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. Boyan Tonev Torosov from the "Institute of Solid State Physics", Bulgarian Academy of Sciences, **in his capacity of a member of the scientific jury according to Order № РД 38-251/23.05.2022 г. of the Rector of Sofia University.**

Title of the dissertation: "Application of Coherent Quantum Control Schemes in Classical Physics"

Author: Mouhamad Al-Mahmoud

1. Candidate details

Muhammad Al-Mahmoud, a candidate, earned a bachelor's degree in physics from the University of Lebanon in Beirut in 2015. He then got a master's degree in Photonics and Optics at the University of Lorraine in Metz (France) in 2018. The candidate's research interests are in coherent quantum control and the analogues of the accompanying mathematical framework for addressing classical optical issues.

2. Presented documents

The candidate's documents completely conform with the criteria of the Law on Scientific and Technological Research Protection, the Rules of

Procedure and Regulations for the Acquisition of Scientific Degrees and Academic Positions at Sofia University "St. Kliment Ohridski." The dissertation (in English), the abstract, a CV, a higher education credential, publications and a list of publications are all included.

3. General characteristic of the scientific achievements of the candidate

The scientific interests of Muhammad al-Mahmoud are similarities between coherent quantum control and classical optics. The dissertation's scientific publications meet or surpass the basic national standards as well as the extra requirements of Sofia University "St. Kliment Ohridski" for acquiring the educational and scientific degree of Doctor.

4. Analysis of the scientific and scientific-applied achievements of the applicant, contained in the materials submitted for the defense

The candidate's key accomplishments, as detailed in the dissertation, are devoted to the study and development of optical systems with specific features. Devices for broad-spectrum polarization change and frequency conversion, as well as optical isolators, are examples. This is accomplished by drawing parallels between quantum coherence control mathematical equipment and processes in traditional optical systems.

The dissertation is divided into nine chapters and is 160 pages long, with 332 bibliographical entries.

The first chapter provides an overview of the dissertation's topic as well as a survey of the literature on quantum-classical comparisons.

Techniques for coherent quantum control over systems with two or three quantum states are discussed in Chapter 2. Composite pulses, adiabatic approaches like STIRAP and RAP, and adiabatic elimination are

among the strategies mentioned.

In Chapter 3, similarities between classical and nonlinear systems in the realm of polarization optics are discussed, as well as approaches for coherent quantum control, with the goal of overcoming optical systems' susceptibility to different external factors.

Using analogies with the composite-pulse approach, Chapter 4 provides a way for building a broadband polarizing rotator with an adjustable polarization rotation angle. Experimental results have proven the procedure.

A non-reciprocal wave retarder is proposed in Chapter 5 utilizing a combination of a reciprocal polarization rotator, a non-reciprocal magneto-optical rotator, and two quarter-wave plates. The technique has been verified experimentally.

Using two Faraday rotators and two half-wave plates, Chapter 6 provides a way for realizing a polarization-independent optical isolator. To corroborate the idea, another successful experiment was undertaken.

The optical broad spectrum amplification approach is discussed in Chapter 7. A mixture of quasi-phase matching and composite pulses is used in the approach.

In Chapter 8, an analogy with a three-level non-Hermitian quantum system with a decaying intermediate state is used to suggest a mechanism for cascaded nonlinear frequency conversion. As far as I understand a paper is submitted and is in review for publication.

The candidate's scientific contributions are organized in Chapter 9.

The abstract, which spans 51 pages and includes an introduction, six chapters, and the formulation of the dissertation's primary scientific contributions, is a brief exposition of the dissertation's findings. There are 143 titles in the bibliography.

Scientific research. The dissertation's findings have been published in

five publications in IF journals, four of which feature the candidate as the primary author.

Interestingly to note that three papers are experimental papers and two papers are pure theoretical papers.

5. Critical remarks and recommendations

I have no criticisms, with the exception of minor technical flaws in the dissertation and abstract.

6. Personal impressions of the candidate

I remember the applicant from his time as a member of Acad. Prof. Nikolay Vitanov's quantum optics and quantum information group. I have a really positive view of him and the way he works. I believe the individual is capable and motivated.

7. Conclusion

I confirm that the scientific achievements correspond to the requirements of ZRASRB, PPZRASRB, and the corresponding Regulations of Sofia University "St. Kliment Ohridski" (PURPNSZADSU) for obtaining the educational and scientific degree" Doctor "after becoming acquainted with the presented dissertation and other materials and analyzing their significance and scientific and applied contributions contained therein.

Based on the foregoing, I submit to the scientific jury that Mouhamad Al-Mahmoud be awarded the educational and scientific degree "Doctor" in the professional field 4.1 Physical Sciences.

05/26/2022

Prepared the opinion: .....

(Assoc. Prof. Dr. Boyan Torosov)