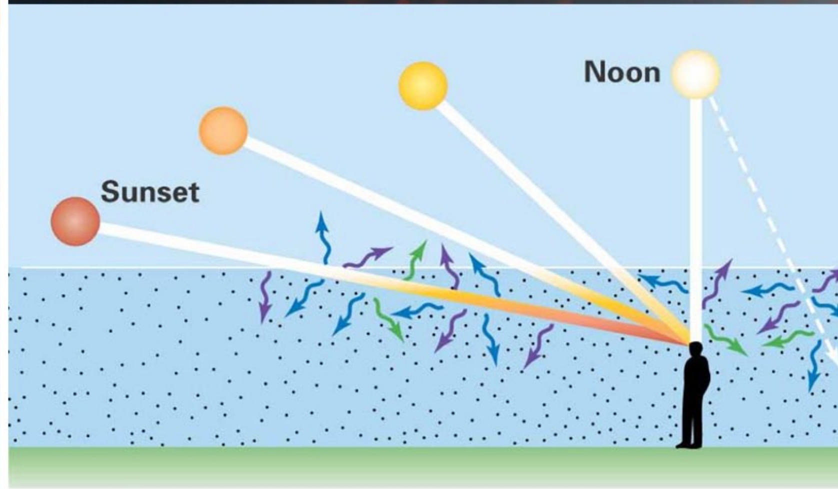
- BACK-SCATTERED LIGHT: gravel to boulders
- FORWARD-SCATTERED LIGHT: dust

FORWARD SCATTERING

- smoke is made of small particles, like dust... it has strong forward-scattering

SCATTERING

- LARGE “particles” like gravel, boulders, planets: back-scattering, the familiar reflection of light off surfaces
- SMALL dust: forward-scattering is stronger. blue light scattered better than red light.
- TINY molecules: scatter in all directions, blue light scattered better than red light



SCATTERING

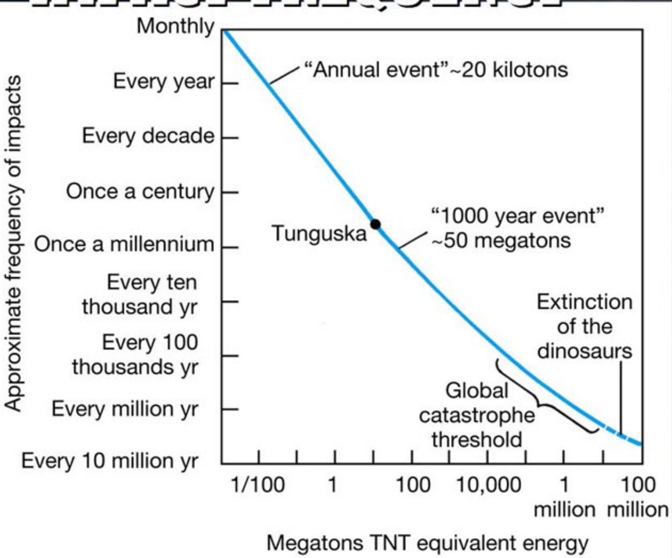
- light changes direction, but is not absorbed, in scattering events
  - Martian sunset
  - our blue sky
  - interstellar dust

No moons were found: What does this mean?

- Hypothesis:
  - The system originally followed a typical power law.
  - Erosion by meteoroids ate away all but the largest bodies, Adrastea & Metis.
  - Suggests that this is a very old ring system, unlike Saturn's "youthful" rings.

1. In the distant past, small bodies were more numerous than large ones.
2. Erosion by meteoroid impacts caused bodies to shrink at a uniform rate.

IMPACT FREQUENCY



COUNTING CRATERS

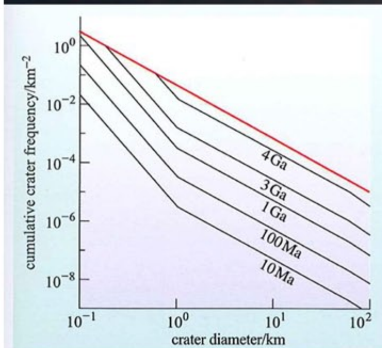


Figure 4.26 'Calibrated' cratering curves for the Moon, based on statistics for surfaces whose ages have been determined radiometrically. The red line shows the crater density on a saturated surface.

