

**EVALUATION REPORT**  
**on Dissertation**  
**for obtaining the scientific degree “Doctor of Physical Sciences”**  
**in professional field 4.1 Physical science,**  
**on defense procedure at the Faculty of Physics (FzF)**  
**of Sofia University “St. Kliment Ohridski” (Sofia University)**

The review was prepared by: Assoc. prof. Snejana Dimitrova Iordanova, Sofia University “St. Kliment Ohridski”, Faculty of Physics, as a member of the scientific jury according to Order № ПД-38-148/15.03.2021 of the Rector of Sofia University.

**Topic of the dissertation: “Energy transport in optically-created densely-populated organic triplet ensembles”**

**Author of the dissertation: Assoc. Prof. Dr. Stanislav Balouchev**

**I. General description of the submitted materials**

**1. Submitted documents**

The candidate assoc. prof. Dr. Stanislav Baloushev Baloushev presented the following documents: 1. Dissertation thesis (in English); 2. Author’s abstract of the dissertation; 3. Information of compliance with the minimum national requirements and the minimum requirements of the Faculty of Physics, including the mandatory tables for Faculty of Physics of the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University “St. Kliment Ohridski”; 4. Copy of the diploma for the educational and scientific degree “PhD”; 5. Copy of the diploma for higher education of the educational-qualification degree “master”; 6. Autobiography; 7. List of citations; 8. The full text of all publications, included in the dissertation.

All documents necessary for the defense are presented and they comply with the requirements of the state laws and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University “St. Kliment Ohridski”.

**2. Professional and biographic data about the candidate**

The candidate is a graduate of the Faculty of Physics, Sofia University “St. Kliment Ohridski”. In 1990 г. he received a master’s degree in engineering physics, eight years later defended his dissertation on “Phase modulation of light beams. Dark spatial solitons”. In the years 1991-1992 and 1995-2003 the candidate held, respectively, a part time assistant and assistant/senior assistant at the Faculty of German Engineering Training and Industrial Management (FaGETIM) at the Technical University – Sofia. In 2009 г. he held the position of associate professor at the Department of Optics and spectroscopy at the Faculty of Physics.

Dr. Baloushev has held numerous scientific positions and abroad (DAAD, Visiting scientist, Leader of the Photophysical Chemistry group, Senior fellow) working on various projects since 1991.

The teaching activity of assoc. prof. Dr. St. Baloushev includes lectures on the Interaction of organic matter with light (bachelors), Wave optics (bachelors), Organic optoelectronics (bachelors), Technique of spectrometry and photometry (masters), Photoadaptation mechanisms (masters). He has been the supervisor of five master theses in physics, of four PhD students completed, in the process of writing their thesis and he is currently supervisor of three PhD students.

### **3. General characteristics of the candidate's scientific achievements**

The dissertation presented by assoc. prof. Dr. Stanislav Baloushev has a volume of 355 pages and contains 12 Chapters. It is based on 19 articles, 2 book Chapters and 9 World patents. 15 of the articles have been published in top international journals with Q1 and the remaining 4 are with SJR. According to the approved additional requirements of Sofia University "St. Kliment Ohridski" for obtaining the scientific degree "Doctor of Physical Sciences" in the professional field 4.1, the World patents equal to the publication in journal with Q1.

All articles are devoted to experimental research in the field of energy transport in densely populated organic triplet ensembles as special attention is paid to the process of incoherent annihilation up-conversion. The actuality of the of dissertation topic is indisputable as special hopes are placed on the process of triplet-triplet annihilation up-conversion, which is the only up-conversion method allowing efficient use of clean energy from a source of incoherent radiation with low intensity – the Sun.

