"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

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QUIZ 2 GRADE

<table>
<thead>
<tr>
<th>grade</th>
<th>cutoff</th>
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<tr>
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<td>16</td>
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<td>B</td>
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<tr>
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</tr>
</tbody>
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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

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NEW HORIZONS CALENDAR

• launch: Jan 2006
• Jupiter encounter: Feb 2007
• Pluto closest approach: July 2015
NEW HORIZONS LAST NIGHT

Distance from Sun (AU): 10.69
Heliocentric Velocity (km/s): 17.98

Distance from Earth (AU): 10.10
Distance from Jupiter (AU): 6.22
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

Gravity Assist

Heliocentric Velocity (mph)

Date
1/28 3/10 3/20 3/30
55000
50000
45000
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

\[ v_{esc.} = \sqrt{2gr} = \sqrt{\frac{2Gm_{planet}}{r}} \]

\[ \bar{v} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8RT}{\pi \mu M_u}} \]

- \( v_{esc} \) = escape velocity from planet
- \( \nu \) = average thermal velocity of a molecule
- if \( 6\nu > v_{esc} \) 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

The Oort Cloud

(comprising many billions of comets)

Oort Cloud cutaway drawing adapted from Donald K. Yeomans’s illustration (NASA, JPL)
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, Adrastaea & 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**

- Monthly
- Every year
- Every decade
- Once a century
- Every ten thousand yr
- Every 100 thousands yr
- Every million yr
- Every 10 million yr

Approximate frequency of impacts

- "Annual event" ~20 kilotons
- "1000 year event" ~50 megatons

Extinction of the dinosaurs

Global catastrophe threshold

**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

AURORA, LIGHTNING

Convective storms
- Cassini ISS images
- red clouds are at P > 2–5 bar

Porco et al. (2003)
SATURN STORMS

- Voyager image

OVAL BA

- 3 white ovals formed in the 1920s
- merged in 1998–2001
- turned red in 2005

HST image
ZONAL WINDS

Global map of Jupiter from New Horizons LORE Image Sequence J094ATM1, 2007 Jan 08

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

**Coordinated Observations with Each Remote Sensing Instrument**

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

- Combined LORRI and MVIC

Temperature of Tvashtar (and other Hot Spots)

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

ONWARD TO PLUTO

LORRI 1x1 967ms
2007 Oct 06 12:50:01 UT

Pluto