

Development of the NIST

Detector-based Color Temperature Scale

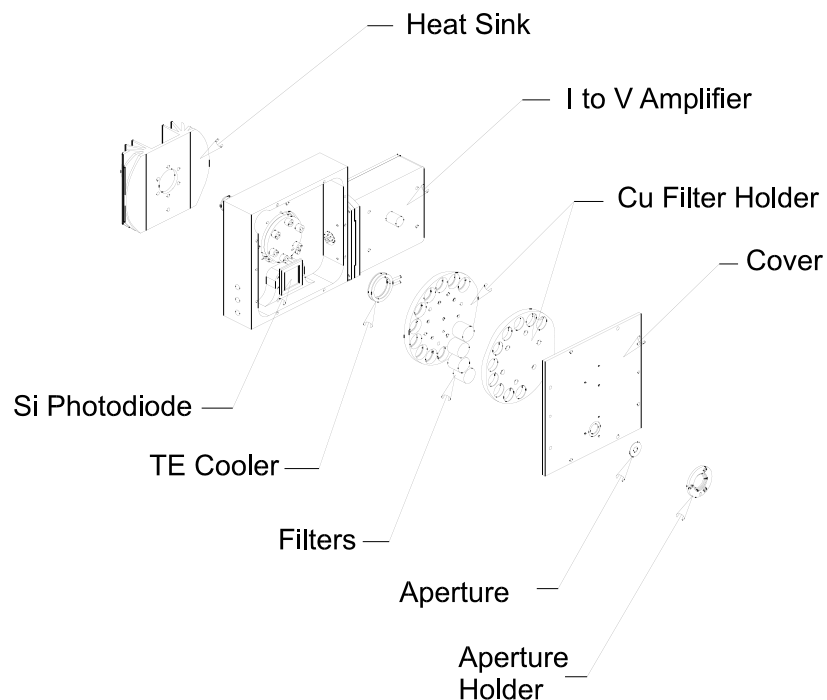
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Abstract

Improvements in detector technology over the past decade have opened a new era in radiometric and photometric calibrations. The detector-based calibration approach is being extended to colorimetry as well. Based on the spectral responsivity of the channels of a tristimulus colorimeter, a colorimetric scale can be realized and maintained [1, 2].

The low uncertainty of the spectral responsivity measurements can dominate the color measurement uncertainty. The achievable detector-based color measurement uncertainties are smaller than the uncertainties of current primary lamp standards. The uncertainty goal for the NIST developed reference tristimulus colorimeters is 4 K at 2856 K ($k=2$) which is a factor of two improvement over the current NIST source-based scale (8 K).

Since the successful preliminary realization of the trap-detector based tristimulus colorimetric scale at NIST [3, 4], new generation, single-photodiode based tristimulus colorimeters are being developed. The large-area single photodiodes are sealed with windows to perform excellent long term stability. The filter wheel is temperature controlled and the filter combinations are individually matched to the photodiode to perform the smallest possible spectral mismatch to the CIE color matching functions.



Exploded view of a new-generation tristimulus colorimeter.

The four channels of a reference tristimulus colorimeter are calibrated on the NIST facility for Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS). The new tristimulus color scale, based on SIRCUS performed spectral responsivity calibrations, is traceable to NIST cryogenic radiometers. A relative expanded uncertainty of less than 0.15 % ($k=2$) can be achieved in the spectral irradiance responsivity determination of the colorimeter channels. This expanded uncertainty will result in a change of 0.0004 in the x , y chromaticity coordinates when measuring a Planckian radiator. The broad-band calibration factors of the colorimeter channels are calculated using the measured spectral irradiance responsivity functions of the channels [1]. After the calculation of the calibration factors and the measurement of the tristimulus values of test light sources using these calibration factors, variable reference source models are applied [4]. These models can adjust the reference spectral source distribution (used to calculate the channel calibration factors) with iterative calculations until the reference spectral source distribution becomes nearly equal to the test source distribution. Using this approach, spectral mismatch errors can be removed from the tristimulus color measurement of tungsten test lamps. The project is funded by the U.S. Air Force where tungsten lamps are used for color temperature measurements.

References

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- [3] G. P. Eppeldauer, and M. Racz, Design and characterization of a photometer-colorimeter standard. *Applied Optics*, 2004, **43**(13) p. 2621-2631.
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