International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

| June 2023 | Issue 55 | Volume 15 | Number 2 | Pages 335-339 |
|---|---|---|---|---|

# RESEARCH ON INFLUENCE OF RADIATION FROM LED LIGHT SOURCES

**S.A. Baghirov [1] S.S. Baghirova [2]**

*1. Department of Electrical Engineering, Azerbaijan Technical University, Baku, Azerbaijan, sabir.bagirov.61@mail.ru*
*2. Department of Automation and Control, Azerbaijan Technical University, Baku, Azerbaijan, selale.bagirova@mail.ru*

**Abstract-** The article deals with the influence of the radiation of light-emitting diode (LED) light sources on the photobiological hazard for the retina. It has been shown that LED lamps with a directional scattering coating and luminaires with scattering and directional scattering diffusers generally do not exceed the zero-risk group (RG0) blue light hazard limits. The specified light sources at brightness not higher than $10^4$ cd/m$^2$ for any values of the correlated color temperature (CCT) in the range of 2700-6500 K refer only to RG0. LED lamps of non-directional, directional light with a diffusing bulb have been studied and assigned to RG0, RG1, respectively. LED directional light lamps without scattering optics are RG1 and due to their high brightness up to $10^6$ cd/m$^2$ can cause discomfort. Most LED lamps and luminaires for indoor lighting are safe for the retina in terms of the photobiological hazard of blue light.

**Keywords:** Light, LED Lamps, Correlated Color Temperature, Blue Light Photobiological Hazard, Brightness.

## 1. INTRODUCTION

At the present stage, the solution to reduce energy consumption for lighting is an actual problem [1, 2]. Equally important problem is the quality of light, although it has received less attention so far [3]. The European legislation has adopted a number of regulations aimed at improving energy efficiency, limiting the usage of inefficient light sources and the quality of lighting [4-8]. Scientists at different levels continue discussions in this direction, and a large number of scientific papers have been published [9-14]. In [9], it is proposed to maintain a balance between the quality of lighting and its energy efficiency. It is shown that today in most countries of the world, particularly in the European Union (EU), at the legislative level, more attention is paid to the energy efficiency of lighting.

The works [10, 11] offer a comprehensive assessment of the quality of lighting. In [11] proposed model for assessing the quality of lighting, which the authors call VBE (visual, biological, emotional), where you need to consider the visual, biological and emotional aspects of lighting. The model is based on indicators of visual perception, comfort (presence of glare, pulsation, brightness variations), life factors (health status, circadian rhythms, safety of exposure to radiation), emotional and aesthetic perception, (ergonomic maintenance, management and adaptation to the environment). Recent results on the biological effects of light, according to [3, 15], require similar action on the quality, photobiological safety of lamps and lighting systems.

It is known that optical radiation (OR) in the tissues of living organisms can cause negative biological reactions, which are determined by the processes of energy conversion at the molecular level [16]. OR is well absorbed by the tissues of the human body, and its penetration depth is small and depends on the radiation spectrum with a wavelength from several micrometers in the ultraviolet region to several millimeters in the near infrared region of the spectrum. The main processes of OR impact on the tissues of the human body is thermal (OR conversion into heat) and photochemical (OR conversion into energy of chemical reactions) processes. Thermal damage mainly depends on the heat transfer of the irradiated tissue, the depth of penetration of OR and the energy illuminance of the irradiated area. Exceeding the corresponding limit values results in bodily injury - local burns.

Due to thermal conduction processes, i.e., diffusion of heat from the volume where OR is absorbed, the limit values for bodily injury depend on the size of the radiation area. Photochemical processes are characterized by action and depend on the energy exposure. The values for safe energy exposure limits are set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and standardized in [17]. This document regulates the limit of dangerous actinic ultraviolet radiation for the skin and eyes, the limit for irradiation of the retina of the eye with blue light and the limit for the danger to the retina of thermal radiation.

