NEAR FIELD GONIOMETRIC SYSTEMS FOR SOLID STATE LIGHTING: LUMINANCE, INTENSITY, COLOR, AND SPECTRA AS A FUNCTION OF ANGLE

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Presentation Outline

- What is a Near Field Measurement?
- Traditional Goniometric Systems and Near Field Measurement Systems
- Applications of Near Field Measurements
  - Intensity
  - Luminance
  - Color
- Adding Spectral Data to Measurements
- Raytracing with Near Field Measurements
- Conclusions
### Near Field Measurements

- Light source is not considered a point source
- Luminance of source is measured

- Imaging system used to measure source rather than spot detector
- Measurement can be done at shorter distance than 5x or 10x rule
Near Field Measurements

Luminance Intensity
- Luminous Flux in a given direction $I(\theta, \phi)$
- By definition a far-field measurement – assumes source is a point.

Luminance
- Luminous flux in a given direction per unit area $L(x, y, \theta, \phi)$
- By definition a near-field measurement – accounts for spatial extent of source
Traditional Goniometric Measurements

- Source mounted on a two axis goniometer
- Stationary photometer placed in **far-field**
- Source is rotated in two axes, allowing entire intensity distribution to be sampled
- Luminous intensity distribution created from point measurements
- Alternate configuration is moving mirror goniometer

Goniophotometer at NPL (National Photonics Lab), UK
http://www.npl.co.uk
Near Field Goniometric Measurements

- Source mounted on a two axis goniometer
- Stationary imaging colorimeter (CCD system) placed in near-field views DUT directly
- Source is rotated in two axes, allowing luminance measurements to be recorded at all angles
- Software produces near-field model of luminance and chromaticity vs. angle
- Ray tracing is used to yield far-field intensity data (or illuminance at any distance)
Near Field Goniometric Measurements

- Ray tracing used to yield far-field intensity data
Advantages of Far Field and Near Field Measurements

- **Traditional System**
  - Stray light control
  - No ray tracing to far-field
  - Data file small

- **Near Field System**
  - Smaller space required (no tunnel)
  - Can use data for optical raytrace software to accurately simulate illuminance distributions at any distance, including far-field
  - Luminance data provided (e.g., measuring direct glare)
Applications of Near Field Measurements

- Create intensity by raytracing to the far-field
  - Rays traced to infinity to determine intensity distribution
  - Statistical effects from raytracing

1M rays

10M rays
Applications of Near Field Measurements

- Create intensity from data as measured
  - Luminance summed across projected area
  - No statistical effects from raytracing
  - Measurement distance may show effects of measuring too close to luminaire
Applications of Near Field Measurements

- Create IES / EULUMDAT files

IESNA:LM-63-2002
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Applications of Near Field Measurements

- Comparison of near field raytrace vs far-field goniometric system:
Applications of Near Field Measurements

Luminance

- Direct glare from luminaire
- Use luminance data set as source model to raytrace for correct illumination of room (rather than using IES files for simulation)
Applications of Near Field Measurements

Color
- Color variation vs angle
Applications of Near Field Measurements

Color
• Color appearance vs angle
Adding Spectra to Measurements

Spectrometer Attached to Imaging Colorimeter
• Spectral Irradiance Meter attached to Imaging Colorimeter

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Adding Spectra to Measurements

Spectrometer Attached to Imaging Colorimeter
• Provides spectral data vs angle for each measurement
Raytracing with Near Field Measurements

Luminance images combined for raytracing
- Tracing to infinity to obtain the correct far-field pattern / IES file
- Optical design SW for accurate NF illumination

Simulate illumination of countertop with under cabinet lighting – cannot be done with IES file
Raytracing with Near Field Measurements

Recommend NF Data for Simulation

- Trend to LED based sources for multiple emitters with different distributions
- Increase accuracy of lighting simulation for improved lighting efficiency

1m, 2m, 3m illumination showing increasing uniformity of illumination
Conclusions

Near Field Measurement Systems

- Goniometric system with Imaging Colorimeter in place of spot detector
- Provides far-field intensity with much shorter working distance
- Provides luminance images for appearance of luminaire at different angles
- Can combine with spectral data
- Can create data for use with optical raytrace software to increase accuracy