S07: Iapetus plus three untargeted flybys of Mimas, Enceladus and Rhea
Iapetus: What we know at the end of 2004

Bonnie J. Buratti, Amanda Hendrix, and Rosaly Lopes

The “SOST Leadership”
<table>
<thead>
<tr>
<th>Vitals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iapetus</strong></td>
<td></td>
</tr>
<tr>
<td>Distance from Saturn (10³ km)</td>
<td>3,561</td>
</tr>
<tr>
<td>Period (days)</td>
<td>79</td>
</tr>
<tr>
<td>Radius (km)</td>
<td>718</td>
</tr>
<tr>
<td>i</td>
<td>14.7</td>
</tr>
<tr>
<td>e</td>
<td>0.028</td>
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<tr>
<td>Density (gm/cc)</td>
<td>1.2</td>
</tr>
<tr>
<td>Geometric albedo</td>
<td>0.02-0.6</td>
</tr>
<tr>
<td>Discovered</td>
<td>1671 (Cassini)</td>
</tr>
</tbody>
</table>
Compositional mixing model (Owen et al., 2001)

$\text{CO}_2$ discovered in July data by VIMS
The evidence, continued


<table>
<thead>
<tr>
<th>Satellite</th>
<th>a (10^4 km)</th>
<th>e</th>
<th>I(°)</th>
<th>T(yr)</th>
<th>m_R</th>
<th>R(km)</th>
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</thead>
<tbody>
<tr>
<td>S/2000 S 4</td>
<td>18.2</td>
<td>0.54</td>
<td>33.5</td>
<td>2.53</td>
<td>22.1</td>
<td>7</td>
</tr>
<tr>
<td>S/2000 S 10</td>
<td>17.5</td>
<td>0.47</td>
<td>34.7</td>
<td>2.35</td>
<td>23.0</td>
<td>4</td>
</tr>
<tr>
<td>S/2000 S 11</td>
<td>17.9</td>
<td>0.38</td>
<td>33.1</td>
<td>2.43</td>
<td>20.5</td>
<td>13</td>
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<tr>
<td><strong>34-degree inclination group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S/2000 S 2</td>
<td>15.2</td>
<td>0.36</td>
<td>45.1</td>
<td>1.88</td>
<td>21.3</td>
<td>10</td>
</tr>
<tr>
<td>S/2000 S 3</td>
<td>17.3</td>
<td>0.27</td>
<td>45.4</td>
<td>2.26</td>
<td>20.1</td>
<td>16</td>
</tr>
<tr>
<td>S/2000 S 5</td>
<td>11.3</td>
<td>0.33</td>
<td>46.1</td>
<td>1.33</td>
<td>22.0</td>
<td>7</td>
</tr>
<tr>
<td>S/2000 S 6</td>
<td>11.5</td>
<td>0.32</td>
<td>46.6</td>
<td>1.24</td>
<td>22.6</td>
<td>5</td>
</tr>
<tr>
<td>S/2000 S 8 alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S/2000 S 8</td>
<td>15.7</td>
<td>0.37</td>
<td>153.0</td>
<td>2.00</td>
<td>23.6</td>
<td>3</td>
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<tr>
<td><strong>Phoebe group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoebe</td>
<td>13.94</td>
<td>0.16</td>
<td>174.7</td>
<td>1.51</td>
<td>15.4</td>
<td>110</td>
</tr>
<tr>
<td>S/2000 S 1</td>
<td>23.1</td>
<td>0.34</td>
<td>173.1</td>
<td>3.59</td>
<td>21.7</td>
<td>8</td>
</tr>
<tr>
<td>S/2000 S 7</td>
<td>20.1</td>
<td>0.45</td>
<td>175.9</td>
<td>2.92</td>
<td>23.9</td>
<td>3</td>
</tr>
<tr>
<td>S/2000 S 9</td>
<td>18.5</td>
<td>0.22</td>
<td>167.4</td>
<td>2.57</td>
<td>23.8</td>
<td>3</td>
</tr>
<tr>
<td>S/2000 S 12</td>
<td>19.7</td>
<td>0.12</td>
<td>175.8</td>
<td>2.84</td>
<td>23.9</td>
<td>3</td>
</tr>
</tbody>
</table>
Does this process occur anywhere else?

