BIPM Capacity Building & Knowledge Transfer Programme

2023 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Thermocouple calibration by using radiation thermometer method and comparison method
Description	The project is for calibration of thermocouple by using three different approaches; 1st by radiation thermometer by using contact temperature, 2nd by comparison method and 3rd radiation thermometer by using fixed point.
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Date	04.09.2023 to 04.11.2023

Motivation & Introduction

The program in the field of radiation thermometry was focused the calibration of radiation thermometer, where three different approaches were used:

- Calibration of radiation thermometer by comparison method.
- Calibration of radiation thermometer by using contact temperature (PRT and thermocouple).
- Calibration of radiation thermometer by using fixed point.

The training was focused on calibration of radiation thermometer at high temperature and low temperature. The main objective of the training was to find the difference between these approaches, and to define how we can calibrate radiation thermometer and calculate the uncertainty.

Research

The project completed at TUBITAK UME covered theoretical information (basic physical principles of radiation temperature measurements), experimental measurements of various parameters of radiation thermometer, as well as other parameters of devices used for calibration purpose. Basic knowledge about the ITS-90 and modern (the ITS-90 and MeP) traceability chain for the kelvin was obtained. Secondary level radiation temperature calibration approaches were investigated in detail. We took the measurements for radiation thermometers in the temperature range from -50 °C to 1300 °C and study the performance of blackbodies and IR calibrators. Furthermore, many practical calibration exercises were carried out and uncertainty calculations were made. The main activities of the training programme are described below.

Calibration of Radiation Thermometer by using Platinum resistance thermometer

During this experiment the cavity was located inside an alcohol bath and the emissivity was 0.998. The stability was good because we were used alcohol bath and used 2 PRTs as references for calibration of radiation thermometer.

	AT -10 °C			
	Reference	Reference	UUT	UUT
	PRT 1 (24213)	PRT 1 (24214)	TRT ε: 0.9994	TRT ε: 0.998
	Ordel	Fluke		
1	-10.303	-10.477	-9.64	-9.77
2	-10.253	-10.444	-9.61	-9.75
3	-10.235	-10.427	-9.62	-9.72
4	-10.236	-10.422	-9.52	-9.74
5	-10.25	-10.431	-9.61	-9.73
6	-10.273	-10.449	-9.66	-9.71
7	-10.301	-10.477	-9.68	-9.74
8	-10.336	-10.504	-9.75	-9.72
9	-10.359	-10.524	-9.72	-9.69
10	-10.373	-10.539	-9.77	-9.73

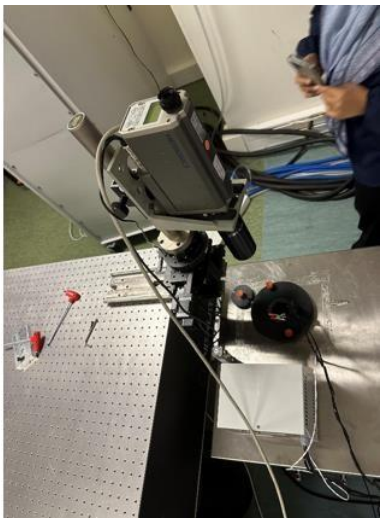

Figure 1. Experimental set-up and measurement results

Calibration of Radiation Thermometer by thermocouple

The following sources were used for calibration: black body for high temperature and alcohol bath and the device under calibration against thermocouple. we used alcohol bath because the junction point for thermocouple, and we made calibration at 1000 °C.

Figure 2. View of calibration set-up

Thermocouples and their calibrations at fixed point and Spectral responsivity measurements

During the training, we conducted the following experimental measurements:

1. Realization of the Silver fixed-point using two different cells.
2. Spectral responsivity measurements for the Transfer Standard Radiation Thermometer (LP5).
3. Linearity and Size-of-Source measurements using the LP5.
4. Realization of the ITS-90 scale using the LP5.
5. Dissemination of the ITS-90 scale using High Temperature Thermocouples (B-type) in the temperature range from 1050 °C to 1300 °C.

In addition to these experimental activities, we acquired knowledge in the realization of the High Radiation Temperature Scale (above 1100 °C) using Metal (Carbide)-Carbon eutectic fixed-points according to the MeP. Techniques for the physical interpolation and extrapolation of the scale, employing a Multi-fixed-point interpolation scheme, and corresponding uncertainty calculations were also part of the training activities.

