Early Results and Ionospheric Observations from LITES on the ISS

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Acknowledgments

LITES is integrated and flown on the International Space Station as part of the Space Test Program – Houston 5 (STP-H5) payload under the direction of the DoD Space Test Program.

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LITES

Limb-imaging Ionospheric and Thermospheric Extreme-ultraviolet Spectrograph (LITES)

- Imaging spectrograph returns one-dimensional vertical (altitude) airglow profiles of Earth’s limb
- UV airglow from 60-140 nm, ~1 nm spectral resolution
- 10°×10° FOV, ~0.2° vertical resolution
- 3 second cadence ≈ 25 km in-track resolution
- Collects data in daytime and nighttime conditions
LITES on the ISS

LITES launched February 19, 2017 as part of the Space Test Program Houston 5 (STP-H5) payload on a SpaceX Falcon 9 commercial resupply mission to the International Space Station (ISS).

- **Launch**: 19 February 2017
- **Payload Installed**: 27 February 2017
- **LITES First Light**: 6 March 2017
LITES Data

- LITES operates continuously observing the dayside and nightside ionosphere
- LITES observes neutrals and ions simultaneously

<table>
<thead>
<tr>
<th>PHYSICAL QUANTITY/OBJECTIVE</th>
<th>MEASUREMENT</th>
<th>EXCITATION PROCESS(ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[e⁻], [O⁺]</td>
<td><strong>Nighttime:</strong> OI 91.1 nm cont., 135.6 nm</td>
<td>O⁺ + e⁻ → O + hv</td>
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<tr>
<td>Ionospheric density</td>
<td></td>
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<tr>
<td>[O], Tₙ</td>
<td><strong>Daytime:</strong> OI 98.9, 130.4, 135.6 nm</td>
<td>O + e⁻ → O⁺ + e⁻</td>
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<tr>
<td>Atomic oxygen composition</td>
<td></td>
<td></td>
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<tr>
<td>[O⁺]</td>
<td><strong>Daytime:</strong> OII 61.7, 83.4 nm</td>
<td>O + hv → O⁺⁺ + e⁻ + hv (61.7 nm)</td>
</tr>
<tr>
<td>Ionospheric density</td>
<td></td>
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</tr>
<tr>
<td>[N₂], Tₙ</td>
<td><strong>Daytime:</strong> N₂ LBH, 127.0-140.0 nm</td>
<td>e⁻ + N₂ → e⁻ + N₂⁺</td>
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<tr>
<td>Thermosphere N₂ density</td>
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</table>
LITES Ionospheric Emission Lines

Wavelength

O+ 61.7 nm
O+ 83.4 nm
O+ 91.1 nm
H 121.6 nm
O 130.4 nm
O 135.6 nm

Photocathode mask

Altitude

~350 km
~150 km

60 nm

Wavelength

140 nm
Two UV emissions, 91.1 nm and 135.6 nm, derive directly from recombination of $O^+ + e^-$

Line-of-sight brightness is proportional to electron density in the F-region ionosphere
G2 Storm, April 22 2017

91.1 nm brightness shown as a function of altitude for a geomagnetically quiet day (left), and a G2 storm day (right).

April 16 2017 – Kp 1
Lat = 37°, 2250 UT (1138 local time)

April 22 2017 – Kp 6 (G2)
Lat = 35°, 2220 UT (0904 local time)
LITES detected both ions and emission lines from the southern auroral zone.
LITES is part of a suite of ionospheric instruments on the payload along with:

**GPS Radio Occultation and Ultraviolet Photometry- Colocated (GROUP-C)**
- Nadir-viewing UV photometer (TIP)
- GPS receiver (FOTON)

LITES imaging spectrograph and the GPS receiver view the same ionospheric volume imaged by the nadir photometer approximately 200 seconds later.
LITES and GROUP-C are positioned to provide ionospheric measurements below 400 km for at least the next two years.

Measurements in ISS orbital plane

- UV limb profile imagery (LITES)
- UV nadir photometry (GROUP-C/TIP)
- GPS Radio Occultation (GROUP-C/FOTON)
- UV Tomography
Tomography

- The capability of LITES to continuously image over all altitudes in its FOV along with the nadir imaging of TIP (GROUP-C) allows better tomographic imaging than has ever been achieved.
- The LITES and GROUP-C UV sensors can reconstruct ionospheric ion density gradients and bubbles.

(Left) Model 135.6 nm O⁺+e volume emission for a LITES/GROUP-C nightside pass. (Right) Retrieved morphological features from synthesized measurements.
Collaborations with ground-based instruments provide ground-truth for LITES observations, while LITES enables global coverage not possible from the ground

- Global Ionospheric Radio Observatory (GIRO) digisonde network
- BU Optical Network
- Millstone Hill ISR
LITES Complements SSULI, ICON, GOLD Missions

Ongoing/Past

- SSULI F18 (2010)
- SSULI F19 (2014)
- LITES & GROUP-C (2017)
- RAIDS (2009)

Upcoming

- ICON (2017)
- GOLD (2018)
Conclusions

• LITES launched in February and is operational from the ISS, collecting EUV limb data.

• LITES data can be used to characterize the comprehensive daytime ionosphere and thermosphere system to improve ionospheric specification and forecasting.

• LITES pairs with GROUP-C as an ionospheric observatory with an uniquely persistent view of the low-altitude ionosphere, below 400 km, and provides complementary data to conduct tomographic inversions of the ionosphere in the ISS orbital plane.

• LITES/STP-H5 mission will operate for at least 2 years (through Feb 2019), with low data latency that open the door for possible inclusion in assimilative ionospheric models.