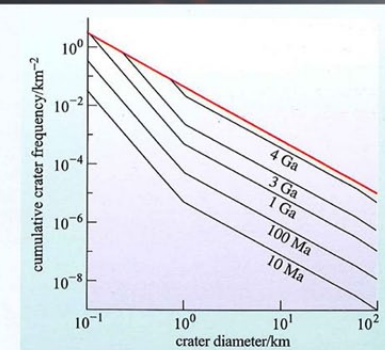
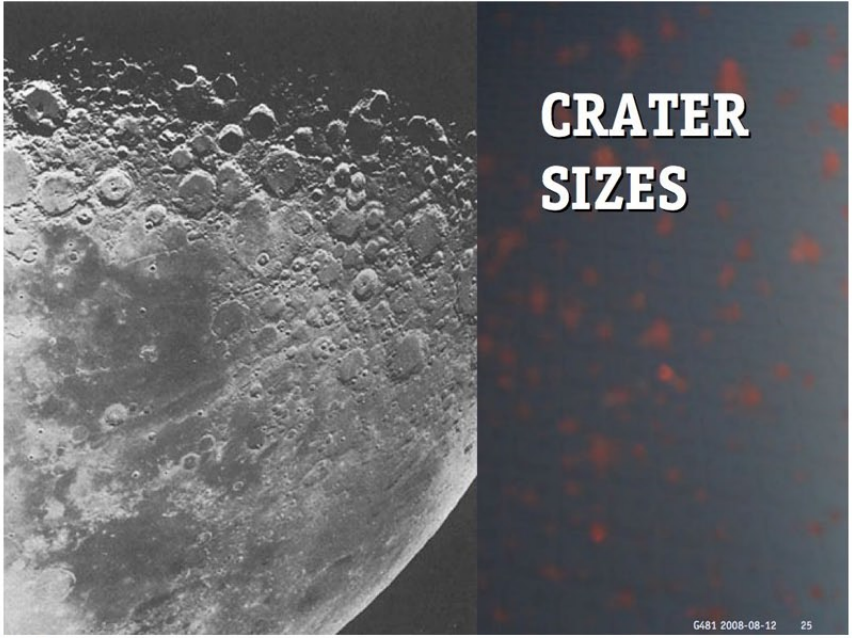


Figure 4.27 Cratering curves for Mars, based on lunar data in Figures 4.25 and 4.26, but adjusted to take account of the slightly higher flux at Mars. Notice it is very similar to Figure 4.26.



