A pulsed Tuneable LAser system for the characterisation of Spectrometers (ATLAS).

WP3510: Ground based instrument calibration

ESA/Ideas+ Task 3 phase 1 2015/03 – 2016/06

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Project Deliverables

Project Duration: March 2015 – June 2016

• **WP1**: Commissioning of tuneable laser system.

• **WP2**: Radiometric characterisation of 2 array spectroradiometers using tuneable laser sources

• **WP3**: Development of correction methodologies for stray light and linearity
The optical laboratory of PMOD/WRC
ATLAS Tuneable laser facility
Tuneable laser setup at PMOD/WRC

- Tuning range 210 - 2600 nm
- Pulse 5 ns
- Repetition rate 1000 Hz
- Pulse power at 450 nm ~300 mW
Instrument characterisations performed on the ATLAS setup

Completed:

- Phaeton/Avantes – DOAS/ mini MAXDOAS System
- PSR 006/ PMOD/WRC- spectral aerosol optical depth
- PFR N02 / GAWPFR – 4 channel Moonphotometer

To be done: (in ESA/Ideas+ Task 3 phase 2)

- Pandora #120 /PANDONIA
  (deployed at PMOD/WRC since April 2016)
Spectroradiometer characterisations

- Phaeton Avantes 1509101U1 (cooled CCD version)
- PSR 006 Precision solar Spectroradiometer

1) Linearity Characterisation at different wavelengths
   a) Intensity fixed, varying integration time (electronic nonlinearity)
   b) Varying intensity (photons/sec nonlinearity)

2) Line-Spread Function measurement
   a) Slit function
   b) Stray-light matrix
Linearity characterisation : photons/second

Each line-spread function contains a large range of intensities &

Several line-spread functions are measured for different intensity levels

Phaeton

>4 orders of magnitude
Sampled range 0.1 to 4898 cpms
Nonlinearity < ±2.1% (95%)
Linearity characterisation: photons/second

Each line-spread function contains a large range of intensities &
Several line-spread functions are measured for different intensity levels

PSR 006

Sampled range 0.1 to 16000 cpms
Nonlinearity < ±1.5% (95%)

>5 orders of magnitude
Linearity characterisation : count space

Constant Intensity, only variation of integration times

Significant nonlinearities of up to 15% at low counts
Line-Spread function measurement

To achieve sufficient dynamic range measurements at different saturation levels are combined into one line spread function

2 orders of magnitude improvement
Line-Spread function measurement

To achieve sufficient dynamic range measurements at different saturation levels are combined into one line spread function.
In-band Stray-light correction

The stray-light corrected in-band signal $Y_{IB}$ can be retrieved from the measurement by applying a stray-light correction matrix $A^{-1}$ to the measured signal, following the method of Zong, 2006.

$$Y_{IB} = A^{-1} Y_{meas}$$

![Graph showing slit function and wavelength (nm)]
In-band Stray light correction procedure for array spectroradiometers

Slit Functions obtained from tuneable laser setup

\[ Y_{IB} = A^{-1} \cdot Y_{meas} = C \cdot Y_{meas} \]

In-band straylight matrix

Calculated Straylight
Characterization of Moonphotometer (Lunar PFR)

- Linearity
- Determination of PFR internal gain
- Filter Function

- Direct Irradiance Calibration Setup

Response (V/W.m\(^{-2}\))
Characterization of Moonphotometer

Filter Functions
Scanning Spectral region 300-950 nm

Filter Central Wavelength (nm)
- 861.3
- 501.2
- 412.4
- 675.6
Characterization of Moonphotometer

Filter Functions – Out-of-band rejection

![Graph showing filter functions with wavelengths and rejection values](image-url)
Characterization of Moonphotometer

Direct Irradiance Setup – Responsivity $V \cdot W^{-2}m^2$

Irradiance at reference distance

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Irradiance - Lamp F467 (W.nm$^{-1}.m^{-2}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>861.3</td>
<td>120</td>
</tr>
<tr>
<td>501.2</td>
<td>100</td>
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<tr>
<td>412.4</td>
<td>80</td>
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<tr>
<td>675.6</td>
<td>60</td>
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Determination of reference plane

Distance Reference Plane (detector) to Front window

<table>
<thead>
<tr>
<th>Distance from Lamp (mm)</th>
<th>Dark Corrected Signal$^{-1/2}$ (mV$^{-1/2}$)</th>
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<tbody>
<tr>
<td>300</td>
<td>0.041</td>
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<tr>
<td>1000</td>
<td>0.015</td>
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<tr>
<td>2000</td>
<td>0.010</td>
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<td>2500</td>
<td>0.009</td>
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<tr>
<td>3000</td>
<td>0.008</td>
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## ATLAS Project schedule, phase 1

Kick-Off (KO) 22 June 2015

<table>
<thead>
<tr>
<th>Deliverable number</th>
<th>Deliverable Description</th>
<th>Due Date (KO+#month)</th>
<th>Work Packages</th>
<th>Progress</th>
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<tbody>
<tr>
<td>TD0</td>
<td>Brief Monthly Reports</td>
<td>Monthly</td>
<td>all</td>
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<tr>
<td>TD1.1</td>
<td>Tuneable laser system operational</td>
<td>12.2015</td>
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<td>SOP for LSF and Oor stray light</td>
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<td>TD4</td>
<td>Final report, Presentation</td>
<td>10.2016</td>
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### ATLAS Project schedule, phase 2

**Kick-Off (KO) 5 July 2016**

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<tr>
<td>T1.1</td>
<td>Report on the Wavelength calibration of ATLAS</td>
<td>report</td>
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<td>T2.1</td>
<td>Report on the field homogeneity of the beam conditioning unit</td>
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<td>Certificate for Linearity correction function</td>
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<td>Report on Bandpass and Line-Spread function and determination of stray-light matrix</td>
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<td>T2.3</td>
<td>Report on wavelength dispersion function</td>
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<td>KO+10</td>
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<td>T2.4</td>
<td>Calibration certificate for spectral irradiance</td>
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<td>Dataset from one Pandora system deployed at PMOD/WRC</td>
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