Novel micro-mirror-based diode array UV solar spectrometer

A. Feldman ³, T. Burnitt ⁵, G. Porrovecchio¹, M. Smid ¹
L. Egli ², J. Gröbner ² and K. M. Nield ⁴

msmid@cmi.cz
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Motivation 1

Solar spectrum

- 5 decades dynamic range in UV 280-400 nm
- >3 decades change over a 20 nm range
- Low irradiance below 300 nm

Measuring Solar UV (290 – 400nm):

- Scanning Double Monochromator
- Advantage:
  - Straylight reduction > 6 orders of magnitude
- Disadvantage:
  - Scanning time for spectrum ~10 – 20 min.
  - Cost and maintenance expensive
DA Spectrometers

Pros:
- Instant acquisition of UV spectrum
- Cost effective for expanding global UV monitoring network

Cons:
- Straylight from other wavelengths with higher intensities
- Low dynamic range of diode array and inherent noise
Conclusion:

To develop some form of a „Double-grating array spectrometer“

Where:

• The role of second grating scanning monochromator is taken by some form of Digital Light Processing Device, responsible for:
  • Suppressing stray-light
  • Extending dynamic range
Micro-mirror-based diode array UV spectrometer

(µ-MUV)

Criteria set for optical design:

• Compact optical set-up matching Optical grating, Digital Light Processor (DLP) and detector array to optimize fill-factor

• To maximize the optical throughput

• Utilizing off-the-shelf commercially available optical and mechanical elements to:
  – Simplify the prototyping
  – Keep the process cost efficient
μ-MUV 1st prototype design

Diagram showing the layout of detected arrays, mirrors, and a grating.
μ-MUV 1st prototype design - side view

- M4
- DLP
- '13'
- Grating
- M2
- M3
- Detector Array
- M1

3D Layout
µ-MUV 1st prototype design
μ-MUV 1st main optical elements

DLP Chip:
Texas Instrument 0.7” XGA, 1024 x 768 micro-mirrors, about 13.92 x 10.44 mm DLP area, VIALUX DLP development kit V4100 with controller suite

Array detector:
Hamamatsu S10141-1108S cooled back-lit detector, pixel size 12 um x12 um 2048 (x 250) pixels, about 24 mm x 3 mm sensitive area

Grating:
Plain ruled 600 G/mm, blazed @ 300 nm, 50 mm x 50 mm x 9.5 mm

All mirrors off-shelf spherical, (f=150 mm, 50 mm diam)
All passive optical and mechanical componants from Thorlabs
\[\text{\(\mu\)-MUV First results}]

**Wavelength scale and Bandwidth:**

- Correction function had to be applied - non-flat focal plain at detector.
- Achieved resolution 0.2 nm, uncertainty within resolution after correction.
- Achieved bandwidth approx. 5 nm, so far wider than expected 2 nm.
μ-MUV First results

Spectral selection of dispersed light:

- QTH Radiation source
- Removing parts of spectra, here 280-350 nm and 350-400 nm
μ-MUV First results

High-speed switching for spectral resolved optical attenuation:
μ-MUV First results

Issues with parasite beams and baffling:

White Light before & after stray light reduction - Log

- Intensity (counts)
- Wavelength (nm)

Before

After
μ-MUV Current activities and future steps

Optimising the mechanical set-up:

- Dedicated customised optical bench
- More robust light-tight housing
- **Thorough baffling for instrumental stray light**

Further optimisation of reflective optics:

- Introducing non-spherical mirrors
- Decreasing entrance slit width from 200 um to 100 um

Extending dynamic range via the tradeoff between spectrally selective filtering (by DLP high-speed switching) and detector’s integration time.