CRATER SIZES
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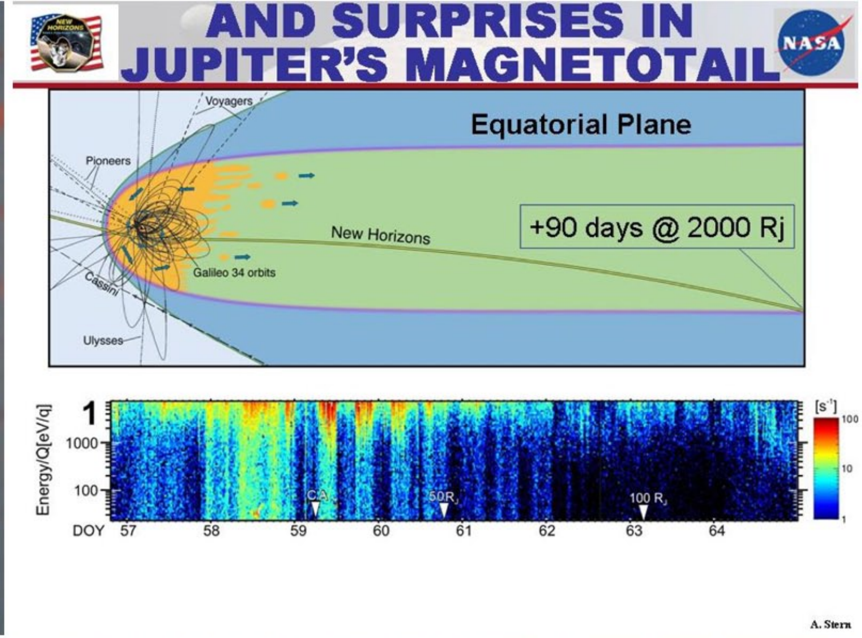
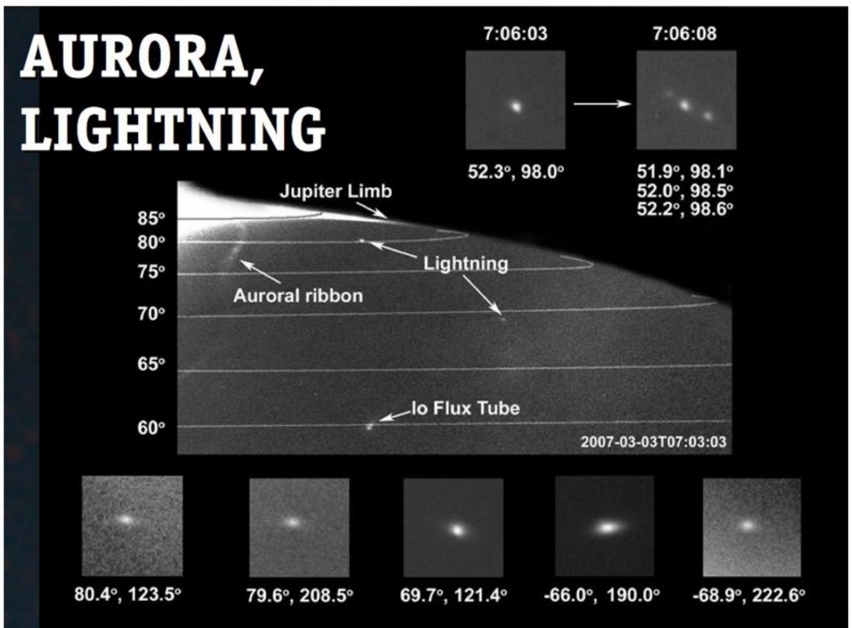
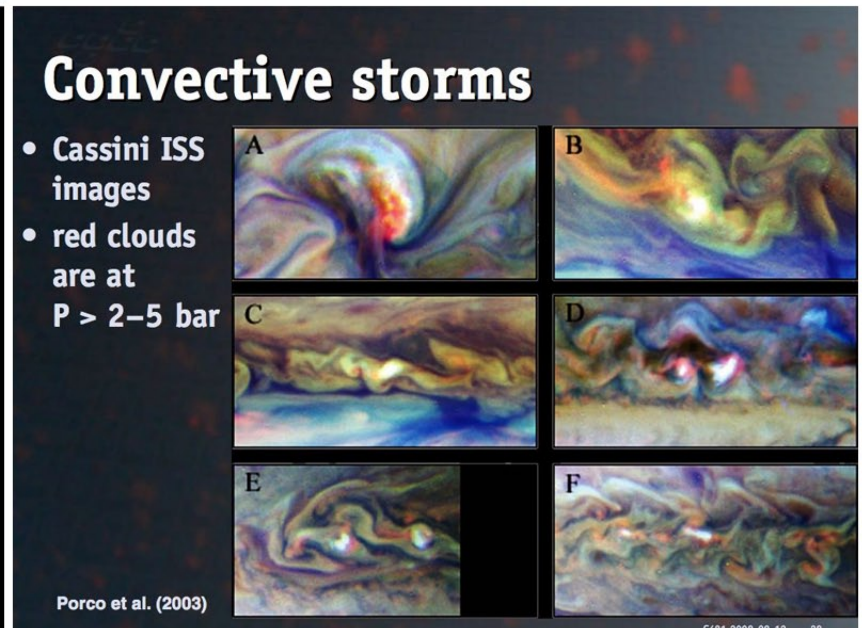


