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BLUE LIGHT HAZARD MEASUREMENT AND UNCERTAINTY ANALYSIS OF SMARTPHONES

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Abstract. Based on the conclusion obtained from the questionnaire survey: Smartphones are currently the electronic device that has been used the longest and most frequently. The blue light harm that smart phones may cause to the retina was measured. Uncertainty analysis of photobiosafety measurements of smartphones and measurement recommendations are given.

Keywords: smartphones, blue light hazards, measurement uncertainty.

ИЗМЕРЕНИЕ ОПАСНОСТИ СИНЕГО СВЕТА И АНАЛИЗ НЕОПРЕДЕЛЕННОСТИ СМАРТФОНОВ

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Аннотация. На основании вывода, полученного в результате анкетирования: Смартфоны в настоящее время являются электронным устройством, которое используется дольше и чаще всего. Был измерен вред синего света, который смартфоны могут нанести сетчатке. Дан анализ неопределенности измерений фотобиобезопасности смартфонов и рекомендации по измерениям.

Ключевые слова: смартфоны, опасность синего света, погрешность измерений.

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Electronic display devices (electronic watches, smart phones, computers, TVs, screens, etc.) have become a part of human social life, which will affect people's physiology and psychology while transmitting information. As a collection of light radiation sources and information sources, electronic display devices are very different from ordinary light sources (lamps, LEDs, natural light, etc.): 1) look directly to obtain information; 2) invest different attention depending on the content of the information; 3) applied to various scenarios (indoor, outdoor, transportation, etc.). People interact with electronic display devices for a long time, so it is very important to further systematically study the effects of electronic display devices on human body.

As the preliminaries of this article, the author conducts a questionnaire survey on people of all ages from various countries, and draws the main conclusions: 1. Mobile phones are the electronic devices that have been used the longest and most frequently, followed by computers (mainly used for work); 2. People prefer to work in a bright light environment and prefer dynamic content; 3. Long-term use of mobile phones and computers may cause visual and mental fatigue and insomnia [1]. Therefore, this article takes smartphones as the research object to analyze the retinal blue light hazards that may be caused by long-term use of this device.

Blue light hazard refers to the photochemical effect caused by human eyes being exposed to blue light, which can cause retinal damage. The spectral radiance of different wavelengths emitted by the mobile phone screen is multiplied by the blue light hazard weighting function, and the wavelength is integrated to obtain the blue light weighted radiance. In order to prevent photochemical damage to the retina caused by long-term exposure to blue light, the spectral brightness energy of the light source and the weighted blue hazard function B(λ), that is, the weighted brightness L_B of blue light should not exceed 10^6 J/ (m^2 sr) ($t \leq 10^4$ s) or 100 W / (m^2 sr) ($t > 10^4$ s), the formula is expressed as [2]:

$$L_B t = \sum_{300}^{700} \sum_t L_\lambda(\lambda, t) B(\lambda) \Delta t \Delta\lambda \leq 10^6 \quad (t \leq 10^4\ s) \quad (1)$$

$$L_B = \sum_{300}^{700} L_\lambda B(\lambda) \Delta\lambda \leq 100 \ (t > 10^4\ s) \quad (2)$$

where: $L_\lambda(\lambda,t)$ is the spectral radiance, the unit is $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$; $B(\lambda)$ is the blue light hazard weighting function (the blue light hazard weighting curve $B(\lambda)$ adopts the data given in GB/T 20145-2006 [3], and its peak wavelength is at 437 nm); Δλ is the wavelength (nm), t is the radiation duration, (s).

Use the goniophotometer SMS 10c (SMS10C10090111 Calibration Certificate BY 01 № 0027203-5022 of 07/22/2022. Calibration Certificate BY 01 № 0017668-4122 of 07/16/2022) to test the luminous intensity and spectral distribution of smartphone screen in 8 colors, respectively, and the spectral distribution test results are shown in Figure.

Calculate the radiance $L_\lambda(\lambda,t)$ measured in the experiment through the above formula to obtain the final retinal blue light harmful effective radiance L_B.

The sources of measurement uncertainty for this test mainly include:

1. The uncertainty u_A caused by the measurement repeatability of the smartphone being tested.

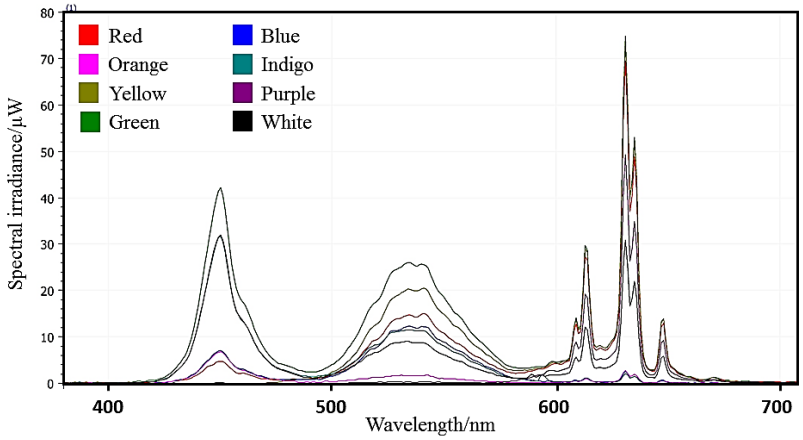
2. The measurement uncertainty u_{B1} caused by the calibration uncertainty of the standard light source.

3. Measurement uncertainty u_{B2} caused by the uncertainty of the spectroradiometer.

4. Uncertainty u_{B3} caused by the placement position of the tested mobile phone.

5. Uncertainty u_{B4} caused by environmental conditions.

In this experiment, a spectroradiometer was used to measure and evaluate the retinal blue light hazard of smartphones. It can be seen from the evaluation results that the uncertainty of the standard lamp and the uncertainty of the spectroradiometer have a greater impact on the measurement uncertainty. Therefore, a high-precision spectroradiometer should be selected as much as possible when measuring, and the standard lamp should be measured regularly to ensure the stability of the standard lamp. Other factors causing uncertainty should also be minimized. The temperature, humidity and airflow of the darkroom should be controlled strictly in accordance with the parameters specified in the standards. Currently, laboratories generally use air conditioners for control. Special attention should be paid to reducing the airflow generated by the air conditioner and reducing its impact on the measurement results.



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