Ultraviolet Observations for Lunar Volatile Detection and Mapping

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KISS: New Approaches to Lunar Ice Detection and Mapping
Ultraviolet defined here as FUV through UVA measurements

- FUV ("vacuum UV"): 100-200 nm
- UVV: 200-280 nm
- UVB: 280-315 nm
- UVA: 315-400 nm
- Can look for water ice, weathering, atmospheric gasses

FUV Water Ice Absorption

Perovich & Govoni (1991)

Gladstone et al., 2010

Warren & Brandt (2008)
PSRs have substantially darker FUV albedos than their surroundings

From Gladstone, 2011
Diviner maximum bolometric surface temperature (E. Sefton-Nash, LPSC 2013)
South Pole

Bottom layer: LPNS epis, smoothed with a gaussian having 30-km FWHM
Top layer: LAMP Ly-alpha Albedo

Elphic, 2012
South Pole

Bottom layer: LPNS epis, smoothed with a gaussian having 30-km FWHM
Top layer: LAMP Ly-alpha Albedo

Elphic, 2012
Example of UV/Vis gas emission sensitivities

The Gas Emission Line Brightness for several Required Species and NEP (Ra/nm)

L1 Requirement Concentrations

<table>
<thead>
<tr>
<th>Species</th>
<th>Requirement Concentration (#/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>$1 \times 10^3$</td>
</tr>
<tr>
<td>Mg</td>
<td>$6 \times 10^3$</td>
</tr>
<tr>
<td>Al</td>
<td>55</td>
</tr>
<tr>
<td>Si</td>
<td>48</td>
</tr>
<tr>
<td>Ti</td>
<td>1</td>
</tr>
<tr>
<td>Fe</td>
<td>$3.8 \times 10^2$</td>
</tr>
<tr>
<td>OH</td>
<td>$1 \times 10^6$</td>
</tr>
<tr>
<td>H$_2$O+</td>
<td>100</td>
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LADEE UVS Observations of OH & H2O+

**Limb**

LADEE UV Spec (1) Science Orbit
- 113 min period
- 40-50 km altitude
- 180 +/− 5 deg inclination

Limb Mode 1
- Instruments on: UV Spec
- Rotating 1 rev/orbit

Limb Mode 2
- Instruments on: UV Spec
- Rotating 1 rev/orbit

Limb Mode 3
- Instruments on: UV Spec
- Rotating 1 rev/orbit

Sunrise terminator
Sunset terminator
North Pole
Earth

### OH

<table>
<thead>
<tr>
<th>Δt x # coadded</th>
<th>For SNR=5 (#/cm²)</th>
<th>For SNR=5 (#/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x1</td>
<td>5.48E+11</td>
<td>12894.78</td>
</tr>
<tr>
<td>1x10</td>
<td>5.48E+10</td>
<td>1289.48</td>
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<tr>
<td>10x10</td>
<td>1.73E+10</td>
<td>407.77</td>
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<td>10x100</td>
<td>5.48E+09</td>
<td>128.95</td>
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<tr>
<td>10x400</td>
<td>2.74E+09</td>
<td>64.47</td>
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</table>

### H2O+

<table>
<thead>
<tr>
<th>Δt x # coadded</th>
<th>For SNR=5 (#/cm²)</th>
<th>For SNR=5 (#/cm³)</th>
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<tbody>
<tr>
<td>1x1</td>
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<td>4246.51</td>
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<tr>
<td>1x10</td>
<td>1.80E+10</td>
<td>424.65</td>
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<tr>
<td>10x10</td>
<td>5.71E+09</td>
<td>134.29</td>
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<tr>
<td>10x100</td>
<td>1.80E+09</td>
<td>42.47</td>
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<tr>
<td>10x400</td>
<td>9.02E+08</td>
<td>21.23</td>
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Possible Applications
• FUV: Similar to LAMP, using Lyman-a as a source to see in the dark, but for longer times for better SNR.
• Dedicated small orbiter or lander/rover
• Monitor impacts (e.g., LRO LAMP)

UVC/B: Monitor for OH mobility
• Beyond LADEE lower altitudes and higher latitudes
• Dedicated small orbiter or lander/rover
• Monitor impacts (e.g., LCROSS VSP)

Strength:
• Good way to look for mobile OH/H2O

Weakness:
• Surface reflectance may be ambiguous