AND SURPRISES IN JUPITER'S MAGNETOTAIL
NASA
Voyagers
Equatorial Plane
Pioneers
+90 days @ 2000 Rj
New Horizons
Galileo 34 orbits
Cassini
Ulysses
Energy/Q[eV/q]
1
1000
100
CA
50 R
100 R
DOY 57 58 59 60 61 62 63 64
[s⁻¹]
100
10
1
A. Stern



AURORA, LIGHTNING
7:06:03
7:06:08
52.3°, 98.0°
51.9°, 98.1°
52.0°, 98.5°
52.2°, 98.6°
Jupiter Limb
85°
80°
75°
70°
65°
60°
Lightning
Auroral ribbon
Io Flux Tube
2007-03-03T07:03:03
80.4°, 123.5°
79.6°, 208.5°
69.7°, 121.4°
-66.0°, 190.0°
-68.9°, 222.6°



Convective storms
• Cassini ISS images
• red clouds are at P > 2–5 bar
A
B
C
D
E
F
Porco et al. (2003)
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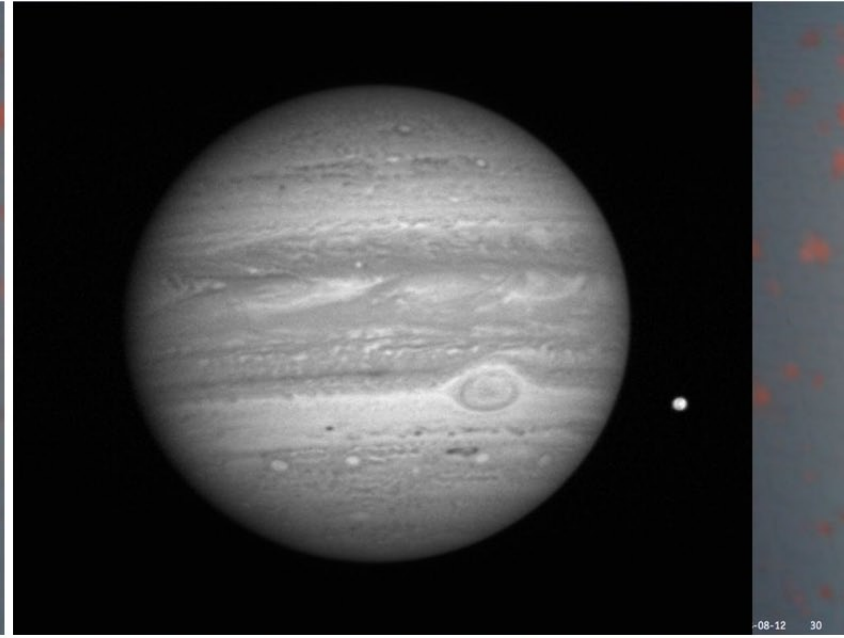
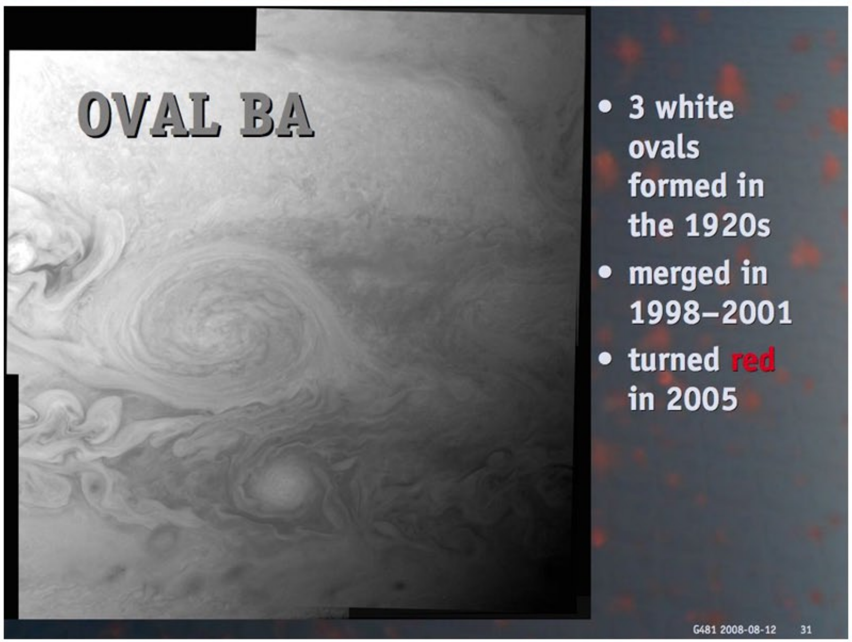
SATURN STORMS
• Voyager image
-08-12 29


