A wavelength ruler for the solar UV wavelength range

Omar El Gawhary, Steven van den Berg

Peter Blattner, Stella Foaleng
Mario Blumthaler
Julian Gröbner, Luca Egli

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Outline

- Principle of the birefringence-based UV wavelength ruler
- Design and implementation of an on-field calibration unit
- Methods and analysis
- Conclusions
Birefringence-based UV wavelength ruler

Why do we need it??

- Large dynamic range of solar radiation measurements in UV (strong absorption below 330 nm) makes UV radiation measurement sensitive to accuracy of wavelength scale
- Not enough intense single lines from lasers or spectral lamps in this wavelength region

Goal

- To decrease the uncertainty for wavelength calibration of detectors in the range 280nm-400nm down to 10 pm
- Create a transportable system, based on birefringent wavelength ruler combined with a broad band source
Birefringence-based UV wavelength ruler

Ruler: the basic structure is made of
- Polarizer
- Birefringent plate of proper thickness (with given tolerance)
- Polarizer

Few constraints are:
- It has to work in the range 280nm-400nm
- Temperature variations should be controlled
- We need enough lines but not too narrow (FWHM~10-20nm)
- It should easily interface with the light source and the radiometer(s)
Birefringence: A material shows different refractive indices for different polarization states → Anisotropic medium
Birefringence-based UV wavelength ruler

- Axis of birefringent plate at 45° with polarizer transmission axis

- The phase difference between slow and fast axis depends on birefringence, plate thickness and wavelength:

\[ \Delta \varphi = \frac{\Delta nL}{\lambda} \]

- So after quartz plate the polarization state depends on the wavelength
Birefringence-based UV wavelength ruler

Simulations based on nominal thickness of the quartz plate of 0.7 mm
Design and implementation of a on-field calibration unit

We made a design based on simulations:
Design and implementation of a on-field calibration unit

Optical components

Housing for thermal control

Controller and isolation plates
Typical experimental setup

We tested it
Ideal vs actual transmission

Forward model

AVOS array spectrometer (PMOD)

Retrieved thick. through Levenberg-Marquardt algorithm

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\lambda \text{ (nm)}
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Results from the 3 instruments

- Plate thickness retrieved from 3 wavelength ranges for 3 instruments
- Indicates a ‘chirped’ scale for some instruments
Retrieved thickness

If we consider all the devices in region 3 we get
L = 0.6962 mm
U (k=2)=0.2 \mu m

With this value we can generate the wavelength scale

For one single device:
SNR = 1000
the uncertainty on the retrieved thickness is at 0.1 nm level (!)
Conclusions

- The principle works. Different spectroradiometers have been compared.
- Potentiality of becoming an absolute and compact calibration device.
- Good portability (appealing for space applications).
- Possibility to extend it to broader spectral ranges.

Outlook: independent calibration of the wavelength ruler based on FT interferometer
Thanks for your attention!