UV-LED radiation source (ULS) for tracking stability and wavelength scale

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UV-LED LIGHT SOURCE FOR TRACKING STABILITY

Objective:

develop a portable UV-LED radiation source for tracking stability and wavelength scale of a newly built UV array spectroradiometer system – ERMIS - by PMOD/WRC

Specification:

Irradiance stability: 0.5 %

WL accuracy: 0.01 nm

WL range: 300 – 350 nm
**UV-LED Light Source for Tracking Stability**

- A multichip LED device (9 LEDs in single TO8 package), 300 nm to 365 nm (by SETi (Sensor Electronic Technology, Inc.) -- > ozone measurement region
- A single LED, 365 nm (Nichia Corp.)
- A single LED, 375 nm (Nichia Corp.)
- A single LED, 405 nm (SETi) 

Added in later phase of development to widen the spectral range and increase the signal level

- All LEDs are operated at a nominal current of 20 mA
- Voltage of each LED is monitored for stability checking
- Temperature is kept stable 25±0.03 °C using peltier element with fan cooled heat-exchanger
- Operated using LabView on a Notebook and dedicated electronics
9-ELEMENT LED CHIP, 300 – 365 NM

- 9-element LED chip in single TO8 package of SETi (price ~2000 €)

Nominal WL-s:
2*303 nm
2*311 nm
2*319 nm
2*332 nm
1*364 nm
365 nm, 375 nm and 405 nm LEDs

365 nm and 375 nm LEDs are from Nichia Corp, 405 nm LED is from SETi TO18 package.
AGING MEASUREMENT WITH INTEGRATING SPHERE

- Initial measurements with 9-element LED attached to a 50 cm PTFE integrated sphere
  - Here shown are LEDs 1-3 (303 nm, 303 nm, 310 nm)

- The PTFE integrating sphere showed changes in its throughput under the UV-LED irradiation* (positive drift) and a recovery without the irradiation manifested by jumps in the measured LED irradiance values after breaking the operation for several hours (marked by vertical green lines)

- LED’s currents and temperature were stable and did not indicate any drift

AGING MEASUREMENTS, FREE SPACE OPERATION

- Behavior of the same UV-LEDs when operated in free space: no more abrupt change of the measured values after pausing the operation for hours. Just a continuous drift of $5 \cdot 10^{-4}/h$ after ca. 100 h operation time.

- Similar behaviour was seen for rest of the LEDs, though shorter burn in times were required.
9-ELEMENT LED

- Wavelength stability of the LEDs during the burn-in time

- LED 364 nm shows different behaviour as compared to the other LEDs
  - For 364 nm, drift: 0.004 nm/h
  - For rest, drift: ~0.0005 nm/h
UV LED SOURCE, UPDATED DESIGN

• Each LED is driven by individual microchip-based current source

• 3 LEDs are added to cover wider spectral range and increase signal level
  – A single LED, 365 nm (Nichia Corp.)
  – A single LED, 375 nm (Nichia Corp.)
  – A single LED, 405 nm (SETi)

• Instead of integrating sphere a diffuser is used at the output
  – The residual non-uniformity is not an issue if reproducible coupling is provided
**CURRENT DRIVER FOR LED**

- Electric current supply for individual LEDs. To improve the temperature characteristics, the chips are fixed on the temperature controlled mount of the LED device.

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**Supertex inc.**

**Simple 90V, 20mA, Temperature Compensated Constant Current LED Driver IC**

**Features**

- 5.0 to 90V operating range ($V_{ns}$)
- 20mA ±10% at 5.0 - 90V
- 0.01%/°C typical temperature coefficient
- Available in TO-243AA (SOT-89), TO-252 (D-PAK), & TO-92 packages
- Can be paralleled for higher current

**General Description**

The Supertex CL2 is a high voltage, temperature compensated constant current source. The device is trimmed to provide a constant current of 20mA ±10% at an input voltage of 5 - 90V. The device can be used as a two terminal constant current source or constant current sink.