Blue radiation risk assessment and classification methods have been developed by the International Commission on Illumination (ICI) jointly with the International Electrotechnical Commission (IEC) [18, 19]. The danger of blue light is classified into four risk groups and is determined by the amount of energy that enters the retina through the pupil of the eye [18]. Hazard parameters for a given exposure time can be represented both as the maximum value of radiance $L_B$ (for light sources with angular dimensions greater than 11 mrad) and as irradiance $E_B$ (for light sources with angular dimensions less than 11 mrad).

The physiological basis for the hazard classification of the zero risk group (RG0) is that when the light source does not pose a danger to the retina for 10000 s. Low risk group (RG1) – the source does not pose a danger (when the limit values RG0 are exceeded) for 100 s. Medium risk group (RG2) - the light source does not pose a danger due to glare or discomfort, which are created by sources of high brightness for 0.25 s. High risk group (RG3) - the source is dangerous even with short-term exposure (at $t$<0.25 s). Exposure time and limit values of energy brightness $L_B$ weighted by the blue light hazard function $B(\lambda)$ and energy illuminance $E_B$ for different risk groups are shown in Table 1 [18].

Table 1. Limit values of energy brightness $L_B$, energy illuminance $E_B$ and exposure time $t$ [18]

| Exposure time $t$, s | Maximum energy brightness $L_B$, W/m²sr | Maximum energy illuminance $E_B$, W/m² | Risk group |
|---|---|---|---|
| $t \geq 10000$ | 100 | 0.01 | RG0 (no risk) |
| $100 \leq t < 10000$ | $10^4$ | 1.0 | RG1 (low risk) |
| $0.25 \leq t < 100$ | $4\times10^6$ | 400 | RG2 (medium risk) |
| $t < 0.25$ | $> 4\times10^6$ | > 400 | RG3 (high risk) |

To determine the danger of blue light, it is necessary to take into account the irradiance of the retina by the image of the light source. With instantaneous exposure, the image on the retina has the same angular size as that of the source. As the exposure time increases, the image spreads more and more over the area of the retina (due to the saccades of the eyes), which reduces its irradiance. Therefore, it is necessary to determine the dependence of the angular size of the image for the exposure time from 0.25 s to 10000 s in the range of angles from 1.7 mrad (the smallest size on the retina) to 110 mrad [20]. The minimum value of 1.7 mrad is set for an exposure time of 0.25 s (limit between RG2/RG3); 11 mrad for 100 s exposure time (limit between RG1/RG2); 110 mrad for 10000 s exposure time (limit between RG0/RG1).

To date, all the positive and potentially negative aspects of the impact of artificial lighting on human safety have not been fully studied, but a number of important consequences of exposure to radiation have been studied sufficiently and standards have been developed that provide recommendations for improving the photobiological safety of lamps and lamp systems. The most vulnerable organs that can be adversely affected by OR are the skin and eyes. The risks of photochemical damage to the retina that can occur with violet and blue light exposure are often associated with LED light sources, although the proportion of blue light in LED sources at the same CCT is about the same as that of light from other sources, such as luminescent lamps (LL) [21]. A number of studies have shown that there is no matter which source of light is generated, an incandescent lamp (IL), LL or LED lamp, the spectrum and brightness of the radiation are important (Figures 1, 2, 3) [18, 19, 22].

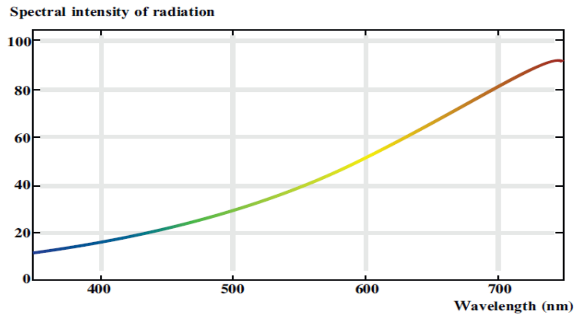

Figure 1. Emission spectrum of IL [22]

