Long-term experience in using deuterium lamp systems as secondary standards of UV spectral irradiance

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Abstract. During the CCPR-K1.b key comparison "Spectral irradiance in the wavelength range 200 nm to 350 nm," a set of 6 newly developed deuterium lamp systems (DLS) have been used as transfer standards. The long-term experiences during this intercomparison demonstrated the quality of the system and confirmed the intention to provide the DLS for the use as a transfer standard of spectral irradiance in the UV spectral range.

The deuterium Lamp system DLS

The DLS consisting of up to four lamps each, a power supply and a monitor-detector have been developed by the Physikalisch-Technische-Bundesanstalt (PTB). They are the result of a thorough investigation of a variety of deuterium lamps and operating conditions in order to test and optimize their capability (stability, reproducibility, sensitivity to misalignment) for the use as traveling standard [1].

Figure 1. Deuterium lamp system (DLS). Lamp housing with lamp exchangeably and reproducibly mounted inside and monitor detector that can reproducibly be aligned on the optical axis in front of the housing.

A Cathodeon J64 30W deuterium lamp is the central part of the DLS. The lamp is mounted within a housing in order to protect the lamp and to achieve sufficiently stable and reproducible operating conditions. It is pre-aligned so that the mechanical axis of the housing is in coincidence to the optical axis of the lamp defined by the direction of the maximum output. The exit port of the housing is designed to either hold an alignment target (jig) or a monitor detector as shown in Fig. 1. The reflecting jig with a reticle in its centre defines both the optical and mechanical axis and the reference plane of the lamp system.

A built-in resistor as well as several electronic circuits are used to permanently monitor electrical voltage, current and heating voltage of the lamp during operation.

A group of these housed lamps are reproducibly operated within one DLS which also comprises an external power supply assigned to the DLS. A typical spectrum of a DLS lamp is shown in Fig. 2.

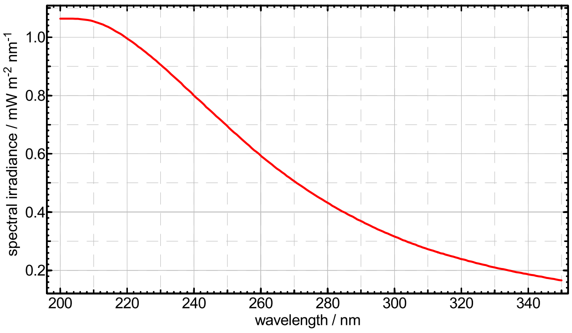

Figure 2. Typical irradiance spectrum of a DLS lamp.

Lamp stability during the intercomparison

During the CCPR key comparison K1.b the lamp systems have been treated in different ways: Two systems remained at the PTB, two systems have been hand-carried to and from the participants and two systems were shipped by courier. In combination with the ageing of the lamps during their operation time of up to 45 hrs and the associated realignment and re-ignition processes, the stability and reproducibility of the DLS could be investigated. Earlier investigations of the lamp system showed that under laboratory conditions the long-term drift is less than $-3 \cdot 10^{-4}$ h^{-1} and the re-ignition reproducibility is better than ± 0.1 % [1].

The analysis of the intercomparison which is still in progress showed that during the intercomparison the majority of the lamps changed by less than 2 % in the whole spectral region from 200 nm to 350 nm during up to 45 hrs of burning time. At the PTB which acted as a pilot laboratory for the intercomparison, the mean drift of all 20 lamps was below -2 %. Compared to precedent experiences with UV working standards [2] and compared to the results of the lamp characterizations, this drift is acceptable low.

Implementation of monitor detectors

In conjunction with these promising results, the ability of external SiC photodiodes to monitor the stability of the DLS could be demonstrated. The monitor detector is an optional part of each DLS. It consists of a hybrid SiC photodiode with built-in operational amplifier. The monitor detector can easily and reproducibly be flanged to the lamp housing and is used before and after spectral measurements of the lamp to monitor the drift of the lamp irradiance at about 280 nm during and between miscellaneous measurements.

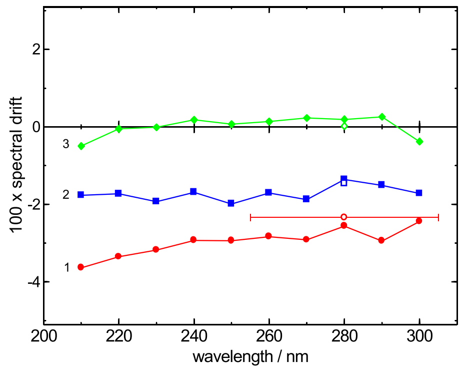

Figure 3. Spectral changes of three different lamps between the first and second calibration sequence at the PTB (the lamp with the highest drift (1), typical example of lamp with medium (2) and low drift (3), respectively). The open symbols at 280 nm refer to the corresponding changes of the monitor detector signals, where the FWHM of the SiC photodiode is indicated.

Using this technique, sudden changes of the lamps as well as the long-term drift can be identified and documented. Thus, it is then possible to at least correct the calibration data by a constant factor which represents the drift. If the spectral drift of a lamp has been measured during the lamp characterization, it is also possible to carry out a spectral correction.

In Fig. 3 three typical examples of lamp changes (low, medium and high drift) and the corresponding variation of the monitor detector signals are shown. This demonstrates the applicability of monitor detectors.

Conclusion and outlook

It could be verified that the new deuterium lamp system (DLS) can be used as transfer standard of spectral irradiance in the spectral region from 200 nm to 350 nm. The use of monitor detectors allows documenting the long-term changes of the lamps and gives the possibility to correct calibration data for lamp changes.

This gives the possibility to extend the recalibration periods of such transfer standards. The DLS which has been developed by the PTB will be the recommended working standard for the UV spectral range. It is commercially available by the Austrian company Schreder CMS [3].

References

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[3] Schreder J., http://www.schreder-cms.com/, Austria, 2005.