The accretion of material onto the leading sides of outer planet satellites should occur wherever outer retrograde satellites are found:

1. **Callisto** (Bell et al., 1985): leading side is darker (except right at opposition)

2. **Uranian satellites**: Leading sides seem to be darker and redder (Buratti and Mosher, 1991), and the effect increases with distance from Uranus

![Galileo image of Callisto](Image)
A Sneak Peak in July
The Iapetus flyby in context

Summary of Flybys

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Flyby date</th>
<th>Closest approach (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoebe</td>
<td>2004 June 11</td>
<td>2000</td>
</tr>
<tr>
<td>Iapetus 1</td>
<td>2004 Dec 31</td>
<td>124,000</td>
</tr>
<tr>
<td>Hyperion</td>
<td>2005 Sept 26</td>
<td>1000</td>
</tr>
<tr>
<td>Iapetus 2</td>
<td>2007 Sept 10</td>
<td>1000</td>
</tr>
</tbody>
</table>

A scene on Iapetus, with Cassini observing in the background, created by electronic artist and Cassini Mission Lead Dave Seal.
Iapetus has “a period of apparent Augmentation and Dimunition, by which period it becomes visible in its greatest Occidental digression, and invisible in Its greatest Oriental digression”

- G.D. Cassini (1671)
## Main Models for Albedo Dichotomy

<table>
<thead>
<tr>
<th>Model</th>
<th>Pros</th>
<th>Cons</th>
<th>Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologic resurfacing</td>
<td>Infill of dark crater floors; clean edge (?)</td>
<td>Hemispheric pattern</td>
<td>Smith et al. 1982</td>
</tr>
<tr>
<td>Accretion from Phoebe</td>
<td>Hemispheric pattern</td>
<td>Color</td>
<td>Soter 1974</td>
</tr>
<tr>
<td>As above + volatization</td>
<td>Hemispheric pattern; color?</td>
<td>The math</td>
<td>Cruikshank et al. 1983; Squyres et al., 1984; Bell et al. 1985; Buratti and Mosher, 1995</td>
</tr>
<tr>
<td>Accretion from Titan or Hyperion</td>
<td>Pattern and spectra</td>
<td>Low albedo</td>
<td>Matthews 1992; Vilas et al. 1996; Jarvis et al. 2000; Owen et al. 2001</td>
</tr>
<tr>
<td>Accretion of D-type material from outer retrograde satellites</td>
<td>Hemispheric pattern and spectra</td>
<td>Sufficient source; Phoebe not red</td>
<td>Cruikshank et al. 1983; Buratti et al. 2002, 2004; Black et al., 2004 (general exogenic)</td>
</tr>
</tbody>
</table>
Evidence for the exogenic model: if corrections are made to the intensity to account for viewing geometry, we get:

The dark floor craters

Bell et al., 1984, argue that the dark floor craters are not really evidence for the endogenic model; it depends on the details of how the dark material is distributed on the surface.

But where does the dark material come from?
Color of the small satellites

The red color is similar to the dark material on Iapetus
Summary of main questions to be answered by flyby

- What is the composition of the dark material and how is it related to other dark material in the Saturnian system, comets, asteroids, KBOs, etc. (*VIMS, UVIS, CIRS, ISS*)? Is it prebiotic?
- What volatiles are present? (*VIMS, UVIS*)
- What is the surface texture of Iapetus as a function of position and depth (*CIRS, RADAR, ISS*)
- What geologic processes have led to the current state of Iapetus, and how are geologic forms related to the composition? (*all*)
- What are its bulk properties? (*all*)
- What is the dust and particle environment like around Iapetus? (*all MAPS*)
Another Sneak Peak in October
ISS Observations of Iapetus
(B/C Encounter, New-Year's Eve 2004/05)

Tilmann Denk

Iapetus Preview Meeting, JPL, Pasadena

Talk request: ISS_00BIA_TILTALK001_PRIME
Start UTC: 2004-355T16:45 UTC (Dec 20)
Cassini

Gezielte Monde-Vorbeiflüge

(...und sehr wichtige ungezielte Vorbeiflüge)

3x Enceladus
(Mrz 2005)
(Jul 2005)
(Mrz 2008)
(Feb 2005)

1x Dione
(Okt 2005)
(Sep 2007)

1x Hyperion
(Sep 2005)

1x Iapetus
(Sep 2007)
(Silvesternacht 2004/5)

1x Rhea
(Nov 2005)
(Aug 2007)