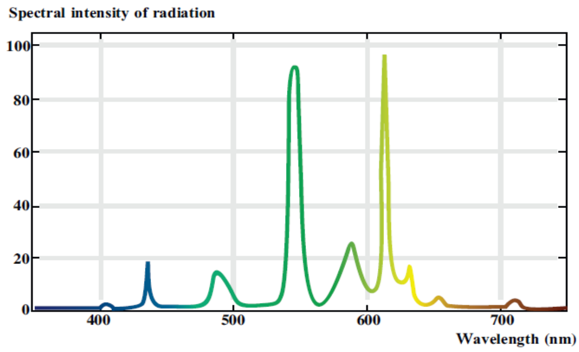

Figure 2. Emission spectrum of LL [22]

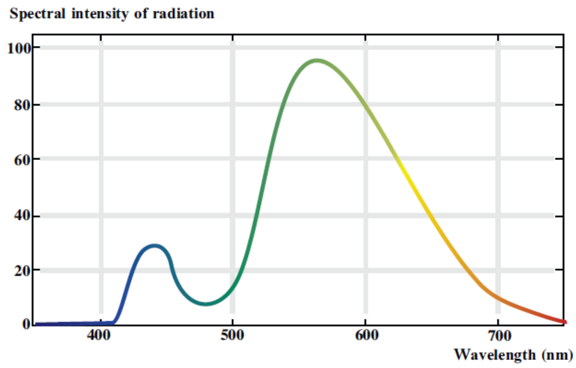

Figure 3. Emission spectrum of LED lamps [22]

Before the advent of bright LEDs, the photobiological safety of lamps and lighting systems was focused on limiting ultraviolet radiation. After the use of white bright LEDs for illumination, the question of the safety of the retina of the blue light arose. According to [23], it must be taken into account when the observer directly looks at the light source, while overcoming the natural desire to avoid bright light. The ICI in [24] clarified the term "blue light hazard". It should only be used when considering the photochemical risk of damage to the retina (photo maculopathy) associated with fixation of sight on bright light sources. The risk of photochemical damage to the retina by blue light depends on the wavelength (with a maximum around 435-440 nm). Looking directly at a bright LED source from a close distance, even for a short period, can be dangerous in terms of photobiological damage.

An analysis of the results of a safety study of OR of LED lamps and luminaires obtained in a number of works [25-28] shows that most of them belong to RG0 of the complete absence of the risk of blue radiation hazard, a small part refers to RG1 and only individual LED lamps and luminaires with high CCT (more than 6000 K) may refer to RG2. The actual photobiological hazard in practice depends on the duration of exposure and is based on the perception response to bright light. The maximum exposure time in RG2 can be changed from 100 to 0.25 s.

If technical solutions are not used to distribute LED light over an area exceeding the area of the emitting crystal, then LEDs may be inferior in photobiological safety, for example, IL with frosted flasks or LL. However, LED lamps and luminaires without optical elements are usually not used. As with traditional lamps and luminaires, various optical devices are used to redistribute the light in such a way as to ensure that the specified requirements are met. Optical systems make it possible to distribute light over large areas and make LEDs suitable for general lighting.

For the further development of LED lighting, the issues of assessing the safety of light are relevant. The transition to LED lighting can be hampered by the fact that inaccurate information is often provided about LED lamps and luminaires. The statement that switching to LED lighting in everyday life threatens health is incorrect. It is also emphasized that LED lighting requires a completely new luminance detection system, since the existing system was designed for conditions not typical for LED. The aim of the work is to study the photobiological hazard of LED lamps and indoor lighting luminaires.

## 2. DISCUSSION OF THE RESEARCH METHOD AND BASIC MATERIAL

Studies of the levels of photobiological hazard of commercial samples of LED lamps and luminaires for indoor lighting of office and domestic premises were carried out. The measurements were carried out using the OST-300 optical radiation test system. The Spectro radiometric system of the complex contains monochromators, a photometric detector, a system for measuring the spectral density of radiation and the dimensions of light sources, as well as an eye simulator in the field of view of 1.7, 11 and 110 mrad, apertures for limiting the field of view, and reference light sources.