-08-12 30


OVAL BA
• 3 white ovals formed in the 1920s
• merged in 1998–2001
• turned red in 2005
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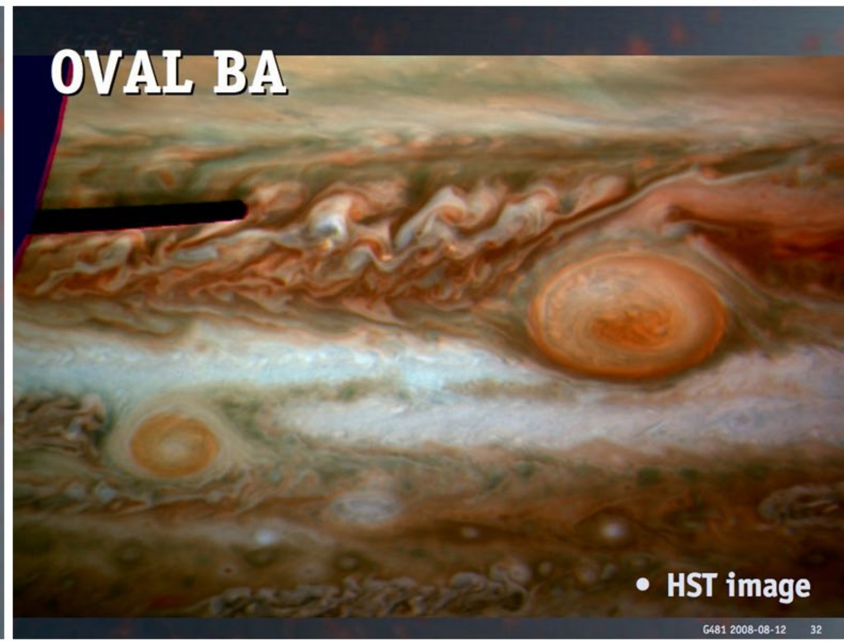
OVAL BA
• HST image
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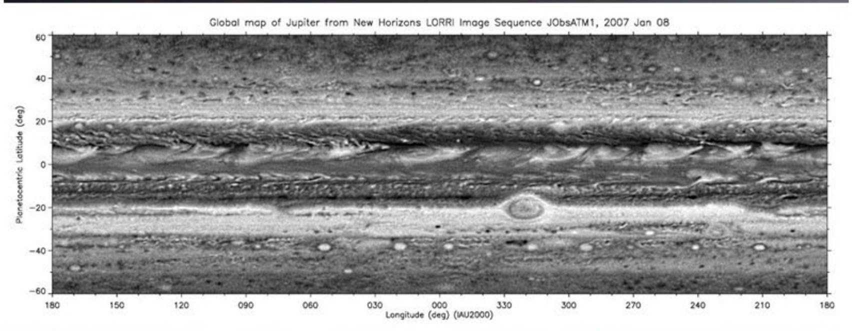
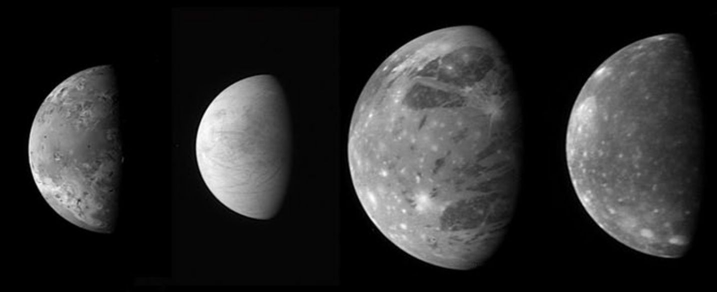
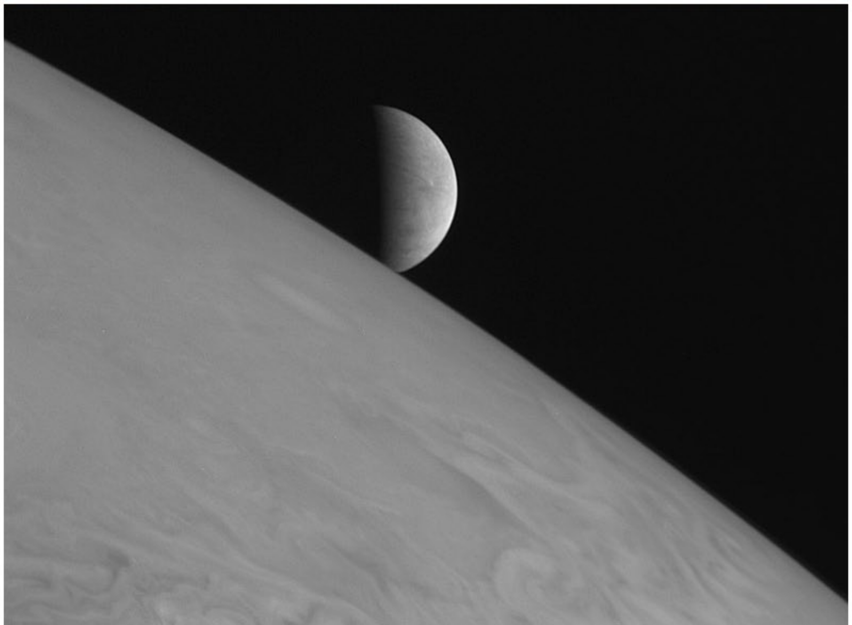
ZONAL WINDS