1x Phoebe
(11 Jun 2004)
Iapetus data up to Dec 2004

Best Iapetus from Voyager (northern anti-Saturn side) (178 pxl diameter, 81° phase)

Best Iapetus's leading side by July data (31 pxl diameter, 10° phase / 56 pxl diameter, 54° phase)

Best Iapetus so far before X-mas 2004 (215 pxl diameter, 111° phase)

OPNAV DOY 360 opportunity (220 pxl diameter, 22° phase)

OPNAV DOY 361 opportunity (258 pxl diameter, 22° phase)

OPNAV DOY 362 opportunity (313 pxl diameter, 22° phase)

100 pxl
ISS Scientific Goals (2)

• Endogenic processes on the surface??
• Large impact structures
• Mapping of color units (0.25 to 1.0 µm); search for small-scale color variations
• Comparison to other satellites (esp. crater distribution, color, crater morphology)
• Geologic history of Iapetus, in particular origin of hemispheric dark/bright dichotomy
Global albedo dichotomy

• Problem known since Iapetus discovery by J.D. Cassini in 1671/72

• S.C. Cassini in 2004/05: B/C data set *might* put us in a position to solve this 333 years old planetologic riddle eventually
ISS Iapetus B/C
Observations Overview (1)

• Flyby near apoapse rev 00B $\rightarrow$ 00C
  $\Rightarrow$ very slow flyby (Iapetus passes the S/C)
  $\Rightarrow$ hours & hours of observation time

• Changed reference trajectory:
  Flyby now at $\geq 117,500$ km altitude
  over northern ,,Voyager“ terrain
  $\Rightarrow$ best ISS resolution: 705 m/pxl
  $\Rightarrow$ $\sim 10x$ better than October data
Sub-S/C location map
ISS Iapetus B/C Observations Overview (4)

**Mapping**

- All 8 prime requests contain full-disk clear-filter imaging
- 2 shutters per footprint (in most cases): 1 long exp. time for dark material, 1 short shutter for bright surface
- Robustness against pointing uncertainties
- WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS Iapetus B/C
Observations Overview (6)

Graylight Imaging

- Observations of bright terrain in “Saturn shine“ (requests LIMBTOPOD and later)
- Rationale: Some regions near “moat feature“ will never be nicely visible during 4-year tour => B/C graylight obs. >5x higher resolution
- Full-resolution and summation mode (2sum) imaging; clear filter; most exposure times 46s, 82s, or 180s
ISS Iapetus B/C
Observations Overview (7)

**Dust Search**

- Experimental observations of Iapetus environment at high phase
- Phase = 140° (was >165° in old ref. traj.)
- Summation mode (4sum) shutters in clear and polarizer filters
ISS_00BIA_GLOBCOL001_PRIME
(2004-366T01:53 UTC; 00:42 hrs)

Trigger #                                2157
Telemetry Rate                            S&ER5a (40)
number footprints                        6
number of images                          61
total Data Volume (predict)               282 Mb

2x3 clr (1x2 color) mosaic

170000 km alt.; 1.0 km/pxl (NAC 1sum);
d_IA=1410 pxl; 50 deg phase;
sub-S/C lat/lon = +29/70;
sun illuminates surface from left

Clear filters: 2 NAC shutters per footprint:
180 ms (bright) and 1.2 sec (dark terrain)

1x2 multi-color mosaic with substantial overlap:
Southern footprint (ftprt 1): 12 col, 3 pol NACs;
shutter times "optimized" for dark terrain.
Northern footprint (ftprt 2): 20 col, 6 pol NACs;
shutter times "optimized" for bright terrain;
4 WAC IR polarizers.

WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS_00CIA_GLOBMAPC001_PRIME
(2004-366T14:00 UTC; 00:30 hrs)

Trigger # 2159
Telemetry Rate S&ER3 (24)
number footprints 11
number of images 24
total Data Volume (predict) 97 Mb

2+3x3 NAC clr mosaic
122500 km alt.; 740 m/pxl;
d_IA=1950 pxl; 78 deg phase;
sub-S/C lat/lon = +54/50;
sun illuminates surface from left

2 NAC shutters per footprint (except #1 and 2):
220 ms (bright) and 1.5 sec (dark terrain)

WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS_00CIA_COMPD001_VIMS
(2004-366T19:00 UTC; 02:00 hrs)

Trigger #                               2998
Telemetry Rate                          S&ER3 (24)
number footprints                       1
number of images                        13
total Data Volume (predict)             76 Mb