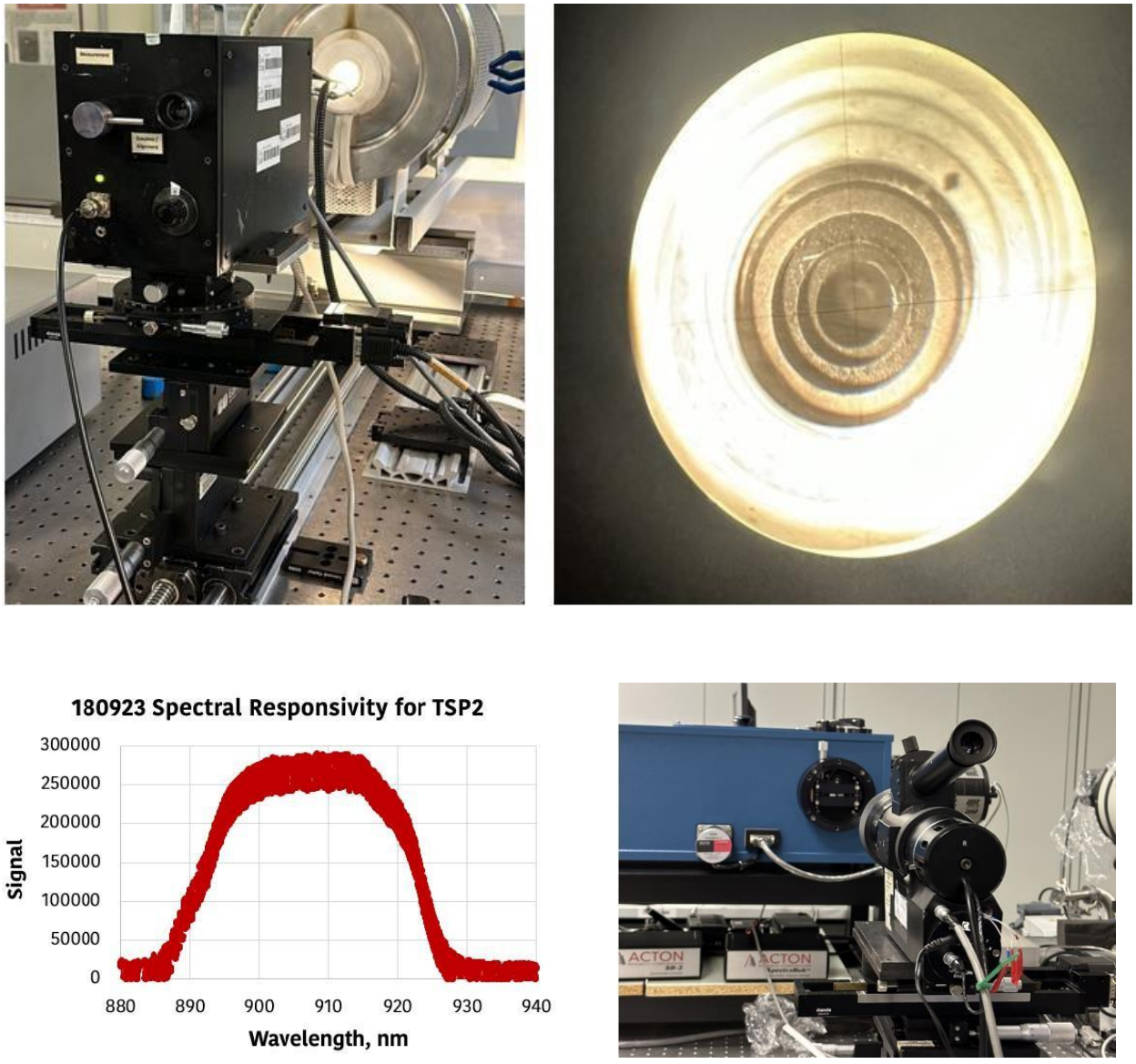

Figure 3. Experimental set-up and graph for measurement results

Conclusions

This work has provided comprehensive and intensive training on calibration of radiation thermometer, which was performed in different ways. The knowledge gained through my studies has contributed substantially to developing skills and gaining experience in the field of metrology. I have plans to develop the capabilities at my institute for measurements of radiation thermometers, participate in an interlaboratory comparison, submit CMCs, and improve the uncertainties of measurements, what will contribute to adding of new services to our institute's services scope.

Acknowledgements

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