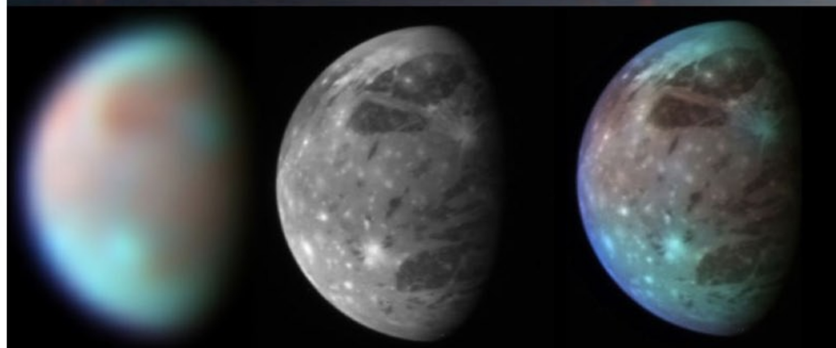


GALILEAN MOONS





GANYMEDE

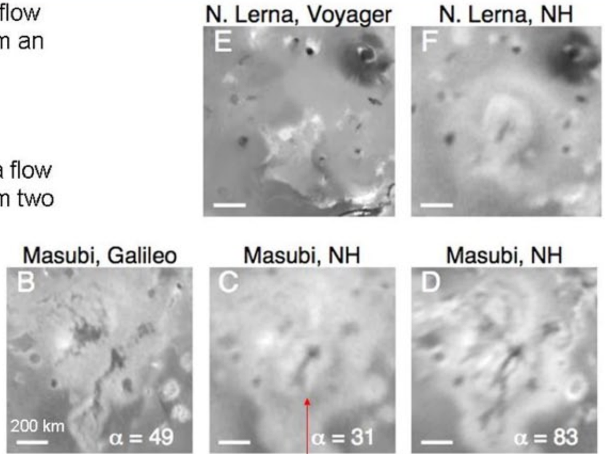


- visible + infrared
- blue = fresh ice
- red = contaminated

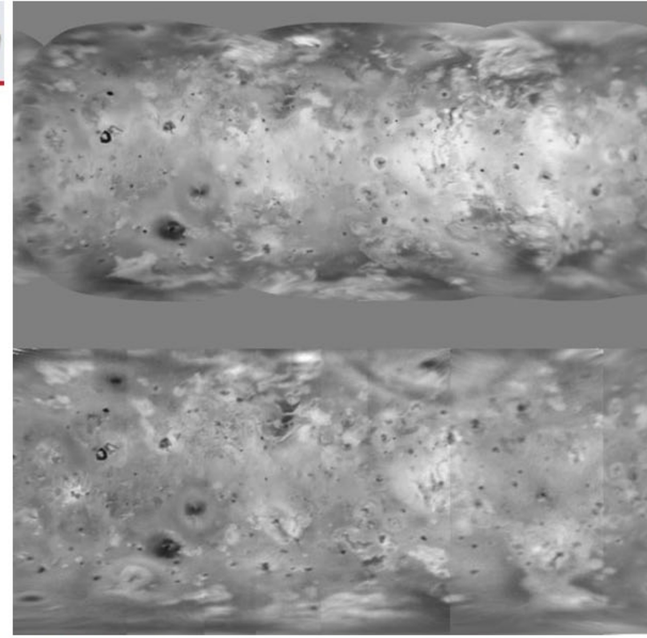
Changes at Lerna and Masubi

Lerna: New lava flow and deposits from an active plume

Masubi: new lava flow and deposits from two active plumes



