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Providing radiometric traceability for the Calibration Home Base of DLR by PTB

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The German Aerospace Center (DLR) is operating the Calibration Home Base (CHB) as an optical laboratory for the calibration of field spectrometers and airborne hyperspectral sensors [1]. To fulfil the radiometric traceability requirements for the CHB, DLR has developed and constructed a novel type of spectral radiance transfer standard, RASTA, operating in the spectral range from 350 nm to 2500 nm. The RASTA consists basically of two elements: a 1000 W FEL type quartz halogen lamp and a Spectralon® diffuse reflection standard aligned in a well defined geometry. Aiming for smallest possible uncertainties, the design of the RASTA was optimized to reduce the uncertainty resulting from possible changes in the irradiance of the lamp and the spectral radiance factor of the reflection standard. This was realized by implementing two narrow-band and three broad-band filter radiometers, spanning the spectral range from 300 nm to 2500 nm, as online monitor detectors.

A dedicated calibration technique was applied for the RASTA at PTB, consisting of two independent but complementing calibration procedures, to provide redundancy and smallest possible calibration uncertainties. Procedure I includes two calibration steps: In a first step the FEL lamp is calibrated in terms of spectral irradiance $E_\lambda(\lambda)$ in the wavelength range from 350 nm to 2400 nm using the PTB Spectral Irradiance Calibration Equipment (SPICE) [2], while in a second step the spectral radiance factor $\beta_{0^\circ:45^\circ}(\lambda)$ of the reflection standard is calibrated in a 0°:45°-viewing geometry in the wavelength range from 350 nm to 1700 nm at the robot-based gonioreflectometer facility of PTB [3]. The achieved relative standard uncertainties (k = 1) range from 1.1% to 6.2% and 0.1% to 0.6% respectively, depending on wavelength. Both calibration steps then allow the calculation of the spectral radiance $L_{\lambda,0^\circ:45^\circ,calc}(\lambda)$ of the reflection standard for a given condition of illumination and alignment geometry according to:

$$L_{\lambda,0^\circ:45^\circ,\mathrm{calc}}\left(\lambda\right) = \frac{E_\lambda\left(\lambda\right)\cdot\beta_{0^\circ:45^\circ}\left(\lambda\right)}{\pi}$$

The second calibration procedure is completely independent from procedure I and allows to cover the entire spectral range of the RASTA up to 2500 nm. In procedure II the spectral radiance $L_{\lambda,0^\circ:45^\circ}(\lambda)$ of the RASTA is directly calibrated at the Spectral Radiance Comparator Facility (SRCF) [4] of PTB by comparison to the spectral radiance of a high-temperature blackbody of known temperature. Due to the RASTA design and the 0°:45°-viewing geometry, the SRCF had to be specially adapted to perform this calibration. The relative uncertainties for this calibration procedure range from 0.8% in the visible up to 7.5% at 2500 nm (k = 1). In the overlapping spectral range of both calibration procedures (350 nm to 1700 nm), the calculated spectral radiance $L_{\lambda,0^\circ:45^\circ,calc}(\lambda)$ from procedure I is in good agreement with the direct measurement of procedure II, i.e. well within the combined uncertainties of both procedures.

[1] P. Gege, J. Fries, P. Haschberger, P. Schötz, H. Schwarzer, P. Strobl, B. Suhr, G. Ulbrich and W. J. Vreeling "Calibration facility for airborne imaging spectrometers", ISPRS Journal of Photogrammetry & Remote Sensing, 64 (2009) 387-397

[2] P. Sperfeld, S. Pape and B. Barton: "From Primary Standard to Mobile Measurements - Overview of the Spectral Irradiance Calibration Equipment at PTB", MAPAN- Journal of Metrology Society of India, 25 (2010) 11-19

[3] D. Hünerhoff, U. Grusemann and A. Höpe: "New robot-based gonioreflectometer for measuring spectral diffuse reflection", Metrologia 43 (2006) S11-S16 doi:10.1088/0026-1394/43/2/S03

[4] D.R. Taubert, R. Friedrich, S. Schiller and J Hollandt: „New Developments in the Calibration of Spectral Radiance at the PTB in the Infrared Spectral Range", Proc. 8^{th} Int. Conf. for Infrared Sensors and Systems (IRS^2) (2004) 219-224