A typical application for the CL2 is to drive LEDs with a constant current of 20mA. Multiple CL2s can also be used in parallel to provide higher currents such as 40mA, 60mA or 80mA. The device is available in TO-243AA (SOT-89), TO-252 (D-PAK) and TO-92 packages.
TEMPERATURE STABILITY OF LED DRIVER

- Tests of single CL2 chip at room temperature, different runs (done within ENV03 “solarUV” project)

![Graph showing temperature and current stability over time](image)

Current stability $\sim 5 \cdot 10^{-4}$
UV LED source, Testing Phase

365 nm LED
9 LED element
405 nm LED
375 nm LED
UV LED SOURCE, DESIGN AND HOUSING

- Fused silica diffuser
- Peltier element, cooling fan and heat exchanger
- Coupling mechanics
- Copper housing

UV-LED light source for tracking stability, ATMOZ Workshop at El Arenosillo, 1. June, 2017
UV LED SOURCE, ELECTRONICS AND CABLING

UV-LED light source for tracking stability, ATMOZ Workshop at El Arenosillo, 1. June, 2017
Irradiance at different distances

- 12 LEDs + diffused silica diffuser
- SETi 9-element chip at 364 nm is very weak
- Irradiance comparable to FEL lamp

Measured WL-s were:
- 365 nm → 371 nm
- 375 nm → 374 nm
- 405 nm → 402 nm
TEMPORAL STABILITY AND AGEING

Irradiance drift at different bands

Stability < 5·10⁻⁴ over 20h

UV-LED light source for tracking stability, ATMOZ Workshop at El Arenosillo, 1. June, 2017
SPECTRAL STABILITY IN LABORATORY CONDITIONS

**ULS spectrum and relative stability**

ULS spectrum (red line, right axis) and its relative stability (left axis) over 12h measurement period. Each coloured line represents measurement after 35 min interval.

**Relative irradiance stability measured with CAS140CT**

Relative irradiance stability at LED peak wavelengths (2 nm bandwidth) marked by vertical lines in left figure. Red curve shows irradiance changes integrated over 295 nm – 420 nm.
SPECTRAL STABILITY IN LABORATORY CONDITIONS

**ULS spectrum**

**Relative irradiance stability measured with CAS140CT**

**ULS temperature**

**Ambient temperature**

**Physikalisch-Technische Bundesanstalt ▶ Braunschweig und Berlin**

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UV-LED light source for tracking stability, ATMOZ Workshop at El Arenosillo, 1. June, 2017
STABILIZATION TIME – INTEGRATED SPECTRAL INTENSITY

Integrated signal of spectral regions after LED switch-on at the temperature of 25 °C

After 5 minute operations stability is less than 0.05 %
AMBIENT TEMPERATURE TEST

ULS can stabilize its temperature at ambient temperatures between ~15-31 degrees C°

An example measurement when increasing the ambient temperature from RT
TEMPERATURE STABILITY OF ULS

Temperature / °C

ULS temperature

25,04
25,02
25,00
24,98


01.09 11.09 21.09 01.10 11.10 21.10 01.11

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UV-LED light source for tracking stability, ATMOZ Workshop at El Arenosillo, 1. June, 2017
ERMIS telescope head attached to ULS
Conclusions and work to do:

- The performance of the individual UV-LED chips under laboratory conditions is very good, i.e. stable and reproducible values achieved after expected burn-in times.

- The irradiance values at 365 nm wavelength LEDs are problematic: not as high irradiance as expected (SETi) and not at correct wavelength (Nichia).

- The integrating spheres change under the UV-LED irradiation and are, thus, not ideal for the monitor source application. Also temperature dependence of the PTFE-based materials may pose a problem.

- Initial field test measurements at Izana campaign indicated no problems in the operation of ULS.

- ULS is currently further tested with ERMIS in this measurement campaign.
UV LED SOURCE FOR TRACKING STABILITY

• THANK YOU!
The ageing studies started with the LED device attached to a 50 cm PTFE integrated sphere.
Further burn-in of the LEDs was carried out without the integrating sphere.
Consider most recent data and outdoor measurements. Look Natalia's data.
STABILIZATION TIME – LED VOLTAGES – 40 MINUTES

mesa_data_CAS.txt vom 30.08.2016 15:31:10

Relative change of LED voltages

0.9992 0.9994 0.9996 0.9998 1.0000

15:30 15:40 15:50 16:00 16:10

30.08.16

time / h

Different direction!
Reduction of 0.08%
Integrated signal
280 nm – 420 nm

0.06 % difference

Changes expected

Probable misalignment due to test tube shortness

Re-insertions

Re-insertions + rotations ±90°

Re-insertion
REPEATABILITY OVER 3 DAYS — FREE SPACE CONFIGURATION

Change of 0.06%

Project target is a 0.5% stability!
9-ELEMENT LED, SPATIAL VS SPECTRAL UNIFORMITY

No diffuser

Ground glass diffuser
An example using strong diffuser. It turned out to be transmitting insufficient amount of radiation. Thus weaker fused silica diffuser is used instead.