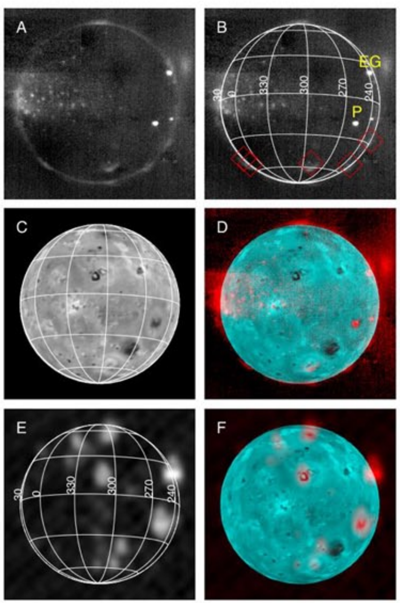
240 km lava flow



10 years of surface changes

Galileo ~1997

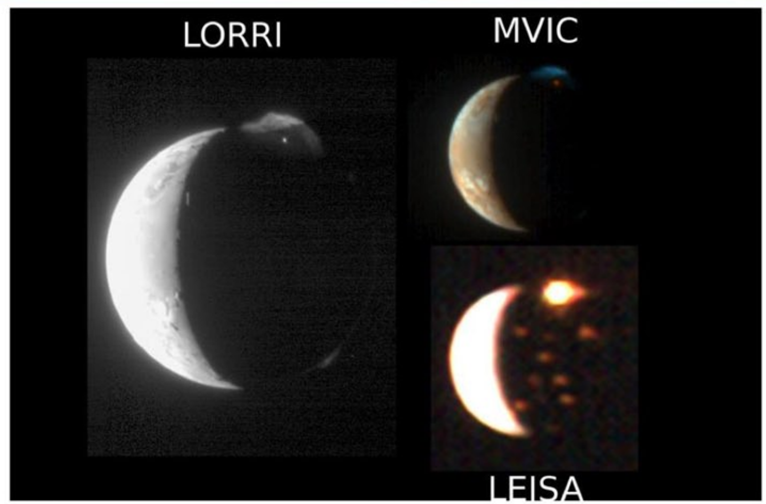
New Horizons 2007



IO

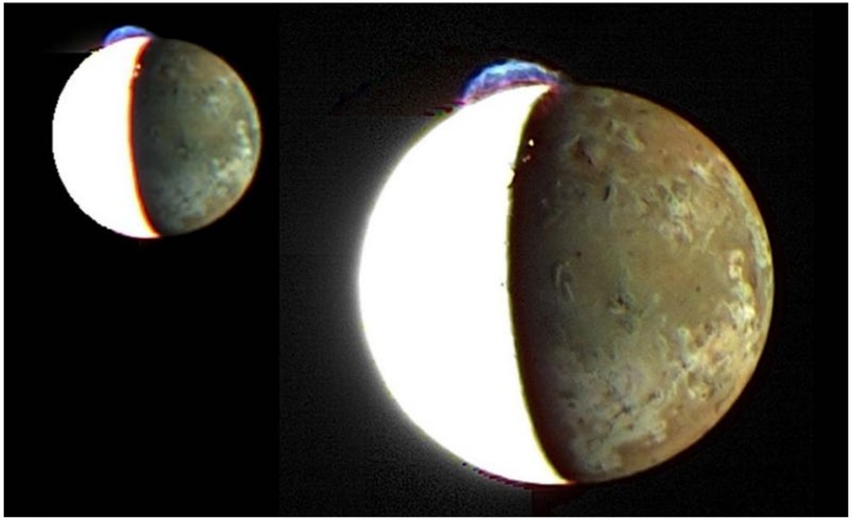
- A, B - visible (eclipse)
- C - visible (sunlit)
- D - eclipse + sunlit
- E - infrared
- F - infrared + sunlit