1x1 NAC color mosaic
117500 km alt.; 705 m/pxl;
d_IA=2050 pxl; 94 deg phase;
sub-S/C lat/lon = +64/24;
sun illuminates surface from left

10 NAC color frames + 3 polarizers

Center of ftprt over dark terrain
==> long exp times selected

Highest resolution color of BC flyby
ISS_00CIA_COMPE001_VIMS
(2004-366T22:30 UTC; 02:00 hrs)

<table>
<thead>
<tr>
<th>Trigger #</th>
<th>2162</th>
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<tbody>
<tr>
<td>Telemetry Rate</td>
<td>S&amp;ER3 (24)</td>
</tr>
<tr>
<td>number footprints</td>
<td>1</td>
</tr>
<tr>
<td>number of images</td>
<td>4</td>
</tr>
<tr>
<td>total Data Volume (predict)</td>
<td>14 Mb</td>
</tr>
</tbody>
</table>

1x1 WAC color context

WAC 4-color context for LIMBTOPOE
(Vio, Grn, Ir1, Ir3; 7.2 km/pxl). Sun illuminates surface from left.
ISS_00CIA_GRAYLITEH001_PRIME
(2005-001T04:00 UTC; 01:00 hrs)

Trigger #                               2165
Telemetry Rate                          S&ER3 (24)
number footprints                       13
number of images                        34
total Data Volume (predict)             123 Mb

3+3+2 NAC clr mosaic

136000 km alt.; 820 m/pixel (NAC 1sum);
d_IA=1760 pxl; 123 deg phase;
sub-S/C lat/lon = +60/319;
sun illuminates surface from left (Saturn also)

2 NAC shutters per footprint:
320 ms (bright) and 2.0 sec (dark terrain)

1x4 NAC mosaic for graylight imaging
(4 shutters/ftprt; 1sum and 2sum)

WAC 4-color context (Vio, Grn, Ir1, Ir3)
## More Iapetus in Nominal Tour

### Planned Cassini flybys at Iapetus (selection)*

<table>
<thead>
<tr>
<th>Date</th>
<th>min. altitude</th>
<th>best ISS pixel scale</th>
<th>visible hemisphere**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul 2004</td>
<td>2,500,000 km</td>
<td>15 km/pxl</td>
<td>CR, southern bright terrain, SP</td>
</tr>
<tr>
<td>Oct 2004</td>
<td>1,110,000 km</td>
<td>6.7 km/pxl</td>
<td>anti-Saturn side (western CR), SP</td>
</tr>
<tr>
<td>31Dec04/ 01Jan05</td>
<td>117,500 km</td>
<td>710 m/pxl</td>
<td>northern CR, high northern latitudes</td>
</tr>
<tr>
<td>Nov 2005</td>
<td>416,000 km</td>
<td>2.5 km/pxl</td>
<td>eastern and central CR, north. bright terrain</td>
</tr>
<tr>
<td>Jan 2006</td>
<td>879,000 km</td>
<td>5.3 km/pxl</td>
<td>eastern CR and trans. zone, &quot;moat&quot; partially</td>
</tr>
<tr>
<td>Apr 2006</td>
<td>603,000 km</td>
<td>3.6 km/pxl</td>
<td>leading side, SP</td>
</tr>
<tr>
<td>Sep 2007</td>
<td>~1,270 km#</td>
<td>~12 m/pxl</td>
<td>CR (high phase), trailing side (low phase)</td>
</tr>
</tbody>
</table>

*...Included are all flybys in 2004 and all flybys below 10^6 km altitude until June 2008.

**...CR = Cassini Regio (dark material hemisphere); SP = south pole.
#...10 Sep 2007: targeted flyby altitude not fixed yet; might be between ~1000 and ~1400 km.
Content

• Context to other satellite flybys
• Context to previous imaging data (Voyager, Cassini)
• ISS scientific goals
• ISS Iapetus B/C observations overview
• Detailed mosaic designs
• More Iapetus in nominal tour
• Summary
Voyager Iapetus

\( \varnothing \approx 1500 \text{ km} \)

9 km/pixel

12 km/pixel

21 km/pixel

100 pixels
ISS Scientific Goals (1)

• Global properties: Size, shape, density

• Characterization of surface morphology:
  - Surface features in general (basins, craters, scarps, mountains(?), what else?)
  - Regional topography
  - Stratigraphy (terrain relative ages)
  - Nature of dark terrain (blanket thickness, material behavior at slopes, search for holes in blanket, craters, ages, ...)

