

OPINION
of dissertation work
for obtaining the educational and scientific degree "Doctor"
in professional field 4.1 Physical Sciences
under the defense procedure at the Faculty of Physics
Sofia University "St. Kliment Ohridski"

The review was prepared by Assoc. Prof. Dr. Peter Alexandrov Ivanov from the Faculty of Physics Sofia University , **in his capacity as a member of the scientific jury according to Order № ПД 38-251/23.05.2022 r of the Rector of Sofia University.**

Topic of the dissertation: “Application of Coherent Quantum Control Schemes in Classical Physics”

Author on the dissertation: Mouhamad Al-Mahmoud

1. Candidate details

Mouhamad Al-Mahmoud graduated with a bachelor's degree in physics in 2015 from the Lebanese University in Beirut. In 2018 he completed a master's degree in Photonics and Optics at the University of Lorraine, Metz (France). From 2018 to 2021 he worked in the group of quantum optics and quantum information of Acad . Nikolay Vitanov. Since 2022 he has been enrolled as a doctoral student in an independent form of education in the doctoral program "Physics of Atoms and Molecules".

2. Data for presented documents

The candidate Mouhamad Al-Mahmoud presented a dissertation (in English), and abstract (in Bulgarian), a resume, a diploma of higher education, and a list of dissertation articles. Presented in full text 5 publications supporting the achievements of the candidate participating in the dissertation were attached. The documents submitted by the candidate fully comply with the requirements of the Law on the Protection of Scientific and Technological Research, the Rules of Procedure and the Regulations for the Acquisition of Scientific Degrees and Academic Positions at Sofia University “St. Kliment Ohridski”.

3. General characteristic on scientific achievements on the candidate

Judging by the content of the dissertation, the interests of Muhammad al-Mahmoud are in the field of the analogies between processes in quantum physics and those in classical (wave, polarization and nonlinear) optics. The scientific publications included in the dissertation meet the minimum national requirements (according to the Law on Public Procurement) and the additional requirements on SU "St. Kliment Ohridski " for acquisition on educational and scientific degree "doctor".

All articles are published in prestigious international journals after successful independent review procedures. I find this indicative, that the published results, as well as those in the dissertation and the abstract, are original scientific contributions of Mouhamad Al-Mahmoud. With this, I reject the possibility of plagiarism under whatever form.

4. Analysis of the scientific and scientific-applied achievements of the candidate, containing in the materials provided

The main problems analyzed in the dissertation of Mouhamad Al-Mahmoud are the forecasting of the possibilities for the creation and, in many cases, the experimental proof of new opportunities for creation on new devices for change on polarization on bundles with broad spectra, of efficient broad spectrum frequency conversion schemes, and of new optical isolator circuits. At the heart of his approach is the search for analogies between the description of processes in quantum mechanics and of processes in classical (wave, polarization and nonlinear) optics. The adiabatic approximation and the concept are correctly introduced for the composite pulse used in the dissertation. The concept of fast adiabatic transition was introduced by citing literature sources.

Dissertation is presented on 160 pages and contains 9 chapters and 332 cited titles.

The first chapter reviews what has been done in the field of quantum-classical analogies so far - the application of methods of quantum physics in optics - interference, diffraction, nonlinear optics, polarization; in the analysis of systems with different number of intrinsic energy levels and electromagnetic phenomena.

Chapter 2 focuses on coherent quantum control techniques with 2 and 3 quantum states. Composite techniques, adiabatic techniques such as Stimulated Raman Adiabatic Passage and rapid adiabatic passage, adiabatic elimination are considered.

Chapter 3 discusses in general all the analogies between quantum systems with 2 and 3 levels and classical systems in the field of polarization optics and nonlinear optics discussed in the dissertation.

In Chapter 4, the purpose of the analysis is to construct polarization rotators that operate in wide spectral range, providing the desired rotation of the plane of polarization. The idea is to use several plates to construct a polarizing rotator instead of two half-wave plates. 2 different configurations are available (for a combination of 3 wave plates and for a combination of N wave plates). The obtained experimental data are in very good agreement with the numerical simulations based on the obtained analytical result.

The studies in Chapters 5 and 6 are devoted to the analysis of new non-reciprocal polarization optical elements such as non-reciprocal wave plate (Chapter 5) and polarization - independent optical insulator (Chapter 6). The experiments described in Chapters 5 and 6 agree well with theoretical expectations.

Chapters 7 and 8 describe nonlinear processes of electric field amplification (Chapter 7) and generation on total frequency by cascading process (Chapter 8) . Chapter 7 uses an analog of Shaka's composite pulses to make a broadband optical amplifier. In Chapter 8, it is assumed that the intermediate generated wave in the cascade process experiences strong absorption in the process of its generation and along the medium (nonlinear crystal). In this direction, an analogy is made with a three-level quantum system in lambda configuration and decay from the intermediate state. Absorption is used as an advantage to stabilize the final frequency generated.

Chapter 9 systematizes the candidate's scientific contributions.

Abstract is set out on 51 pages and consists of an Introduction, six chapters and a formulation of the main scientific contributions. The bibliography consists of 143 titles. The abstract essentially repeats the dissertation in a concise version in Bulgarian. The abstract correctly reflects the results obtained and correctly interprets the cited literature.

Scientific works. The results presented in the dissertation have been published in 5 articles in journals with IF (1-Physical Review Applied , 1-Applied Sciences , 1-OSA Continuum , 1-Applied optics , 1-Journal of Optics). There are already 2 independent citations.

5. Critical remarks and recommendations

I have no critical remarks on the merits. There are some minor terminological inaccuracies in the abstract, which are rather the result of the translation to Bulgarian.

6. Personal impressions of the candidate

I know the candidate vaguely from several conferences we have been to together.

However, I have good impressions of him and his presentations. Also, the materials presented to me for my opinion made a very good impression on me and created in me the opinion of well-planned, justified and conducted at a high level research work.

7. Conclusion

After I got acquainted with the presented dissertation and others materials, based on the analysis of their significance and the scientific and applied contributions contained in them, I confirm that the scientific achievements correspond to requirements on ZRASRB, PPZRASRB and the corresponding Regulations on Sofia University "St. Kliment Ohridski " (PURPNSZADSU) for obtaining the educational and scientific degree“ Doctor ”.

Based on the above, I recommend the scientific jury to award the educational and scientific degree "Doctor" in the professional field 4.1 Physical Sciences to Mouhamad Al-Mahmoud.

17/06/2022

Prepared the opinion:

(Assoc. Prof. Dr. Petar Ivanov)