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**Dissertation title: Circadian radiation metrology**

## Abstract

The subject of this PhD dissertation concerns the development of the measuring path of the broadband measuring head of a compact meter of circadian active radiation parameters. This head was designed for environmental measurements of optical radiation in the wavelength range (380÷600) nm, according to the spectral weight function of melanopsin sensitivity. The dissertation presents the original method of integrated spatial and spectral correction of the semiconductor photodetector for use in the measuring head of the optical irradiance meters.

The measuring head corrected by this method enables irradiance measurements weighted to the function of the circadian active radiation. The need of development this type of measuring head comes from the fact that the currently known, portable broadband integrating measuring instruments do not guarantee spectral and spatial mismatch index level, which is required by international standards specified by CIE and they do not cover all 5 photopigments sensitivity characteristics.

The value of spectral mismatch index $f_1'_{mel.D65}$ of the measurement instruments designed for circadian radiation known from literature is at least at level 40% and spatial mismatch index is not lower than 20%. In result, such instruments cannot be classified according to the CIE standard, because maximum value of these parameters cannot be higher than 9% and 6% respectively for the lowest $1^{st}$ class of instruments.

In order to develop this type of measuring head and prove the thesis, a number of studies on broadband optical meters have been carried out. A set of diffusers and detectors was measured with laboratory equipment developed by the author. Research on absorption filters was based on original mathematical models which were also developed by the author. The data of best in class optical filters were used in simulations. In result measuring head has low spectral mismatch index at level 4,14%, what allows to categorize it into class 2 according to CIE 231:2019 standard (while class 4 stands for highest quality of laboratory equipment).

Based on the results of the research, the sources of measurement errors of broadband optical irradiance meters were identified and a novel method of integrated design of the optical path of the measurement head was proposed. This method takes into account spectral and spatial properties of the components used in optical path, what allows to minimize the spectral mismatch index. In addition, a modification of the optical path of the measuring head was proposed. Adding an original beam shaping element (which is not affecting spatial correction), can further reduce spectral mismatch index to the level of 2,69%, (what is nearly half of the index of the head which does not employ such component). This method can be used with the other spectral sensitivity characteristics of photopigments (erytropic, rhodopic, cyanopic, and chloropic) and reduce spectral mismatch index of respective measurement heads to level which is below 3%. The modified head design has become the subject of patent application No. P.434998 (applied on 18 August 2020 at Polish Patent Office).

Presented broadband measuring head of circadian radiation is currently the only one, which meets international quality standards of CIE in terms of spectral index below 3% and spatial index below 2%, what allows to categorize it in class 3, which stands for high quality equipment.

Finally, it has been proved in this doctoral dissertation that there is a possibility of spectral and spatial correction of the photodetector of the measuring head of the optical radiation meter, that enables to measure the parameters of circularly active radiation with the quality required by the CIE International Commission on Lighting.