Possible classification of Iapetus global albedo dichotomy origin hypotheses:

1. Exogenic origin/ dust is coming in over long time
   (a) Dark grayish dust from Phoebe hits Iapetus's leading side and gets chemically altered/ reddened
       (Soter 1974, Burns et al. 1979, 1996; Hamilton 1997)
   (b) Dark reddish dust from smaller retrograde outer Saturnian satellites covers Iapetus's leading side (Buratti et al. 2002)

2. Asymmetric exogenic influence removes thin ice veneer from leading side, but not from trailing side and poles
   (a) Viewpoint of orbit mechanics:
       (a1) Circumsaturnian dust is the cause (from Phoebe or other outer Saturnian satellites)
           (Cruikshank et al. 1983; Bell et al. 1985; Buratti and Mosher 1995)
       (a2) Interplanetary micrometeoroid flux is the cause
           (Cook and Franklin 1970; Squyres and Sagan 1983; Wilson and Sagan 1996)
   (b) Viewpoint of physical processes on the surface:
       (b1) Exposing of the dark subsurface layer by bright material erosion (Cook and Franklin 1970; Wilson and Sagan 1996)
       (b2) enrichment of formerly intimately mixed dark material due to sublimation of the bright ice component
           (Cruikshank et al. 1983; Bell et al. 1985; Buratti and Mosher 1995)
       (b3) synthesis of the dark material by chemical/irradiation processes made possible by bright icy material erosion
           (Squyres and Sagan 1983)

3. Exogenic origin/ dust and debris originates from a major single event
   (a) from collision with reddish Hyperion (Matthews 1992, Marchi et al. 2002)
   (b) from collision with Iapetus itself (Tabak and Young 1989)
   (c) from collision of an outer Saturnian satellite with a heliocentric object with the result of a retrograde debris cloud crossing Iapetus's orbit (Denk and Neukum 2000)
   (d) material comes from Titan (Owen et al. 2001)

4. Endogenic origin: Dark material from interior (Smith et al. 1981, 1982)
Cassini Saturn Arrival and First Orbits

Huygens targeting: 16/17 Dec 2004
Huygens release: 25 Dec 2004
Cassini deflection: 28 Dec 2004
MIA uplink: 29 Dec 2004
Iapetus observations: 31 Dec 04 – 02 Jan 05
ISS Iapetus B/C
Observations Overview (2)

- Naming convention:
  - GLOBCOL = global color
  - GLOBMAP = global mapping
  - LIMBTOPO = limb topography
  - GRAYLITE = Saturn-shine imaging
  - DUSTSEAR = Iapetus environment imaging

- A, B, C, D, E, F, H ... time order

- However: New reference tour made these discriminations somewhat obsolete
ISS Iapetus B/C
Observations Overview (3)

• ISS spatial resolution:
  1.0 km/pixel @ 50° phase (2004 Dec 31 02:00 UTC)
  710 m/pixel @ 93° phase (2004 Dec 31 19:00 UTC)
  1.1 km/pixel @ 140° phase (2005 Jan 1 14:00 UTC)

• ISS: 8 full-disk mosaics, 5 NAC-color ftprts., 288 frames total

• Iapetus size @ C/A: >2000 NAC pixel
ISS Iapetus B/C
Observations Overview (5)

Color

• GLOBCOLA: 1x2 multi-color/polarizers mos.
  - southern ftprt. dark-material optimized
  - northern ftprt. bright-material optimized

• COMPD_VIMS: 1x1 10-color, 3-pol mosaic over dark hemisphere; 705 m/pxl

• LIMBTOPOD, GLOBMAPF:
  - 4-color shutters (2sum; Uv3, Grn, Ir1, Ir3)
  - Were added very late to cover trailing side
Saturn-facing Hemisphere

Voyager 1 data (1980)

Cassini observations (July 2004)

Cassini in October 2004 in “Saturn shine”
9.3 km/pixel; 44° “phase”; sub-S/C lat/lon = 0°/316°
Content

• Context to other satellite flybys
• Context to previous imaging data (Voyager, Cassini)
• ISS scientific goals
• ISS Iapetus B/C observations overview
• Detailed mosaic designs
• More Iapetus in nominal tour
• Summary
ISS_00CIA_LIMBTOPOB001_PRIME
(2004-366T08:00 UTC; 00:30 hrs)

