

REVIEW STATEMENT

of DISSERTATION

for awarding THE SCIENTIFIC DEGREE DOCTOR OF
SCIENCE in PHYSICS

Code 4.1

Sofia University "St. Kliment Ohridski"

Faculty of Physics

This Review is made by: Assoc. Prof. Lachezar Georgiev, PhD, Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, in his capacity as Member of the Scientific Jury, according to Order № ПД 38-249 / 20.05.2022 г. Of the Rector of the University of Sofia.

Title: Critical phenomena and quantum metrology with strongly correlated quantum-optical systems

Author: Assoc. Prof. Peter Aleksandrov Ivanov, PhD

I. General description of the materials

1. Documents data

The Applicant Assoc. Prof. Peter Aleksandrov Ivanov, PhD has presented a Dissertation and Abstract, as well as the obligatory tables for the Department of Physics according to Regulation for the conditions and order to acquire Scientific Degrees and occupying Academic positions in the University of Sofia (Regulation SU).

The presented documents by the Candidate correspond to the requirements of the ZRASRB, PPZRASRB and the Regulation SU.

2. Candidate data

The Candidate has graduated as Bachelor from the Department of Physics, Sofia University “St. Kl. Ochriski” in 2002. He has received a PhD Degree in the same University in 2008. In 2012 he occupied the Academic position “Chief Assistant” and in 2015 the Academic position “Assoc. Professor”.

He has participated in International collaborations with the Universities of Kassel, Mainz and Kaiserslautern in Germany and with the University of Madrid in Spain.

3. General characteristics of the Candidate’s scientific achievements

The Candidate’s Scientific results are in the area of Theoretical Quantum Physics, more precisely in the field of Quantum Optics, Quantum Phase Transitions, Quantum Metrology and Quantum Information.

- a) the scientific publications included in the Dissertation correspond completely to the Minimal National Requirements (according to Art. 2b of ZRASRB) and respectively to the Additional Requirements of Regulation SU for acquiring the Scientific Degree Doctor of Science in the respective Scientific Area;
- b) the scientific publications included in the current Dissertation do not repeat publications from previous procedures for acquiring Scientific Degree or Academic position;
- c) there is no evidence for plagiarism in the presented Dissertation and Abstract.

4. Characteristics and evaluation of the Candidate’s Teaching activity

The Candidate’s teaching activity includes lectures and exercises in Quantum Mechanics, Methods and Applications of Quantum Mechanics, Theoretical Mechanics, Quantum Phase Transitions, Quantum Simulations and Quantum Metrology.

5. Analysis of the Scientific and Applied achievements of the Candidate

The Candidate's scientific achievements are theoretical research of strongly correlated quantum-optical systems simulated with ions in a Paul trap. The potential applications of the quantum phase transitions in multiparticle systems for quantum metrology are investigated.

The subject of the Dissertation is extremely topical taking into account the intensive development of the quantum technologies in the recent years (quantum sensors and quantum metrology are one of the pillars of the Quantum Flagship). The obtained results for the simulation of the Jaynes-Cumming-Hubbard with ions in a Paul trap are in good agreement with the experiments. A very interesting theoretical setup is proposed for using an ion trapped in a Paul trap as a high-precision sensor for weak forces of the order of 10^{-24} N. Another promising proposal investigated in the Dissertation is the opportunity to implement a so called Quantum Thermometer using the collective spin-phonon interaction for precise measurement of the vibration temperature of an ion crystal. The detailed description of the experimental setup reveal deep understanding of the considered problems and good knowledge of the existing literature.

The Dissertation is based on the research of the Candidate and his Co-Authors published in 23 papers with impact factor, 17 of which are in Q1 and 6 in Q2. These papers do not repeat the publications used for acquiring the PhD Degree. According to the presented reference 448 citations have been noticed, without auto-citations and the Hirsch index is 12. Significant contribution has been claimed for 21 publications.

6. Critical remarks and recommendations

The Abstract is too big – I would recommend reducing it to about 50 pgs.

7. Personal impressions about the Candidate

I don't have.

8. Conclusion

After getting acquainted with the Dissertation, the Abstract and the other materials and based on the analysis of their significance and scientific contribution **I confirm** that the scientific achievements correspond to the requirements of ZRASRB, the Regulation for its application and the Regulation SU **for acquiring the Scientific Degree Doctor of Science in Physics**. In particular, the Candidate satisfies the Minimal National Requirements in the Professional

Area and there is no evidence of plagiarism in the Dissertation, the Abstract and the scientific papers.

I give a positive evaluation of the Dissertation.

II. GENERAL CONCLUSION

Based on the above-mentioned **I recommend** with conviction that the Scientific Jury **to award the Scientific Degree Doctor of Science in Physics** in Professional Area 4.1 Physical Sciences (Physics of Atoms and Molecules) to Assoc. Prof. Peter Aleksandrov Ivanov, PhD.

26.08.2022

Reviewer:

Assoc. Prof. Lachezar Georgiev, PhD