The processing of the measurement results is carried out by a computer with software based on spectral measurements and allows you to calculate the blue light energy brightness $L_B$, energy illuminance $E_B$, CCT, brightness $L_V$, illuminance $E_V$ at a distance at which the photobiological hazard of light is determined. Light intensity curves and luminous flux are measured using a GO 2000 goniophotometer. The measurement error of lighting parameters on an OST 300 setup and a GO 2000 goniophotometer does not exceed 5%.

The energy brightness $L_B$ is determined using the Equation (1) [17]:

$$L_B = \sum_{300}^{700} L_\lambda \cdot B(\lambda) \cdot \Delta\lambda \leq 100 \text{ [Wm}^{-2}\text{sr}^{-1}\text{nm}^{-1}] \text{ , } t > 10^4 s \quad (1)$$

where, $L_\lambda$ is spectral energy brightness, $Wm^{-2}sr^{-1}nm^{-1}$, $B(\lambda)$ is the spectral weighting function of the blue light hazard, in relevant units, $\Delta\lambda$ is the wavelength range in nanometers, and $t$ is the exposure duration in seconds.

### 2.1. Measurement of Light and Energy Characteristics

The measurement was carried out in accordance with the recommendations of the standards [18, 19] at a distance of 200 mm in a field of view angle of 11 mrad. We measured LED lamps in flasks with a directionally scattering coating and luminaires for indoor lighting with various types of diffusers - with scattering and directionally scattering transmission. The results of the study of the energy and light characteristics of LED lamps and luminaires are shown in Tables 2 and 3. As can be seen from the obtained results, the blue light hazard of LED lamps with a directional scattering surface, luminaires with a directional scattering and scattering transmission refers to RG0.

Table 2. Parameters of LED spotlights for general lighting

| Lamp characteristics | Lamp numbers | CCT, K | $L_B$, $W/m^2 \cdot sr$ | RG |
|---|---|---|---|---|
| Bulb type A with directional diffusing surface | 1 | 3729 | 22.1 | 0 |
| | 2 | 3748 | 21.6 | 0 |
| | 3 | 3788 | 18.7 | 0 |
| | 4 | 3793 | 7.2 | 0 |
| | 5 | 3796 | 46.1 | 0 |
| | 6 | 3816 | 23.1 | 0 |
| | 7 | 3857 | 27.1 | 0 |
| | 8 | 3883 | 1.5 | 0 |
| | 9 | 3910 | 27.3 | 0 |
| | 10 | 3929 | 33.2 | 0 |
| | 11 | 3935 | 27.4 | 0 |
| | 12 | 5707 | 42.7 | 0 |

Table 3. Parameters of LED luminaires designed to illuminate office and retail premises, educational and children's institutions, household premises

| Luminaire characteristics | Lamp numbers | CCT, K | $L_B$, $W/m^2 \cdot sr$ | $L_V$, $cd/m^2$ | RG |
|---|---|---|---|---|---|
| With directional scattering transmission | 1 | 3720 | 7.4 | 17090 | 0 |
| | 2 | 3905 | 23.2 | 47230 | 0 |
| | 3 | 4590 | 36.2 | 59250 | 0 |
| | 4 | 2852 | 30.4 | 104000 | 0 |
| | 5 | 2883 | 43.3 | 136000 | 0 |
| | 6 | 3377 | 44.6 | 139200 | 0 |
| | 7 | 3706 | 21.1 | 51010 | 0 |
| | 8 | 3742 | 25.3 | 56880 | 0 |
| | 9 | 3780 | 9.4 | 21300 | 0 |
| | 10 | 3938 | 379.8 | 802200 | 0 |
| | 11 | 5130 | 7.2 | 9156 | 0 |
| With scattering transmission | 12 | 3652 | 2.9 | 7326 | 0 |
| | 13 | 3689 | 1.3 | 3182 | 0 |
| | 14 | 3714 | 1.7 | 4186 | 0 |
| | 15 | 3736 | 2.2 | 5300 | 0 |
| | 16 | 3770 | 2.0 | 4694 | 0 |
| | 17 | 3920 | 2.7 | 5989 | 0 |
| | 18 | 3925 | 6.5 | 13230 | 0 |
| | 19 | 3932 | 1.5 | 3342 | 0 |
| | 20 | 4739 | 6.9 | 11670 | 0 |

The assessment of the photobiological hazard of LED lamps and luminaires shows that in the vast majority of lamps belong to RG0 and are safe for indoor lighting. For illumination of rooms in which the photobiological hazard of blue light should not exceed RG0 for any CCT, the brightness of the emitting surface should not exceed $10^4$ $cd/m^2$.