Trigger #                               2158
Telemetry Rate                          S&ER3 (24)
number footprints                       9
number of images                        22
total Data Volume (predict)             93 Mb

3x3 NAC clr mosaic

142000 km alt.; 850 m/pixel;
d_IA=1690 pxl; 62 deg phase;
sub-S/C lat/lon = +40/64;
sun illuminates surface from left

2 NAC shutters per footprint:
220 ms (bright) and 1.2 sec (dark terrain)

WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS_00CIA_LIMBTOPOD001_PRIME
(2004-366T18:30 UTC; 00:30 hrs)

Trigger #                               2160
Telemetry Rate                          S&ER3 (24)
number footprints                       7
number of images                        26
total Data Volume (predict)             92 Mb

2x3 NAC clr mosaic

117500 km alt.; 710 m/pxl (NAC 1sum);
d_IA=2040 pxl; 93 deg phase;
sub-S/C lat/lon = +63/27;
sun illuminates surface from left

2 NAC shutters per footprint:
260 ms (bright) and 1.5 sec (dark terrain)

Ftprt 1: 4-color NAC 2sum (getting mini-piece of trailing side)

Last ftprt: graylight imaging
(6 long exp NAC; 1sum and 2sum)

WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS_00CIA_LIMBTOPOE001_PRIME
(2004-366T22:00 UTC; 00:30 hrs)

Trigger # 2161
Telemetry Rate S&ER3 (24)
number footprints 14
number of images 26
total Data Volume (predict) 100 Mb

Approx. 2+3x4 clr mosaic
120000 km alt.; 720 m/pxl (NAC 1sum);
$\text{d}_{IA}=1990$ pxl; 105 deg phase;
sub-S/C lat/ion = +66/359;
sun illuminates surface from left

2 NAC shutters per footprint (except #1, 2, 13, 14):
260 ms (bright) and 1.8 sec (dark terrain)

Last ftprt: Includes graylight imaging
(2 long exp NAC; 1sum and 2sum)

WAC context is in VIMS_COMPE
ISS_00CIA_GLOBMAPF001_PRIME  
(2005-001T01:00 UTC; 01:00 hrs)

Trigger #                               2163  
Telemetry Rate                          S&ER3 (24)  
number footprints                       10  
number of images                        41  
total Data Volume (predict)             149 Mb  

2+3+2 NAC clr mosaic  
126000 km alt.; 760 m/pxl (NAC 1sum);  
d_IA=1900 pxl; 115 deg phase;  
sub-S/C lat/lon = +64/335;  
sun illuminates surface from left  

2 NAC shutters per footprint:  
320 ms (bright) and 1.8 sec (dark terrain)  

Ftprt #2: 4-color NAC 2sum (get small piece of trailing side)  

1x3 NAC mosaic for graylight imaging  
(6, 7, 6 long exp/ftprt; 1sum and 2sum)  

WAC 4-color context (Vio, Grn, Ir1, Ir3)
ISS_00CIA_DUSTSEAR001_PRIME
(2005-001T13:30 UTC; 01:00 hrs)

- Trigger #: 2166
- Telemetry Rate: S&ER5a (40)
- Number footprints: 17
- Number of images: 37
- Total Data Volume (predict): 81 Mb

- 176000 km alt.; 1.06 km/pxl (NAC 1sum);
- \(d_{IA}=1355 \text{ pxl}; 140 \text{ deg phase}\);
- Sub-S/C lat/lon = +47/300;
- Sun illuminates surface from left

Crescent imaging: 7 NAC-frames clr mosaic (most 1sum)
2 NAC shutters per footprint:
380 ms (bright) and 2.0 sec (dark terrain)

Graylight: 1x5 NAC clr mosaic (1sum and 2sum)
3 NAC clr shutters per footprint

Dust search: 1x5 NAC mosaic (4sum)
1 clr plus 1 P0/clr shutter/ftprt
Summary

• 2nd best lapetus of tour
• 10x higher resolution than all previous data
• 8 full-disk mosaics, 288 frames total
• ISS NAC pixel size up to 710 m/pxl; lapetus size up to >2000 NAC pxl
• Solution of the dark/bright dichotomy riddle?? (This option makes the B/C data set quite unique!)
• Help finding out best observation strategy for Sep 2007 targeted flyby (another 100x closer)
• Many thanks to all involved people who made these observations possible
Cassini

VIMS

S07 Iapetus
Cassini

VIMS

S07 Iapetus
VIMS
Visual and Infrared Mapping Spectrometer
• 0.35 to 5.2 microns in 352 wavelengths
• IFOV: 0.5 x 0.5 mrad (standard)
• High resolution IR: 0.5 x 0.25 mrad
• High resolution VIS: 0.17 x 0.17 mrad
• Images up to 64 x 64 pixels square.
VIMS Iapetus Science

Identification of minerals and other materials on the surface of Iapetus.
Mapping the abundance, and grain sizes of surficial materials.

