Lecture

Progress in Photometry

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Some new developments and recommendations for photometry are discussed.

1. Introduction

The basic methods of photometry are known for a long time. With the important change from visual to physical measurements about 50 years ago, faster measurements with lower uncertainty became possible, mainly by the introduction of $V(\lambda)$ -corrected photovoltaic cells. Better electronic and computer, as well as some new ideas, made measurements and evaluations possible that could not be done before.

2. Uncertainty

Standards for luminous intensity from governmental institutions are available with an uncertainty of $4 \cdot 10^{-3}$. In industrial laboratories the measured values for different quantities have hardly less than 1 % deviation. Some times special relative values can be measured more accurately.

The new definition of candela and especially the self-calibrating method of silicon diodes-introduced by J. Geist-allows a basic uncertainty for photometric measurements of 10^{-3} .

3. Photometer Heads

A correct characterization of photometer heads-and photometers-is now possible through the introduction of error definitions for all relevant parameters¹⁾. Classification²⁾, evaluation and comparison³⁾ is now possible.

Photometer heads with good $V(\lambda)$ -correction ($f_i < 1.5$ % full-filtering and partial-filtering) are available. It is often ignored that, because of the local uniformity of responsivity, full-filtered silicon cells are to be preferred for laboratory work. These cells reach high responsivity with small acceptance area.

For precise measurements thermostatisation using thermoelectric cooler (Peltier effect) is used. Special photometer heads with thoroughly defined directional evaluation⁴⁾ have been developed for the measurement of

- cylindrical illuminance E_z
- semi-cylindrical illuminance E_{zh}
- spherical illuminance E_o

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-hemispherical illuminance $E_{2\pi}$ (Fig. 1)

A special detector for the measurement of ratio-temperature-necessary for the calibration of working standard lamps-should be mandatory for industrial laboratories.

At times the relative spectral responsivity of solar cells depends on the level of irradiance. If so, the measurement of the differential spectral responsivity with a filter monochromator, developed for these measurements is necessary.

New reference solar cells for calibration and outside permanent measurement are shown⁵⁾ (fig. 2).

Fig. 1 Photometer Heads for E_o , E_z , E_{zh} , $E_{2\pi}$

Fig. 2 Reference Solar Cells

4. Photocurrent Meter

The measurement of photocurrent of Si-cells and photomultiplier must virtually be done in a short circuit. A resolution of 10^{-14} A (10^{-6} lx) is reached. For fast changes of photocurrent, a photocurrent meter with $2 \cdot 10^4$ measurements/s is used (Fig. 3).

Fig. 3 Fast photocurrent measurements

5. Luminous intensity

The measurement of luminous intensity distribution of luminaires and its evaluation is important for the lighting industry. Goniophotometers⁶⁾ of different types should have an angular resolution of 10^{-2} degree.

Simple automatic goniophotometers with turning the luminaire must use an auxiliary detector. A facility for the burn-in of the luminaires is available. Special laser adjusting for the photometer head is used.

More development of the I-measurement via luminance integration must be done. A special positioning equipment with laser adjustment of luminous intensity standard lamps on a photometric bench was built.

6. Luminous flux⁷⁾

Different goniophotometers with short distance between source and detector are used. Fast and correct Φ -measurement can also be done in industrial laboratories with a goniophotometer with detector array⁸⁾ (30 s measuring time) (fig. 4).

A goniophotometer with turning the luminaire with some

additional equipment is recommended for the measurement in luminaire factories (Fig. 5).

Still a larger number of integrating spheres (up to 3 m ϕ) with automatic data acquisition is sold. Often a good tristimulus colorimeter is used for the direct measurement of lamp colour and correlated colour temperature (Fig. 6). A special CIE TC 2.14 is preparing a report on the measurement of reflectance and transmittance. Simulated spectral power distribution of D65 and global irradiation can be used (Fig. 7). A definition for the spectral quality of the simulation is proposed⁹⁾.

A large sample port is necessary for the measurement of diffusing samples¹⁰⁾ and for the measurement of the characteristics as a function of the angle of incidence (fig. 8).

Fig. 5 Goniophotometer with turning the luminaire used for luminous flux measurement

Fig. 4 Goniophotometer for fast luminous flux measurement with detector array
a) turning the source
b) turning the array

Then an auxiliary screen is used instead of an auxiliary lamp.

