New Horizons at Jupiter

Hal Weaver
New Horizons Project Scientist
Johns Hopkins University Applied Physics Laboratory
hal.weaver@jhuapl.edu
To Pluto and Beyond

The Initial Reconnaissance of The Solar System’s “Third Zone”

KBOs 2016-2020
Jupiter System Feb-March 2007

Launch Jan 2006
Launch 2006 January 19 14:00 EST

- Nearly perfect trajectory

- Fastest Earth departure ever (36,000 miles per hour)

- Passed Moon’s orbit in 9 hours

- Pass orbits of:
  - Mars on 4/7/2006
  - Jupiter on 2/28/2007
  - Saturn on 6/8/2008
  - Uranus on 3/18/2011
  - Neptune on 8/24/2014

- Pluto system encounter on 7/14/2015
New Horizons Trajectory

New Horizons Current Position

Distance from Sun (AU): 6.38  Heliocentric Velocity (km/s): 20.90

New Horizons Full Trajectory - Overhead View

Distance from Earth (AU): 5.36
Distance from Jupiter (AU): 1.07
Distance from Pluto (AU): 26.19
7 Jun 2007 00:00:00 UTC

7 Jun 2007 00:00:00 UTC
New Horizons Year-by-Year

Diagram showing the trajectory of New Horizons from 2006 to 2015, passing by Saturn, Jupiter, and heading towards Neptune.
New Horizons Instruments

- **Alice UV Spectrograph**, 520-1870 A, CBE mass 4.15 kg, power 4.0 W
- **Ralph visible & IR imager**, CBE mass 10.67 kg, power 5.3 W
- **Radio Science Experiment (REX)**, CBE mass 0.1 kg, power 2.1 W

**Core Payload**

- **Long Range Reconnaissance Imager (LORRI)**, panchromatic imager, CBE mass 8.59 kg, power 5.1 W
- **Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI)**, CBE mass 1.41 kg, power 2.32 W
- **Solar Wind Around Pluto (SWAP)**, CBE mass 2.94 kg, power 2.25 W
- **Student Dust Counter (SDC)**, CBE mass 1.75 kg, power 6.5 W
<table>
<thead>
<tr>
<th>Instrument Name</th>
<th>PI</th>
<th>Wavelength / Energy / Mass Range</th>
<th>Field of View (milliradians)</th>
<th>Angular resolution (milliradians / pixel)</th>
<th>Wavelength / Energy / Mass Resolution per pixel</th>
<th>Mass, kg</th>
<th>Power, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice: Ultraviolet mapping spectrometer</td>
<td>Alan Stern, SwRI</td>
<td>52 - 180 nm</td>
<td>1.7 x 70 (slit), 35 x 35 (solar occultation aperture)</td>
<td>1.7 x 5.2</td>
<td>0.183 nm</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>LORRI: Long-Range Reconnaissance Imager</td>
<td>Andy Cheng, APL</td>
<td>350 - 850 nm</td>
<td>5.06 x 5.06</td>
<td>0.00494</td>
<td>N/A</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Ralph MVIC: Multispectral Visible Imaging Camera</td>
<td>Alan Stern, SwRI</td>
<td>450 - 1000nm (Pan); 425 - 550nm (Blue); 540 - 700nm (Red); 780 - 1000nm (IR); 860 - 910 nm (CH4)</td>
<td>Multicolor: 100 x N (pushbroom). OpNav, pan only: 100 x 2.6 (framing)</td>
<td>0.02</td>
<td>See filter bandpasses</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Ralph LEISA (Linear Etalon Imaging Spectral Array): Infrared spectrometer</td>
<td>Alan Stern, SwRI</td>
<td>1250 - 2500 nm</td>
<td>15.9 x 15.9</td>
<td>0.062</td>
<td>Full spectral range: R=300 (~6.5 nm / pixel). 2100 - 2250 nm: R=600 (~3.7 nm / pixel).</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>REX: Radio Science Experiment</td>
<td>Len Tyler Stanford University</td>
<td>4.1 cm.</td>
<td>20</td>
<td>20</td>
<td>Radiometry mode: N/A. Occultation mode: 3 x 10^{-12} in Δf/f</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDC: Student Dust Counter</td>
<td>Mihaly Horanyi, U. Colorado</td>
<td>4x10^{-12} - 4x10^{-9} g</td>
<td>N/A</td>
<td>N/A</td>
<td>~ factor of 2 in mass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEPSSI (Pluto Energetic Particle Spectrometer Science Investigation): Medium energy particle spectrometer</td>
<td>Ralph McNutt, APL</td>
<td>25 - 1000 keV (protons); 60-1000 keV (atomic ions) 25 - 500 keV (electrons)</td>
<td>160 deg x 12 deg</td>
<td>25 x 12 deg</td>
<td>0.25 keV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWAP (Solar Wind Around Pluto): Low energy plasma instrument</td>
<td>Dave McComas, SwRI</td>
<td>30 eV - 7.7 keV</td>
<td>270 deg x 10 deg (deflection angles up to +15 deg additional)</td>
<td>N/A</td>
<td>1 eV (&lt;2 keV), 9% (&gt;2 keV)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**New Horizons Jupiter Encounter**