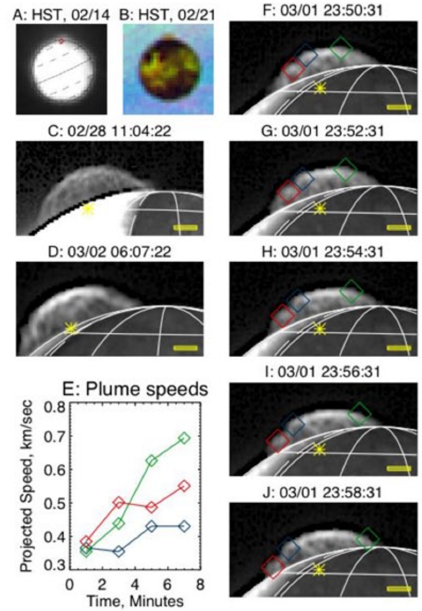
Coordinated Observations with Each Remote Sensing Instrument



Nightside Color Imaging

- Combined LORRI and MVIC



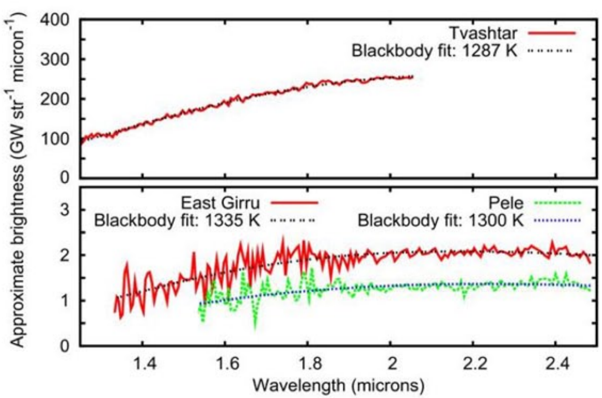


IO

- plume studies

Temperature of Tvashtar (and other Hot Spots)

- LEISA spectra
- In basaltic range- no evidence for exotic high-T magmas



ONWARD TO PLUTO