Grain-Size Mapping
Reflectance from 0.35 to 5.2 microns
Phase function
surface microstructure
Bond albedo
Temperatures > 120K
CIRS Iapetus Preview: Rev B/C


J. Pearl, J. Spencer, M. Segura
20 Dec. 2004
CIRS Rev B/C Iapetus objectives

- Surface temperature mapping.
- Evaluate surface thermal inertias for dark, bright regions.
- Search for spectral signatures of surface components.
# CIRS Observation Timeline

<table>
<thead>
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<th>Request</th>
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</tbody>
</table>
Expected Temperatures

-7, +7 hours from c/a for the old trajectory
  - New trajectory is north of the equator, twice as distant
- Note model temperature discontinuity at the bright/dark boundary
  - Bright polar and trailing sides are typically ~10 K colder
Duration=00:57
AD=8.5 mrad
Sub S/C=(29, 070),
LT=14.4
\(\phi=51^\circ\)

Disk map; Cassini
Regio (subsolr
point \(T_s\approx125\) K)

(1)
Disk map of late afternoon, early evening midlatitudes.

Duration = 04:00
AD = 11.7 mrad
Sub S/C = (54, 049),
LT = 15.9 - 17.4
$\phi$ = 79°
Duration=01:00
AD=12.1 mrad
Sub S/C=(66, 010),
LT=18.6
ϕ=101°

Disk map of polar Latitudes

(3)
Duration=00:30
AD=11.5 mrad
Sub S/C=(65, 342),
LT=20.5
ϕ=112°

Disk map, scan of nighttime high and polar latitudes

(4)
Duration=02:00
AD=11.1 mrad
Sub S/C=(64, 332),
LT=21.2
ϕ=117°

Disk map, scan of nighttime high and polar latitudes (Roncevaux Terra)
Duration = 01:30
AD = 8.4 mrad
Sub S/C = (49, 301),
LT = 23.4
ϕ = 138°

Disk map, scan of nighttime high and polar latitudes (Roncevaux Terra)
UVIS Science at Iapetus

C. J. Hansen, A. Hendrix

20 December 2004
Iapetus Science Objectives

- UVIS Icy Satellite Science Objectives are to Investigate
  - Surface age and evolution
  - Surface composition and chemistry
  - Tenuous atmospheres / exospheres
Surface Age and Evolution

General

• The surface albedo of Saturn’s icy satellites is affected by radiation darkening and surface chemistry, and thus will vary with the amount of time a surface unit has been exposed to the magnetosphere’s radiation and high energy particles. Leading / trailing side asymmetries are expected.
  – Also determined by nature of interactions (e.g. Ganymede’s radiation exposure is affected by its own internal magnetic field)

• Moderate to high resolution global maps of the satellites orbiting in Saturn’s magnetosphere will be used to analyze surface exposure, thus age. These uv maps will be compared to surface age derived from crater counts.

• Surface microstructure will be investigated via the phase function. For example Voyager results on the albedo, color and photometric function properties of Enceladus show a degree of uniformity, regardless of surface age, that suggests the possibility of a thin ubiquitous layer of geologically fresh frost.