**Encounter Closest Approach at:**
2007 Feb 28 05:43:40 UTC

**CA Distance = 32 R_J**

- **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
Jupiter science included studies of Jovian meteorology, Jovian rings, satellite geology and composition, auroral phenomena, irregular satellites, and magnetospheric physics.
Jupiter Imaging: 2007 January 24

- Ganymede
- Io
- GRS
- LRS
Jupiter’s Little Red Spot: Most Detailed View Yet

Feb 10, 2007

Feb 27, 2007

GRS LRS

LRS
Jupiter Storm Observations

Mapping with LEISA

GRS

Ammonia cloud

Feb 26, 2007 19:35

10 hours later

20 hours later
Mapping NH$_3$ Clouds with LEISA

- Region northwest of GRS was unusually tranquil, but there were other turbulent regions where NH$_3$ upwelling observed

- LEISA is especially useful for probing compositional structure of the atmosphere

LEISA Spectral Cube of Jupiter (Spencer)

1.94/1.99 ratio
NH$_3$ band depth
R = 2.05
G = 1.60
B = 1.94/1.99
Jupiter in the NIR with LEISA

- Random wavelengths to illustrate the richness of the data
• MVIC Color Imaging

• Mesoscale waves near equator (visible in LORRI images too)

• Chevron pattern near S-Pole

• Use multiple filters to probe 3-dim atmospheric structure
• MVIC Methane Band Imaging

• Probes high altitude clouds

• Incredible detail
• Io is the most volcanically active body in the solar system

• Range to Io = 4.0 million km = 2.5 million miles

• Resolution = 21 km (13 miles)

• Plume extends 275 km (170 miles) above surface

• Everest-sized mountains on limb near 2 o’clock position
Io on 2007 Feb 28 11:04 UT

- At least 3 volcanic plumes
- Most detailed view ever of a volcanic plume on Io
- Tvashtar is near north pole; visible in all Io images
- Tvashtar plume stretches 290 km (180 miles) above the surface
- Range to Io = 2.4 million km = 1.5 million miles
- Resolution = 12 km (7.6 miles)
Tvashtar Falling Over Terminator

- 2/28 15:15 UT
- Sunset on the Tvashtar plume and hot spot
- Nightside illuminated by Jupiter
Io images: 2007 Mar 01 00:30 UT

LORRI

Tvashtar

Hot Spot

Plateau

MVIC: Blue + CH₄

Masubi
LORRI + MVIC Combo of Io

(Lakdawalla)
Three near-simultaneous views of Tvashtar
Io Plume Movie

• 5 frames
• 2 mins between frames
• Ballistic trajectories with fallout time of ~30 mins
Io & Europa: LORRI + MVIC
Last Io Image : Near Limb of Jupiter

- 3/4 00:20
- Phase 159 deg
- Processed by “dilo”, UMSF
Europa science goals

- **Atmosphere**
  - Variability of disk-integrated UV emissions (neutral O at 1304, 1356 Å) with:
    - Europa Longitude
    - Magnetospheric longitude
    - Eclipse
  - Visible emissions in eclipse (disk-resolved)

- **Surface composition**
  - Disk-resolved 1.2 – 2.5 μm spectra at better spectral resolution than NIMS (R = 300), ≤20 pixels across the disk

- **Surface geology**
  - Distribution of large, broad, depressions (“crop circles”) seen in near-terminator imaging…
Unmapped Europa

ECOMP02

Anti-Jupiter
Europa: “Crop Circles”

- Global pattern of arcuate depressions following small circles
  - Near-terminator LORRI imaging at selected longitudes to complement Galileo

Schenk et al.
Unmapped Ganymede

![Diagram of Ganymede showing Trailing and Leading sides with GCOMP02 and GBEST01 areas marked.]
Ganymede: Composition

- Global distribution of water ice and other hydrated species on Ganymede?
  - Gap-fill and trailing side coverage at much better spectral resolution than Galileo NIMS (Gcomp01, 02, Gbest01)

Grundy et al.
Ganymede: Atmosphere

- Response of Ganymede’s atmosphere to the Jupiter magnetosphere?
  - Disk-integrated Alice spectra of neutral O emission (1304, 1356 Å) on all 5 Ganymede visits (including 8 hours surrounding Gocc01 for magnetic longitude response study)
  - Visible-wavelength imaging of auroral emissions in eclipse with LORRI and MVIC (Gclipse01)
  - NIR imaging in eclipse with LEISA (serendipity?)

- Response of Ganymede’s atmosphere to Jupiter eclipse?
  - Time sequence of disk-integrated Alice spectra through an eclipse (Gclipse01, 02)

- Abundance and distribution of the molecular atmosphere?
  - Occultation of Sigma Arietis (Gocc01, +4.5 days)
  - Latitude 70 N
  - Star is bright, expected signal is moderate: (S/N ~9)
UV Spectroscopy with Alice

- Spatially-resolved UV spectroscopy of Jovian system
- Io plasma torus
- Auroral emissions from Jupiter and satellites
- UV continuum from Jupiter + satellites
- Stellar occultations of Jupiter and satellite atmospheres
Flying Down Jupiter’s Magnetotail

Equatorial Plane

New Horizons
+90 days @ 2000 Rj

Noon-Midnight Plane

100 Rj
Jupiter’s Ring System: 2007 Feb 24

- Halo
- Gap
- Main Ring
High Resolution Ring Image
Rings at Different Phase Angles

Low Phase

High Phase