Characterization of a Highly Emissive 10- to 100-Micron Blackbody

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Introduction

Fully characterized blackbodies are essential for calibrating instruments under test because they transfer calibration standards such as radiance responsivity to the instrument. Characterization of a blackbody requires a sound understanding of the blackbody design, its emissivity, temperature monitoring and stability.

SDL has developed a Long Wave Infra-Red Calibration Source (LWIRCS) to be used in the calibration of instruments in the 10 to 100 micron range. LWIRCS was first used to calibrate the FIRST (Far InfraRed Spectroscopy of the Troposphere) instrument with great success. The design forces any ray entering the blackbody at near normal incidence to encounter a minimum of six surfaces before exiting. The calculated cavity emissivity is 0.9997 over most of the wavelength range with a minimum of 0.9984.

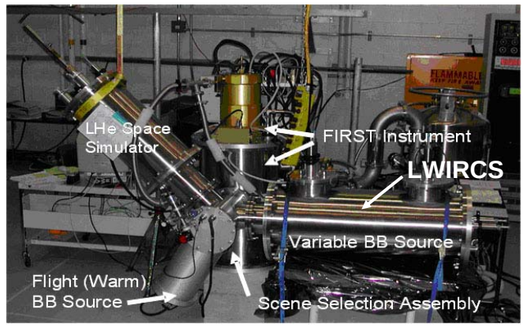

Figure 1. FIRST under calibration with the LWIRCS blackbody.

The calibrated radiance response of the FIRST sensor to data collected with the LWIRCS at various temperatures is shown in Figure 2A, below. The structure on the radiance curves is the result of errors in the relative response function due to small values in the responsivity curves where the beamsplitter transmission is low. In Figure 2B the spectral (brightness) temperature response curves resulting from applying the inverse Planck function to the curves in 2A, showing the temperature of the source.

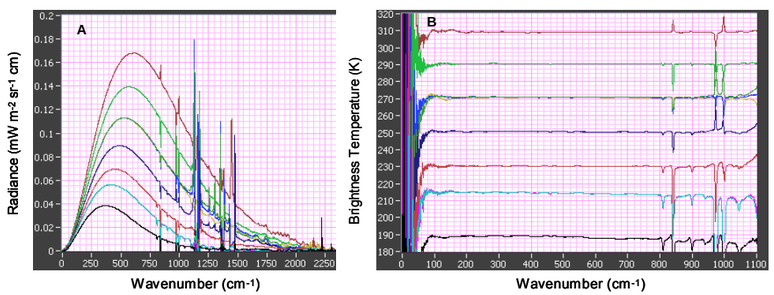

Figure 2. FIRST data collected with LWIRCS at various temperatures.

LWIRCS Design

- 3 levels of cooling available
- Liquid nitrogen heat exchanger included
- 100 W heaters on heater plate, 250 W on shroud, additional 200 W (uncontrolled) on outer cylinder
- Uses 8 PRTs to cover full range
- 2 thermistors also included
- ~1:30 to raise temperature 20 K

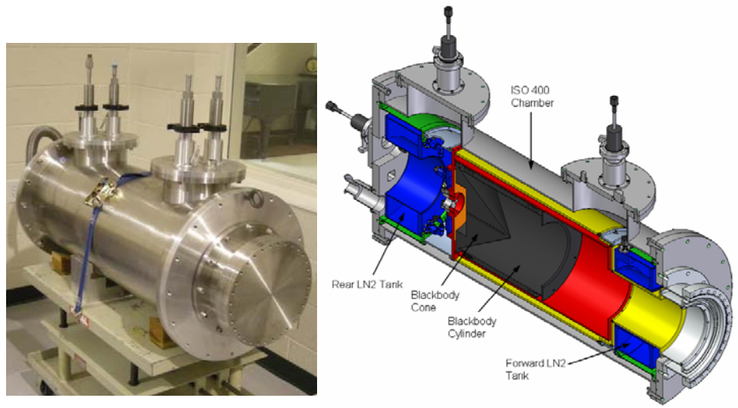

Figure 3. LWIRS blackbody assembly, photograph and sectional view.

Mechanical

Blackbody ISO400 Tube Length:	40” total length
Blackbody ISO400 Tube Diameter:	**16” outer**
Blackbody Cone Diameter / Height:	10” / 7.5”
Blackbody Cylinder Length:	12”

Thermal Performance

Control Temperature Range:	100 – 353 K
Control Stabilization Time	
(15 K increments with a 0.1 K/min stability requirement):	
Near 150 K:	~2 hours
Near 300 K:	~3 hours

Emissivity

Normal Emissivity (10-80 μm):	0.9994
Normal Emissivity (80-100 μm):	0.9963

LWIRCS Results

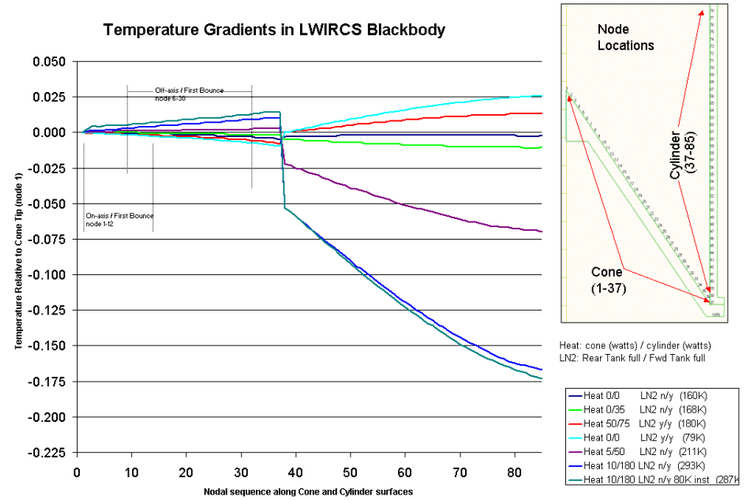

Figure 4. Levels of temperature gradients along the LWIRCS cone and cylinder surfaces at several different operation temperatures.

Conclusion

The performance of LWIRCS was characterized for use during the calibration of FIRST. CORSAIR and the SDL effort are focusing on achieving an absolute radiance responsivity calibration in cooperation with NIST. LWIRCS stability and design for long wave use will be critical to climate programs such as CLARREO and other programs that aim to make measurements in the far infra-red. LWIRCS stability is being enhanced by including phase change cells as part of the temperature monitoring capability in LWIRCS. The performance these cells will also be verified at NIST.

References

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