**2.2. Study of LED Lamps for Non-Directional and Directional Light for General Lighting**

On the installation of OST-300 photobiological hazard studies were carried out on commercial samples LED lamps rated 6 watts in the number of 6 pieces of non-directional and directional light for general lighting. Measured and calculated parameters of photobiological safety of LED lamps are shown in Table 4.

Table 4. The results of the assessment of the photobiological safety of LED lamps

| Lamp numbers | Radiation angle, mrad | CCT, K | Color rendering index, rel.un. | Brightness, cd/m$^2$ | Risk group |
|---|---|---|---|---|---|
| 1 | 280 | 3932 | 83.3 | 5300 | RG0 |
| 2 | 260 | 3770 | 84.1 | 4694 | RG0 |
| 3 | 120 | 3929 | 73.6 | 6780 | RG1 |
| 4 | 120 | 3748 | 74.4 | $4.546 \cdot 10^4$ | RG1 |
| 5 | 36 | 3726 | 85.4 | $1.243 \cdot 10^6$ | RG1 |
| 6 | 36 | 2845 | 82.3 | $1.048 \cdot 10^5$ | RG1 |

The LED lamps of non-directional light with a diffusing bulb is referred to RG0, and the directional light lamps with diffusing optics to RG1. In this case the LED non-directional lamps below $10^4$ cd/m$^2$ do not cause any discomfort when these lamps are in the human field of view. Directed light lamps without scattering optics pose no photobiological hazard above RG1, but high luminance up to $10^6$ cd/m$^2$ and can cause discomfort. Therefore, direct exposure to light from these lamps in the field of view is not desirable.

## 3. RESULTS

1) The photobiological hazard of blue light depends on the energy brightness, the angular size of the light source, the CCT, the distance to the observer;
2) Directional LED lamps, scattering and directional transmittance luminaires generally do not exceed the RG0 blue light hazard limits. At brightness's not higher than $10^4$ cd/m$^2$ for any CCT values in the range of 2700-6500 K, they refer only to RG0. LED lamps and luminaires for indoor lighting in terms of blue light photobiological hazard are safe for most applications;
3) Photobiological processes significantly depend on the emission spectrum, exposure time, and to some extent on the geometry of lighting devices, therefore it is important when implementing energy efficient lighting projects to use lamps and luminaires that meet the requirements of photobiological safety standards and recommendations regarding the safe conditions for the use of these products. These should be mandatory conditions for LED lighting;
4) The vast majority of LED lamps and luminaires are RG0 and RG1, so they are safe for general lighting.

## NOMENCLATURES

**1. Acronyms**

| | |
|---|---|
| LED | Light-Emitting Diode |
| EU | European Union |
| CCT | Correlated Color Temperature |
| OR | Optical Radiation |
| IEC | International Electrotechnical Commission |
| ICI | International Commission on Illumination |
| LL | Luminescent Lamp |
| IL | Incandescent Lamp |

**2. Symbols / Parameters**

$L_B$: Energy brightness
$E_B$: Energy illuminance
$t$: Exposure duration
$B(\lambda)$: Spectral weighting function of the blue light hazard
$L_V$: Brightness
$E_V$: Illuminance
$L(\lambda)$: Spectral energy brightness