Iapetus

• Iapetus, Phoebe and Hyperion all orbit mostly outside Saturn’s magnetosphere (except for time in the magnetotail), thus provide the important end cases of primarily exposure to the solar wind

• UVIS uv albedo maps will be produced. We will look for uv albedo differences that correlate to geologic ages derived from the imaging data and analyze deviations between our data and crater counts that might suggest more recent modification to the exposed surface skin
Example: Phoebe UV Albedo Map

Time: C/A-01:22
Range: 31,300 km
Phase angle: 83°
Lat/Long: 21°S, 349°W

Blue/green=reflected solar
Red=background Ly-α (IPH)
Surface Composition and Chemistry

**General**

- Surface composition and the existence of an atmosphere are affected by sputtering processes. Investigation of photolysis and radiolysis of water ice is currently a very active area of research, propelled by Galileo results, earth-based observations and laboratory work. UV radiation dissociates $\text{H}_2\text{O}$ producing $\text{H}$, $\text{OH}$, $\text{H}_2$, $\text{O}$, and $\text{O}_2$. H and $\text{H}_2$ are quickly lost to thermal escape. Further charged particle interactions produce ozone and hydrogen peroxide.
  - Hydrogen peroxide was identified in the surface ice of Europa. Condensed $\text{O}_2$ has been detected at Ganymede. Spectral absorption suggestive of ozone has been detected by the Galileo UVS on Ganymede, and by HST on Ganymede, Rhea, and Dione. (Note however that these were at longer uv wavelengths than UVIS.)
  - Cassini offers the opportunity to compare a suite of icy satellites even further from the sun than Jupiter’s moons, in a different magnetospheric environment. Being able to compare surface ice oxygen chemistry at a variety of temperatures and radiation environments will help to investigate the process of evolution of surface composition.
- Theoretical and laboratory spectra of various ices are available (e.g. J. Wagner, G. Hansen, S. Warren) and can be compared to UVIS data to map surface composition. Water ice has been detected on all Saturnian satellites - we will show how the amount and distribution varies.

**Iapetus**

- The dramatic albedo difference between the dark and bright sides of Iapetus has been attributed to endogenic or exogenic processes – but which is it? How similar is the composition of the dark side of Iapetus to Phoebe? UVIS reflectance spectra of Iapetus will be compared to Phoebe.
- UVIS spectra may show evidence of $\text{CO}_2$, ammonia, or other interesting species. The amount and distribution of water and other ices will be mapped. The dark and bright sides of Iapetus will be compared.
H₂O, CO₂ frosts contribute to Phoebe’s FUV spectrum; other (dark) materials unknown at this time - similar to C ring non-ice material
Note brightness difference between high and low latitudes
Phoebe’s spectral variations with latitude
Latitude Variations on Phoebe
(No strong correlation with solar incidence angle)

• At longer UV wavelengths
  – Poles - brighter
  – Mid-latitudes - darker

• At shorter UV wavelengths
  – Poles - darker
  – Mid-latitudes - brighter (and emission features stronger)

• => Spectral reversal

• Must have material at poles that is bright at long UV wavelengths, dark at short UV wavelengths.
  – H₂O + red material??
  – Conversely, mid-latitudes are spectrally bluer than poles
Tenuous Atmospheres / Exospheres

General

• Molecules are sputtered and sublimated from the surfaces of the icy satellites. By determining the composition of these exospheres we may determine surface composition. Molecules sputtered from the surface are a source of neutrals in and influencing the magnetosphere. We will look for oxygen atmospheres created by processes analogous to Europa. Determination of atmospheric density, and source and loss rates of atmospheric molecules feeds into models of the magnetospheric interaction. Of particular interest are trace constituents such as $\text{NH}_3$ or $\text{CH}_4$. For example, an ammonia-water ice composition has been proposed to explain the young geology on Enceladus.

Iapetus

• UVIS spectra will be examined for emission features such as 130.4 and 135.6 nm (atomic and molecular oxygen), 149.3 nm (atomic nitrogen), etc.
Europa Oxygen Features

Europa
January 6, 2001

Counts px^{-1} 17000s^{-1}

- sum: rows 31,32
- average: rows (29+30), (33+34)
- model: solar reflection

λ (nm)

115 125 135 145
Preview of Cassini RADAR Observations of Iapetus

Steve Ostro
(for the Cassini RADAR Science and Instrument Operations Teams)

JPL, Dec. 20, 2004
The RADAR Instrument

- 13.78 GHz
- 2.176 cm
- 46 watts
- “SL” polarization
$J_0(\theta) \sim \cos^m \theta$

$m = 1, 2, 4, 10, 100$

$55^\circ, 45^\circ, 35^\circ, 24^\circ, 8^\circ$
GOLDSTONE RADAR DETECTION OF MERCURY
1999 DECEMBER 3 (DOY 337)

18:17:33–18:34:00 UTC
1 run
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<tr>
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<tr>
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S07: Mimas, Enceladus, Rhea, Non-targeted Mosaic Designs