Development of a Collimated Large Area Uniform Light Source and New Capability of Solar Diffuser BRDF Tests in Support of NASA Satellite Instrument Programs

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Logan, UT
Purpose

1. Development of collimated large area uniform light source simulating the on-orbit illumination of solar diffusers
   Irradiance level/signal from scatter light, collimation, beam size, and uniformity
2. To support system level test and solar diffuser calibration to realize “Test as you fly”
3. Requirement of OCI SCA QVD BCT BRDF Validation
   Full illumination is required for characterization of Quasi Volume Diffuser
4. Verification of laser scan method in determining BRDF
   Determination of detector FOV footprint, alternative method of large uniform light source, spatial non-uniformity correction
5. Establishment of capability of characterizing large area uniform light source
   Spatial non-uniformity, collimation

BCT
X=140 mm
Y=145 mm

OCI Sensor FOV FP
X=110 mm
Y=90 mm

Integrating sphere like diffuser
Waveguide — — QVD effect
Realization of collimated large area uniformity light source

SORL 6" dia. Spherical mirror

SORL 9" dia. OAP mirror
Realization of collimated large area uniformity light source

**SORL TOAN5-12Q Collimator**

Polarization effect of the folding mirror

**Specifications:**
- **Design type:** Off-Axis Newtonian
- **System focal length:** 60.000"
- **Output clear aperture:** 12.000"
- **System wavefront error:** λ/4 P-V @ 633 nm
- **System length:** 67.00"
- **System width:** 20.20"
- **System height:** 18.875"
- **System weight:** 165 lbs.
- **Mirror substrate material:** Zerodur or Clear Ceram Z
- **Optical Coatings:** AlSiO & AlMgF2
Realization of collimated large area uniformity light source

18” dia. Telescope with FL 80” spherical mirror
Large area Uniform Illumination Scatterometer (LUIS)
Characterization capability of large uniform light source

1. Spatial uniformity of beam
2. Collimation of beam

Pyrocam IV
Beam Profiling Camera
25.6 mm x 25.6 mm
Resolution 80 μm
13-355nm, 1.06-3000μm

L11059 Beam Profiling Camera
35 mm x 24 mm
Resolution 9 μm
190 - 1100 nm
### Irradiance estimation of LED uniform light source vs Sun E

<table>
<thead>
<tr>
<th>$\lambda_0$ (µm)</th>
<th>Sun $E_\lambda^*$ (W/m² µm)</th>
<th>Δ$\lambda$ (µm)</th>
<th>SCA Baffle Area** (m²)</th>
<th>Solar Power (W)</th>
<th>Laser Power (mW)</th>
<th>Comments</th>
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<tr>
<td>0.532</td>
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Sun E 532 nm: 9.43 µW/mm²
Sun E 538 nm: 8.26 µW/mm²
Sun E 785 nm: 5.9 µW/mm²

**M530L4 - 530 nm, 370 mW (Min) LED, 9.46 µW/mm² @200 mm, 0.092 µW/mm²@80”, 1 %
M625L4 - 625 nm, 700 mW (Min) LED, 21.9 µW/mm² @200 mm, 0.212 µW/mm²@80”, 2.6 %
M780LP1 - 780 nm, 800 mW (Min) LED, 47.3(13.3) µW/mm² @200 mm, 0.458 (0.129) µW/mm²@80”, 7.8 %
Collimated Laser-Diode-Pumped DPSS Laser Module, 532 nm, 4.5 mW, Round Beam, Ø6 mm, 159 μW/mm², 17 times higher than Sun E
Verification of signal levels of LUIS using a Spectralon panel + LED@565 nm

**Si Trap Detector**

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Y (mm) | X (mm)
Verification of signal levels of LUIS using a Spectralon panel + LED@565 nm InGaAs Detector

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Preliminary results of a home-made “QVD” and a Spectralon using laser scan method
Preliminary results of home-made “QVD” and Spectralon using laser scan method

\[ QVD \propto \frac{1}{d^2} \]

Home-made QVD

Spectralon
Preliminary results of home-made “QVD” and Spectralon using laser scan method

Spectralon

Home-made QVD

Sample

Detector

High

Low

QVD effect

$\alpha \propto \frac{1}{d^2}$
Preliminary results of home-made “QVD” and Spectralon using laser scan method
Uncertainty evaluation of laser scan method

Total absolute uncertainty = \sum_{i}^{#\text{Scan}} \sqrt{(Unc(S)_i^2 + Unc(M)_i^2)} \times \text{Ratio}_i

Unc(S)_i = \frac{\text{Std}(S)_i}{\text{Mean}(S)_i} \quad \text{Unc}(M)_i = \frac{\text{Std}(M)_i}{\text{Mean}(M)_i}

\text{Ratio}_i = \frac{\text{Mean}(S)_i}{\text{Mean}(M)_i}

Total contribution of all the scans to the fixed FOV = \sum_{i}^{#\text{Scan}} \text{Ratio}_i

Total combined uncertainty in % = \frac{\sum_{i}^{#\text{Scan}} \sqrt{(Unc(S)_i^2 + Unc(M)_i^2)} \times \text{Ratio}_i}{\sum_{i}^{#\text{Scan}} \text{Ratio}_i}
Comparison of uncertainty of integrated signal and each point

- SpecH5_SiPD2inLens2mmSt2.5: Total 0.3181 %
- SpecH5_SiPD2inLens10mmSt2.5: Total 0.2422 %
- QDGrit220_SiPD2inLens2mmSt2.5: Total 0.1974 %
- QDGrit220_SiPD2inLens10mmSt2.5: Total 0.1156 %
Summary

1. Developed a collimated large uniform light source for the OCI BRDF test using 18” dia. Telescope of spherical mirror of FL 80”

2. Characterization of the collimated large uniform light source
   Beam size: 6” dia, Non-uniformity: about 2 - 3 %, Collimation,
   Even if low Irradiance of LED uniform light source, acceptable signal levels of scattered light from Spectralon (Std Dev to mean: < 0.3 %)

3. Comparison of measurements of scattering light from Spectralon and home-made QVD to demonstrate the QVD effect using laser scan method

4. Demonstration of laser scan method for determining the detector FOV FP, simulating the full illumination, and the total uncertainty of the integrated signal is about 0.1 to 0.3 %, Estimation of the irradiance of laser scan at small spot.