Physikalisch-Technische Bundesanstalt
National Metrology Institute

Moritz Feierabend[1], Julian Gröbner[2], Ingmar Müller[1],
Dirk Fehse[1], Max Reiniger[1], Christian Monte[1]

Blackbody Comparison Measurements for Improved Traceability of Longwave Downward Radiation Measurements

Objective

Longwave downward radiation refers to the infrared radiation emitted in the atmosphere and incident on the surface of the Earth. Pyrgeometers are broadband infrared detectors with a hemispherical acceptance angle and are used to measure longwave downward radiation. Such measurements take place at many stations globally and are, for example, organised by the Baseline Surface Radiation Network (BSRN) [1]. Within the BSRN, the Tilted Bottom Cavity BB2007 [2] at PMOD/WRC has long served as a reference for tracing longwave downward radiation measurements to the SI.

Given the importance of the BSRN, a comparison of the BB2007 to an independent realisation of a reference irradiance source is desirable from a metrological point of view. In this work, a new independent traceability path for the BB2007 was established by means of a comparison to the Hemispherical Blackbody (HSBB). The HSBB has been developed at PTB in recent years and is specifically designed for broadband infrared detectors with a hemispherical acceptance angle.

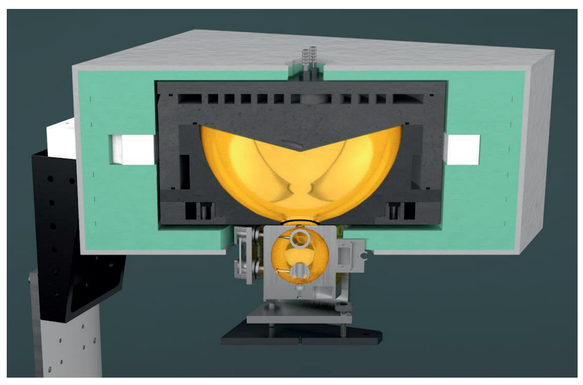

Figure 1: The new Hemispherical Blackbody (HSBB). In the picture, an Infrared Integrating Sphere (IRIS) instrument is placed below the HSBB.

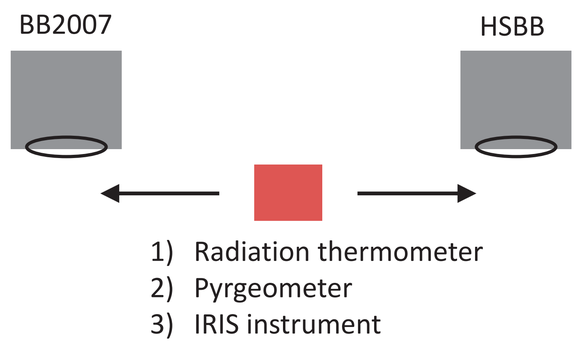

Figure 2: Schematic setup for the comparison measurements between the Tilted Bottom Cavity BB2007 and the HSBB. Different detectors serve as transfer instruments.

Setup

The HSBB, which is shown in a sectional view in Figure 1, consists of a black coated cone in combination with a highly specular reflecting golden hemisphere.

The measurements were carried out in two stages. In the first stage, the HSBB was characterised against the ammonia heat-pipe blackbody that serves as national standard for the Radiation Temperature Scale of PTB [3]. Measurements were carried out with a radiation thermometer as a transfer instrument at normal incidence. In the second stage, the HSBB was brought to PMOD/WRC and comparison measurements took place between the BB2007 and the HSBB. These measurements were performed not only with the radiation thermometer, but also with a pyrgeometer and an Infrared Integrating Sphere (IRIS) [4] as transfer instruments with a hemispherical acceptance angle.

The schematic setup corresponding to the second stage of the measurements is demonstrated in Figure 2. Because the BB2007 and the HSBB were operated face down, a tilted mirror was placed in front of the radiation thermometer to redirect the radiation beam.

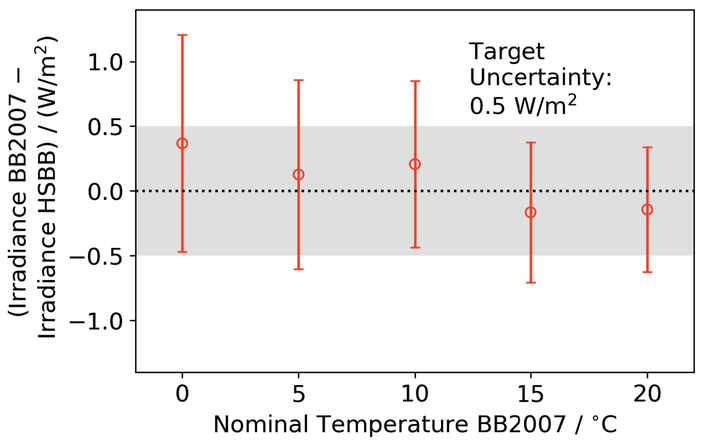

Figure 3: Results for the comparison measurements between the BB2007 and the HSBB. The data points correspond to the measurements performed using an IRIS instrument. The uncertainties correspond to combined uncertainties.

Results

For the comparison measurements between the BB2007 and the HSBB, the results are shown in Figure 3 as examples of measurements using the IRIS instrument. Very good agreement was found within the target uncertainty. Similar results with small but insignificant trends were obtained from the measurements using the radiation thermometer and the pyrgeometer.

References

[1] A. Driemel et al. „Baseline Surface Radiation Network (BSRN): structure and data description (1992-2017)". In: *Earth System Science Data* 10.3 (2018), pp. 1491-1501.

[2] J. Gröbner. "Operation and investigation of a tilted bottom cavity for pyrgeometer characterizations". In: *Applied Optics* 47.24 (2008), pp. 4441-4447.

[3] I. Müller et al. „Non-contact temperature measurement at the Physikalisch-Technische Bundesanstalt (PTB)". In: *Quantitative InfraRed Thermography Journal* 18.3 (2021), pp. 187-212.

[4] J. Gröbner. "A transfer standard radiometer for atmospheric longwave irradiance measurements". In: *Metrologia* 49.2 (2012), pp. S105-S111.

Conclusion

A radiometric comparison between the BB2007 and the HSBB was performed using a radiation thermometer, a pyrgeometer and an IRIS instrument. Good agreement was found with respect to the target uncertainty of 0.5 W/m^2 associated with the HSBB that is traceable via the Radiation Temperature Scale of PTB.

The comparison has shown that there is no unknown bias in the realisation of the irradiance scales of PMOD/WRC and PTB in the temperature range investigated. The results are to be considered an achievement in improving the significance of longwave downward radiation measurements in the realm of climate research and determining the surface energy budget of the Earth.

EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

Physikalisch-Technische Bundesanstalt
National Metrology Institute

Abbestraße 2–12
10587 Berlin, Germany
www.ptb.de

Moritz Feierabend
Working Group 7.32
Infrared Radiation Thermometry
phone: +49 30 3481-7610
e-mail: moritz.feierabend@ptb.de

1 Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany
2 Physikalisch-Meteorologisches Observatorium Davos / World Radiation Center (PMOD/WRC), Switzerland