Intensity Calibration of Acton SpectraPro-500i Spectrograph and ICCD Detector

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March 5, 2002
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**Purpose:**
To achieve calibration of the 0.5 m Acton SpectraPro –500i spectrograph plus ICCD unit in the region 350-900 nm using an automated integrating sphere calibration standard.

Calibration of detectors is the tracing of their response to a reference standard. Calibration of sensitive detectors like intensified charged coupled device (ICCD) and spectrographs for response generally requires a large area, uniformly radiating source that is accurately calibrated for luminance, radiance or spectral radiance over a relatively wide dynamic range.

A 12-inch diameter integrating sphere calibration standard (Optronics Laboratories, Inc., Model 455-12-1) which consists of a source module and an electronic controller (Optronics Laboratories, Inc., Model 450) is used for the calibration of the spectrograph equipped with three gratings and coupled to the ICCD. The source module has a 150 W tungsten-halogen lamp with a micrometer controlled variable aperture between the lamp and integrating sphere. Light emitted from the tungsten-halogen lamp is collected by the integrating sphere and uniformly reflected and scattered around the sphere’s interior. So the output is quite uniform in radiance. A precision silicon detector-filter combination with an accurate photopic response mounted in the sphere wall monitors the luminance.

The standard calibration of integrating sphere includes luminance and color temperature. Calibration of spectral radiance is available over wavelength ranges from 350nm to 1100 nm. Figure 1 shows an ideal Planck curve corresponding to a color temperature of 3000 K characteristic of the 12-inch Integrating sphere used for the present calibration studies. Calibration of the integrating sphere source for spectral radiance is based on NIST traceable standards of spectral radiance.
Fig. 1. Spectral radiance vs wavelength for the 12-inch Diameter Integrating sphere Source.

The measuring procedure used is given in fig.2. The 0.5 m Acton SpectraPro spectrograph is equipped with 3 gratings, viz., 150 g/mm (blazed at 500 nm), 600 g/mm (blazed at 500 nm) and 2400 g/mm holographic grating (David Richardson Gratings). The spectrograph is coupled to an intensified charged coupled device (ICCD, PI.MAX Model 512 RB, Princeton instruments). Two quartz bi-convex lenses (f = 25 cm) are used for collimating and focusing the lamp light to the entrance slit of the spectrograph. The wavelength calibration of the set up is performed using the Mercury-Argon lamp (Ocean Optics).

Fig. 2. The set-up used for calibrating the spectrograph + ICCD unit.
The lamp spectra are recorded using the spectrograph-ICCD. The raw data obtained with 150g/mm grating is given in fig. 3.

![Lamp spectrum recorded using 150 g/mm grating](image)

**Fig. 3.** The lamp spectrum recorded using 150 g/mm grating

Knowing that the integrating sphere spectrum should be a Planck curve at 3000 K, one can calculate the spectral responsivity function $F(\lambda)$ where $\lambda$ is the wavelength:

$$I(\lambda) \cdot F(\lambda) = R(\lambda)$$

$I(\lambda)$ is the blackbody spectral irradiance and $R(\lambda)$ is the measured response of the spectrograph. The function $F(\lambda)$ is determined on the assumption that the lamp curve is indeed a $T=3000$ K blackbody curve. Figure 4 shows the responsivity function determined in this manner for 150 g/mm grating. The measurements are repeated with 600g/mm and 2400 g/mm gratings and are given in figure 5 and 6 respectively.
Fig. 4. Spectral response curve of Spectrograph + ICCD + 150 g/mm grating.

Fig. 5. Spectral response curve of Spectrograph + ICCD + 600 g/mm grating.
Summary:
The spectral response of the spectrograph +ICCD is recorded in the region 350-900 nm and calibrated using an Integrating Sphere Calibration Standard. The spectral response of the Spectrograph and ICCD are not measured in the UV region due to the poor emissivity of the lamp in this region.

Thanks to Dr. Dennis Whyte for providing the Integrating Sphere Calibration Standard.