A T T I T U D E

to dissertation to obtain science degree " **DOCTOR OF SCIENCE**"

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Theme of the dissertation:

Classical and Quantum Brownian Motion

Reviewer: **Borian Penkov Radoev, Professor, D.Sci, pensioner**

The 247-page paper presented to me for opinion is on 3 chapters, introduction, contributions and literature from 365 foreign literary sources. It is written in a foreign language and if I understood correctly, according to a ministerial decree. Such decrees are incomprehensible and unacceptable to me personally, as the dissertation is defended in Bulgaria; there is no foreigner in the jury, and as far as foreign scientists are concerned, they are interested in the author's scientific production, which is in the accepted international language. But my note is not addressed to Prof. Tsekov, who, like all of us in the jury, is obliged to comply with official regulations.

The writing of a dissertation for the degree of Doctor of Science nowadays deserves explicit mention. Freed from his commitment to career development (as was the case under the old provisions of the Higher Attestation Commission), such an endeavor in any case reflects the author's authentic scientific interests. This positive feature in the commented act is emphasized especially strongly by the topic of the dissertation – fundamental in the full sense of this definition, as well as by the level of the results obtained there.

Moving specifically to my opinion, I will mainly limit myself to the way and level of presentation of the author's ideas. The comments on the substance of the studies and the ucometric indicators are subject to reviews, where I have no doubt they will be evaluated competently enough. I have addressed a limited number of issues of principle to which I have formulated the relevant issues. I am based on the author's (extremely tight, clear and informative material) and on the original articles presented to me by the author. I will repeat the exhibition in the Author's Book is completely satisfactory, exposing concise, consistent and clear, both the issues themselves and the corresponding contributions from the author. This is also evident in the Introduction, where the author marks the historical development of this not particularly popular branch of science. I allow myself such a pretentious assessment, as I have research in the field, among others, and in co-authorship with Prof . Tsekov. In relation to the historical review, it is also my first question related to the so-called Wiener process. On page 7 of the Author's Book, the author commented that Viner's process is inherently irregular, while the classic Brownian movement, as a real physical process, is regular. He has confined himself to pointing out the undifferentiatedness (interruption) only of speed by correctly noting that this singularity is formally a consequence of the neglect of the accelerator member in the Langevin equation. But without continuing to describe the problem in the same consistent and analytical spirit, Prof. Tsekov concludes this comment with the conclusion that the Wiener process is a mathematical abstraction describing the approximately physical Brownian motion, while Schrödinger's equation is accurate. The obscure moment here is the Brownian motion – Schrödinger equation connection. As is well known, the inclusion of inertia in the Langevin equation partially corrects but does not solve the problem by only shifting the singularity from velocity to acceleration. My knowledge on the subject is that the existence of a principled (innate) singularity in classical mechanics is no exception. It is the basis of the so-called chaos and is attacked by the methods of fractal calculus, without attracting quantum-

mechanical postulates. So my question to the applicant is whether there is a place ur. of Schrödinger in clarifying the singularities of the physical Brownian motion and, if YES, what is the final conclusion on this basis?

The thematic arrangement of the three chapters is fully sustained in scientific and didactic terms – from the known and established level to expansion in new areas, with the inclusion of hypothetical boundaries. A similar gradation can be seen inside the chapters themselves, with their own contributions very clearly marked. A similar gradation can be seen inside the chapters themselves, with their own contributions very clearly marked. They are formulated separately in 10 points at the end in the relevant section. I do not undertake to comment on them in full, as I do not have the necessary competence. I have chosen only one of them (marked with the letter B), which would attract the attention of anyone interested, not to mention teaching concepts such as heat and temperature. In particular, it concerns the temperature operator introduced by the author. Details and comments on the introduction of the operator in question are published in an article [30] from the list of publications, and for the level of the article it is enough to mention the journal where it was published – Physics Letters A. So my question does not specifically concern the essence and properties of the temperature operator, but rather is provoked by its introduction. Traditionally in the classical literature, temperature is interpreted as energy, rarely specifying that it is only the energy of chaotic motion, and practically lacks the exact definition that temperature is proportional to the dispersion of the pulse. In this sense, the temperature of a regular movement is zero and the citation of the so-called A third thermodynamic principle (in the source [30]) requires serious reservations. Otherwise, the conversion of the energy of regular movement into heat, ie. –in raising the temperature and vice versa is a question studied and largely clarified by the pioneers of thermodynamics (Joule, Carnot, etc.). Specifically, my question is the generalization of the concept of temperature in the field of quantum mechanics,

does it retain its classical meaning as a variance of the momentum or of the quantity corresponding to the momentum?

Is there a quantum generalization of Carnot's theorem?

Conclusion

Based on the above and my long-term scientific contacts with the applicant, I strongly recommend the scientific jury to award Professor Dr. Rumen Tsvetanov Tsekov the scientific degree "DOCTOR OF SCIENCES".

23 August 2021 Reviewer:

Sofia