## REFERENCES

[1] K. Dursun, H. Mordt, "Effect of Led Lighting in Electricity Consumption of Norway", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 15, Vol. 5, No. 2, pp. 143-147, June 2013.
[2] S.A. Baghirov, H.M. Kozhushko, Y.A. Basova, L.N. Guba, "Ways to Increase the Energy Efficiency of Lighting Products in Azerbaijan through the Development of a Technical Regulation System", Materials of the VI International Scientific and Practical Internet Conference, Poltava, Ukraine, pp. 219-221, 14-15 March 2019.
[3] O.S. Pitiakov, S.A. Baghirov, P.I. Neyezhmakov, S.V. Shpak, S.H. Kyslytsia, H.M. Kozhushko, "Photobiological Safety of Image Projectors with Halogen Incandescent Lamps", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 53, Vol. 14, No. 4, pp. 123-127, December 2022.
[4] Commission Regulation (EC) No 244/2009 of 18 March 2009, "Implementing Directive 2005/32/EC of the European Parliament and of the Council with Regard to Ecodesign Requirements for Non-Directional Household Lamps", Official Journal of the European Union, p. 14, 24 March 2009.
[5] Commission Regulation (EU) No 1194/2012 of 12 December 2012, "Implementing Directive 2009/125/EC of the European Parliament and of the Council with Regard to ecodesign Requirements for Directional Lamps, Light Emitting Diode Lamps and Related Equipment", Official Journal of the European Union, p. 22, 14 December 2012.
[6] Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012, "Supplementing Directive 2010/30/EU of the European Parliament and of the Council with Regard to Energy Labelling of Electrical Lamps and Luminaires", Official Journal of the European Union, p. 20, 26 September 2012.
[7] "Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-Use Efficiency and Energy Services and Repealing Council Directive 93/76/EEC", Official Journal of the European Union, pp. 22, 27 April 2006.
[8] "Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the Indication by Labelling and Standard Product Information of the Consumption of Energy and other Resources by Energy-Related Products", Official Journal of the European Union, p. 12, 18 June 2010.

