Estimating Uncertainty due to Stray Light in Spectroradiometric Measurements

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Overview

I. Background: Stray Light Model of Zong et al.

II. Application to Estimating Uncertainty

III. Further Investigation: Thought Experiments
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I. BACKGROUND:
Stray Light Model of Zong et al.
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• Characterize Spectroradiometer
  • Measure multiple line sources at different wavelengths
  • Derive Line Spread Functions (LSF)
  • Interpolate to construct a distribution matrix (A)

\[ Y_{\text{meas}} = A Y_{IB} \]

• Stray Light Correction
  • Apply inverse transform (A^{-1}) to measured spectrum
\[ Y_{\text{meas}} = A Y_{IB} = [I + D] Y_{IB} \]

\[ A^{-1} Y_{\text{meas}} = Y_{IB} \]
II. APPLICATION:
Estimating Uncertainty due to Stray Light
Estimating Uncertainty due to Stray Light

- Adopt a “typical” $D$ matrix*
- Apply $D$ to both DUT and REF
- Calculate the quotient:
  \[ Y'_{\text{meas}}(\text{DUT}) = Y_{\text{meas}}(\text{DUT}) / Y_{\text{meas}}(\text{REF}) \]
- Apply assigned REF value as usual, e.g.
  \[ \Phi_{\text{meas}}(\text{DUT}) = Y'_{\text{meas}}(\text{DUT}) \cdot \Phi(\text{REF}) \]
- Compare $\Phi_{\text{meas}}(\text{DUT})$ to $\Phi(\text{DUT})$

*Note: “Typical” $D$ matrix can be scaled...
Spectrometer Readings [counts] for Given Source Spectra

**Given:** \( \Phi(DUT), \Phi(REF) \)

\[ Y_{IB}(DUT) = R\Phi(DUT) \]
\[ Y_{IB}(REF) = R\Phi(REF) \]
Stray Light Effect on Spectrometer Readings [counts]

\[ Y_{\text{meas}} = AY_{IB} = [I + D]Y_{IB} \]

\[ Y_{\text{meas}} = Y_{IB} + DY_{IB} \]
Stray Light Effect on Spectroradiometric Measurement

\[ \Phi_{\text{meas}}(\text{DUT}) = \Phi(\text{REF}) \cdot \frac{Y_{\text{meas}}(\text{DUT})}{Y_{\text{meas}}(\text{REF})} \]

*Also applies to:
irradiance, intensity, and radiance
Compare

$\Phi_{\text{meas}}(\text{DUT})$ to $\Phi(\text{DUT})$

$$\Delta \Phi_{L_{\text{rel}}} = \left( \frac{\Phi_{L_{\text{meas}}}}{\Phi_{L_{0}}} \right) - 1$$

Also: $\Delta x, \Delta y, \text{etc.}$
III. FURTHER INVESTIGATION:
Thought Experiments
Thought Experiments

• Prioritizing Effort and Expense
  – Stray-light characterization & correction
  – State of the art vs. mid-range spectroradiometers
  – Expectations for low-end spectroradiometers

• Evaluating simplified stray light specifications
  – Reconciling different types of stray light standards
  – Proposing standard specifications?
Conclusion

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