We recommend for the measurement of samples with regular reflectance a standard for regular reflectance, instead of the earlier standard for diffuse reflectance. For samples with diffuse transmittance, standards are also prepared. For mixed reflectance and transmittance an interpolation method is developed.

Fig. 6 Tristimulus colorimeter

Fig. 7 Simulation of standard illuminant D 65 with $f_1=2.5\%$

A correct sphere arrangement for spectral radiometers is necessary.

Special photometers have been built for the measurement of straylight and haze, where basic mistakes are avoidable. The measurement of retro-reflection can now be done with high resolution.

7. Lighting installations

Recommendations for lighting installations must be controlled by measurements. Data of artificial lighting is superposed, where it is to be eliminated during daylight. A simultaneous execution of measurements with several photometers at working places with subtraction facility for eliminating daylight influence has been developed. (fig. 9).

Correct and simple instrumentation for all relevant quantities is available¹¹⁾

- illuminance
- cylindrical illuminance
- reflectance¹²⁾ ρ_{diff} (fig. 10)
- shielding angle
- average luminance of luminaires¹³⁾
- daylight factor meter¹⁴⁾ (fig. 11)

Fig. 9 Luxmeter with remote control transmitter

Fig. 8 ρ/τ - Meter
1 : Port for regular reflectance
2 : Port for regular transmittance

Fig. 10 ρ_{dif} - Meter

Fig. 11 D - Meter

Special equipment was developed for the measurement of emergency lighting.

References

- 1) Methods of Characterizing Illuminance Meters and Luminance Meters
Publ. CIE No. 69 (1987)
- 2) DIN 5032 part 7. Lichtmessung
- 3) J. Krochmann Messung von Beleuchtungsanlagen
E. Krochmann Tagungsbericht "Licht 84", Mannheim, Bd. 1,
Vortrag 4, LiTG Berlin, 1984
- 4) J. Krochmann The Characterization of the Directional Response
G. Czibula of Illuminance Meters
Proc. Photonics Meas. Braunschweig 1987, 14-17
p. 130-142, Imeco Sekretariat Budapest
ISBN : 963 592 7525
- 5) H. Kaase Messung der spektralen und integralen Empfindlichkeit von photovoltaischen Solarelementen
OptoElectronic TECHNIK Springer Verlag Berlin 1984 p. 641-645
- 6) The Measurement of Absolute Luminous Intensity Distributions
Publ. CIE No. 70, 1987
- 7) The Measurement of Luminous Flux
Publ. CIE No. 84, 1989
- 8) J. Krochmann Fast and Correct Measurement of Luminous Flux
E. Krochmann Tagungsbericht 21, Tagung CIE 1987, Bd. 1, S.
R. Ziese 152-153
- 9) J. Krochmann Über die Simulation von Normlichtarten
S. Aydinli Tagungsbericht 6. Europäischer Lichtkongress,
G. Czibula 1989, Magyar Elektrotechnika Eggesulett, Budapest 1989
- 10) J. Krochmann On the Measurement of Photometric Characteristics
E. Krochmann of Diffusing Materials
Proc. 20th Session CIE Amsterdam, 1983, Vol. 1, D 203 / 1-4
- 11) J. Krochmann Empfehlungen zur Messung von Beleuchtungsanlagen
F. Lindemuth Schriftenreihe Bundesanstalt für Arbeitsschutz FB 567, Wirtschaftsverlag NW, Bremerhaven 1, 1989
- 12) J. Krochmann Reflexionsgrad von Reflexionstafeln
Schriftenreihe der Bundesanstalt für Arbeitsschutz, Forschung FB 388, Dortmund 1984
- 13) J. Krochmann Meßverfahren zur Blendung am Arbeitsplatz
F. Lindemuth Schriftenr. Bundesanstalt für Arbeitsschutz FB
X. Wang 504, Wirtschaftsverlag NW, Bremerhaven, 1987
H. Pieper
- 14) Ch. Synwoldt Daylight Factor Meter
Symposium on Daylight and Solar Radiation Measurement ISBN 3 900 734 18 6
Proc. CIE Berlin 1989