In Chapter 1 of the dissertation an overview of the processes leading to photon up-conversion is made. The motivation for considering densely populated triplet ensembles is presented, as well as the process of triplet-triplet annihilation (TTA-UC) is described. Chapter 2 and 3 discuss the process (TTA-UC) in a soft matter matrix that is of the main interest in the dissertation. The presented investigations claim to lead to overcoming of fundamental limitations regarding the effective functioning of the up-conversion process. Chapter 3 of the dissertation defines 4 empirical rules for selection of parameters of singlet and triplet energy states of optically active dyes, which guarantee high quantum yield of the TT-UC process in a soft matter matrix. Chapter 4 of the dissertation presents the optimization of the TT-UC process by modifying the molecular structures. Chapter 5 presents the first implemented organic, flexible and transparent multicolor display based on annihilation up-conversion. In Chapter 6, using the TTA-UC process, an increase in the spectral brightness of the Sun in the working area of organic, dye-sensitized solar cells was demonstrated. Chapter 7 demonstrates the extension of the IR boundary for oxygen photosynthesis by annihilation up-conversion. Chapter 8 shows that the degree of local mobility of the involved dyes is the reason for the different efficiency of energy exchange between triplet states and for the TTA-UC process in a soft matter matrix. Chapter 9 presents the transfer of the TTA-UC process to the nanoenvironment as well as the solution of the problem of longterm sealing of the organic solvents used in the previ-

ous chapters of the dissertation, followed by oxygen penetration. This chapter demonstrates the TTA-UC process in aqueous medium with unlimited sealing time. Chapter 10 demonstrates the application of nanoencapsulation techniques to minimize the effect of present oxygen in soft matter that adversely affects the TTA-UC process. Chapter 11 presents various technological solutions for the reduction of singlet oxygen involved in oxidative processes. Chapter 12 presents fully optical simultaneous and minimally invasive testing of temperature and oxygen content in malignant cells.

The scientometric data far exceed both the minimum national requirements (under Art. 2b, para. 2 and 3 of ZRASRB) and the additional requirements of the Faculty of Physics of Sofia University “St. Kliment Ohridski” for obtaining the scientific degree “Doctoral of Physical Science” in the professional field 4.1. Physical Science.

The abstract correctly reflects the material included in the dissertation and its contributions. There is no legally proven plagiarism in the submitted articles, dissertation and abstract. The scientific publications included in the dissertation do not repeat those from previous procedures for acquiring a scientific title or degree.

#### **4. Scientific and scientific-applied achievements**

The dissertation thesis, which is extremely experimental and multidisciplinary, has been developed on the basis of a large number of publications and world patents. This reverberation of the obtained results shows contributions of the candidate in various areas such as creation and confirmation of hypotheses, enrichment of existing knowledge, applications of scientific achievements in practice, etc. The full list of the candidate’s contributions, which I fully accept, is set out at the end of the Abstract.

The publications co-authored with assoc. prof. Dr. Stanislav Baloushev have been cited 2 463 times and the Hirsch index of the candidate is 25.

#### **5. Critical remarks and recommendations**

The dissertation is written in English. The exposition is detailed and well-illustrated. I have no critical remarks on the methods and approaches used. In the abstract there are words with inaccurate translations in Bulgarian such as:

- anti-reflective coating (p. 55);
- solubilization (p. 75);
- utilizes (p. 81).

There are also minor spelling and punctuation errors.

#### **6. Conclusion**

After getting acquainted with the presented dissertation, abstract and other materials, and based on the analysis of their significance and contained in them scientific and scientific-applied contributions, I confirm that the scientific achievements meet the requirements of ZRASRB and the Regulations for its application and the relevant Regulations of Sofia University “Kliment Ohridski” for obtaining the scientific degree “Doctor of Physical Sciences”. The candidate satisfies the mini-

mum national requirements in the professional field and no plagiarism has been established in the dissertation, abstract and scientific papers submitted at the competition.

I give my positive assessment of the dissertation.

## **II. OVERALL CONCLUSION**

Based on the above, I recommend the scientific jury to award the degree of "Doctor of Physical Sciences" in the professional field 4.1 Physical Sciences (Physics of Atoms and Molecules) to Stanislav Baloushev Baloushev.

26.05.2021

Reviewer: .....

(assoc. prof. Snejana Iordanova)