[9] A. Ludwig, "The Problem of Balance - A View from the Lighting Industry on Energy Efficiency and Lighting Quality", Lighting Engineering, No. 3, pp. 3-7, 2010.
[10] J.A. Veitch, G.R. Newsham, C.C. Jones, C.D. Arsenault, S. Mancini, "High-Quality Lighting: Energy-Efficiency That Enhances Employee Well-Being", CIE 2010, Lighting Quality and Efficiency, pp. 197-204, 2010.
[11] B. Martau, P.S. Scarazzato, M.P. Hidalgo, I. Torres, "Clarice Luz-Lighting and Health: Case Study in Retail Stores", CIE 2010, Lighting Quality and Efficiency, pp. 234-246, 2010.
[12] O.C. Ozerdem, S. Biricik, "Overview of Energy System and Major Power Quality Problems in North Cyprus", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 8, Vol. 3, No. 3, pp. 71-75, September 2011.
[13] M. Ari, M.C. Taplamacioglu, "In the Light of Global Developments, Turkey's Electricity Market, Role and Capacity of Electricity Generation Companies", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 12, Vol. 4, No. 3, pp. 152-156, September 2012.
[14] O.B. Sezgin, H. Gozde, M.C. Taplamacioglu, M. Ari, "Energy Efficiency Works at the Airports", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 30, Vol. 9, No. 1, pp. 23-29, March 2017.
[15] P. Neyezhmakov, O. Pitiakov, S. Shpak, S. Baghirov, T. Sakhno, G. Kozhushko, "Luminance Flicker of LED Lamps and Lighting Fittings for General Lighting", Ukrainian Metrological Journal, No. 3, pp. 33-42, Kharkov, Ukraine, December 2022.
[16] S.A. Baghirov, Sh.S. Baghirova, S.H. Kyslytsia, H.M. Kozhushko, S.Z. Mammadzada, "Circad Efficiency of Light-Emitting Diode Radiation for General Lighting", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 50, Vol. 14, No. 1, pp. 172-176, March 2022.
[17] IEC 62471, "Photobiological Safety of Lamps and Lamp Systems", p. 89, July 2006.
[18] IEC/TR 62778, "Application of IEC 62471 for the Assessment of Blue Light Hazard to Light Sources and Luminaires", p. 37, June 2014.
[19] IEC/TR 62471-2, "Photobiological Safety of Lamps and Lamp Systems - Part 2: Guidance on Manufacturing Requirements Relating to Non-Laser Optical Radiation Safety", p .45, 2009.
[20] L. Lyons, "IEC Publishes Blue Light Hazard Assessment Guidelines", Semiconductor Lighting Engineering, No. 4, pp. 64-67, 2014.
[21] S.V. Shpak, L.N. Guba, Y.A. Basova, S.A. Baghirov, H.M. Kozhushko. "Research of the Quality of Color Rendering of LED Lamps and Luminaries", Scientific Bulletin, No. 1, Vol. 91, pp. 105-116, Poltava, Ukraine, November 2019.
[22] www.comsol.ru/blogs/calculating-the-emission-spectra-from-common-light-sources/
[23] D.X. Slayn, "The Impact of New Lighting Products on Human Health and Safety", Lighting Engineering, No. 3, pp. 49-50, 2010.
[24] ICNIRP "Guidelines on Limits of Exposure to Incoherent Visible and Infrared Radiation", No. 105, Issue 1, pp. 74-96, 2013.
[25] F. Behar Cohen, C. Martinsons, F. Vienot, G. Zissis, A. Barlier Sals, J.P. Cesarini, O. Enouf, M. Garcia, S. Picaud, D. Attia. "Light-Emitting Diodes (LED) for Domestic Lighting: Any Risks for the Eye?", Progress in Retinal and Eye Research, Vol. 30, pp. 239-257, 2011.
[26] S.V. Shpak, H.M. Kozhushko, S.H. Kyslytsia, T.V. Sakhno, O.S. Pitiakov. "Research of the Photobiological Safety of LED Lamps and Luminaires for General Lighting", Ukrainian Metrological Journal, No. 4, pp. 29-35, Kharkov, Ukraine, 2020.
[27] C. Martinsons, "Light Emitting Diodes (LEDs) and the Blue Light Risk", The International Review of Ophthalmic Optics, p. 7, May 2013.
[28] W.H. Guo, S. D. Yuan, T. Zhang, "Research on Blue Light Hazard Measurement Method Based on Actual Light Environment", Conference Proceeding by Commission International de L'Eclairage, pp. 1173-1180, 23 October 2017.

## BIOGRAPHIES

Name: **Sabir**
Middle Name: **Aghabaghir**
Surname: **Baghirov**
Birthday: 20.04.1961
Birth Place: Jalilabad, Azerbaijan
Bachelor: Lighting Technology and Light Sources, Department of Lighting Technology and Light Sources, Faculty of Power Supply and Lighting of Cities, Kharkov Civil Engineering Institute, Kharkov, Ukraine, 1983.
Doctorate: Lighting Technology and Light Sources, Faculty of Power Supply and Lighting of Cities, Kharkov Institute of Municipal Engineers, Kharkov, Ukraine, 1990
The Last Scientific Position: Assoc. Prof., Department of Electrical Engineering, Azerbaijan Technical University, Baku, Azerbaijan, Since 2023.
Research Interests: Lighting Technology and Light Sources, Electric Machines, Electrical Apparatuses
Scientific Publications: 42 Papers, 18 Scientific-Methodical Sentences, 8 Patents, 6 Certificates of Authorship, 1 Book

Name: **Shalala**
Middle Name: **Sabir**
Surname: **Baghirova**
Birthday: 31.10.1998
Birth Place: Baku, Azerbaijan
Bachelor: Electrical Engineering, Department of Electrical Engineering, Faculty of Energy and Automation, Azerbaijan Technical University, Baku, Azerbaijan, 2020
Master: Energy Management, Department of Automation and Control, Faculty of Energy and Automation, Azerbaijan Technical University, Baku, Azerbaijan, 2022
Research Interests: Lighting Technology and Light Sources, Energy Management
Scientific Publications: 10 Papers