Spectral Irradiance Measurement Based on Large-area WC-C Fixed Point Blackbody

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We realized spectral irradiance measurement of standard lamp based on large-area WC-C fixed-point blackbody for the first time. The wavelength range is from 390 nm to 1000 nm. We measured spectral irradiance of standard lamp based on traditional variable temperature blackbody and large-area WC-C fixed-point blackbody respectively. The average measurement difference of the two methods is 0.29% within this wavelength range. Compared with the traditional measurement method, the fixed-point method could reduce the average measurement uncertainty from 0.53% (*k*=2) to 0.39% (*k*=2).

INTRODUCTION

Spectral irradiance from 250 nm to 2500 nm is CCPR K1-a Key Comparison [1]. The tungsten halogen lamps are used for the transfer lamps. The lamps are also the most widely used for spectral irradiance measurement. In many national metrology labs, the lamps are measured against the variable high temperature blackbody. The temperature is measured by pyrometer. This is the most common traceability chain for source based method. For this method, the major uncertainty is the temperature measurement uncertainty of the blackbody.

The melting temperature of WC-C fixed point is 3021 K around, which is close to the colour temperature of the tungsten halogen lamps (about 3000 K) [2]. Therefore, this kind of fixed point is very useful for spectral irradiance measurement. For the purpose of spectral irradiance measurement, the large-area WC-C fixed point has been developed [3]. In the following, we will introduce the fixed-point method for spectral irradiance measurement. This is the first time that fixed-point method is used for the spectral irradiance measurement directly.

MEASUREMENT METHOD AND RESULTS

The experimental schematics is shown in Fig. 1. Blackbody A is a variable high temperature blackbody. Blackbody B is large-area WC-C fixed point blackbody. The opening diameter of the fixed point is 14 mm, which is large enough for spectral irradiance measurement.

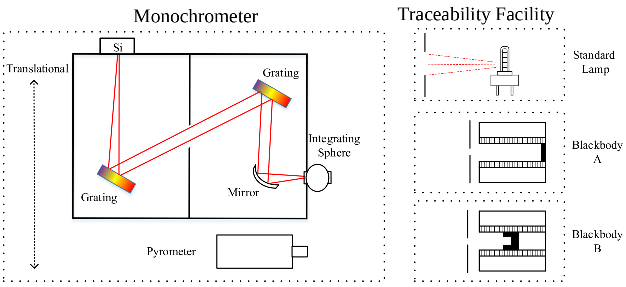

Figure 1. Experimental schematics.

Firstly, we set the temperature of blackbody A at the temperature of 2972.09 K. The temperature is measured by the pyrometer. The system including the monochrometer and Si detector is calibrated by blackbody A. And then, we measure the spectral irradiance of the standard lamp. The wavelength range is from 390 nm to 1000 nm, which is limited by the detector and the gratings. This is method A.

For the fixed point method, we use the melting plateau as the primary standard. We could know the temperature exactly without the pyrometer. The plateau shape is shown in Fig. 2. Using the first and the second derivative of the melting curve, which is shown in Fig. 3, we can obtain the duration of the melting plateau [4-5], about 14.7 min. We also use the same pyrometer to measure a small WC-C fixed point. Then, we obtain the temperature of the large cell,

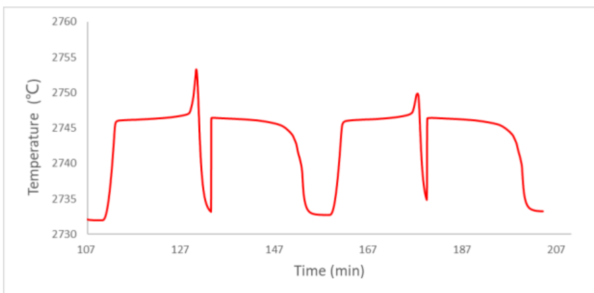

Figure 2. Plateau shape of large-area WC-C fixed point.

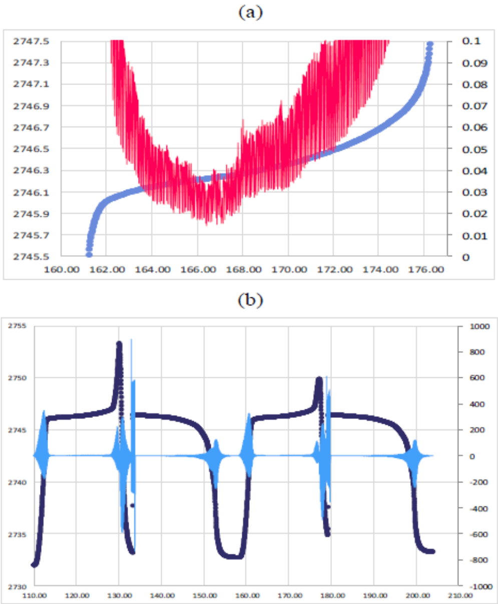

Figure 3. (a) First derivative of the melting curve. (b) Second derivative of the melting curve.

3020.02 K. By the second, third, and fourth melting plateau, which is shown in Fig. 4, we calibrate the system. The blank of the melting plateau means the calibration is going on. We repeat the measurement for three times. The curve shape is not good enough because we put a small diaphragm in front of the blackbody. However, it will not affect the results. This is Method B.

The measurement results are shown in Table. 1. The average measurement difference of the two methods is 0.29%. Compared with Method A, Method B could reduce the average measurement uncertainty from 0.53% (k=2) to 0.39% (k=2).

CONCLUSION

We realized a fixed point method for spectral irradiance measurement of tungsten halogen lamps. The measurement results agreed very well with the traditional variable blackbody method. The fixed point method could shorten the traceability chain and reduce the measurement uncertainty of the primary spectral irradiance scale significantly. The method could be extended to the whole wavelength range from 250 nm to 2500 nm in the near future.

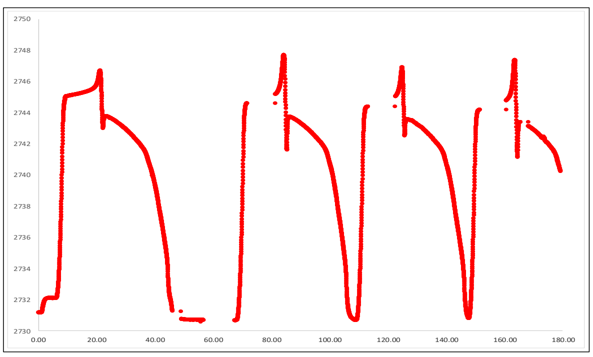

Figure 4. Melting curve for the spectral irradiance measurement.

Table 1. Measurement results.

Wavelength (nm)	Method A ($\mu Wcm^{-2}nm^{-1}$)	Uncertainty A (% k=2)	Method B ($\mu Wcm^{-2}nm^{-1}$)	Uncertainty B (% k=2)	Difference (% B-A)
390	1.44E+00	0.71	1.43E+00	0.44	-0.66
450	3.54E+00	0.64	3.55E+00	0.43	0.47
500	5.94E+00	0.60	5.96E+00	0.42	0.24
550	8.67E+00	0.52	8.69E+00	0.35	0.20
600	1.14E+01	0.50	1.14E+01	0.35	0.10
650	1.39E+01	0.47	1.40E+01	0.34	0.28
800	1.88E+01	0.46	1.89E+01	0.37	0.32
900	1.99E+01	0.46	1.98E+01	0.40	-0.12
1000	1.95E+01	0.45	1.95E+01	0.40	-0.20

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