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February 27, 2024

Opponent's report on the habilitation thesis
"Critical phenomena and chaos in collective many-body systems"
by Dr. Pavel Stránský

In his habilitation thesis, Dr. Pavel Stránský focused on critical phenomena in quantum systems, their signatures and manifestations in energy spectra or in quantum thermodynamics. The thesis is based on a selection of papers co authored by Dr. Stránský that were published in the last decade.

The thesis consists of two main parts. The first part is introductory while the second part is composed from the selected research papers. The introductory part aims to supply the reader with the essential concepts and results from the considered research area. It is divided into three main chapters where each of them is dedicated to a different topic.

First, excited-state quantum phase transitions (ESQPT) are discussed. After making the reader familiar with the concepts of quantum phase transition (QPT), the ESQPT, as well as with the level density and the spectral flow, these quantities are exemplified with the use of explicit models, e.g. CUSP, Creagh-Whelan, Lipkin-Meshkov-Glick or molecular vibron models. This chapter serves as the introduction to the research papers presented in the appendices A, B, C, D, E, J and K where diverse aspects of ESQPT are analyzed. For instance, there was discussed the existence of ESQPT in the systems with small number of degrees of freedom, finite-size effects, classification of ESQPT singularities in dependence on the stationary points of the classical limit of the considered systems.

The next chapter is dedicated to classical and quantum chaos. Indicators of chaotic behavior are introduced, be it classical Lyapunov exponent measuring local stability or fraction of regularity that allows to study chaoticity on the whole energy hypersurface. Out-of-time-ordered correlators (OTOC) are presented as the chaos indicators for the quantum systems. The quantum-classical correspondence of the chaos indicators is discussed with help of the explicit, previously presented, models. This chapter serves as the introduction to the appendices L, H and I. In the research papers presented therein, the role of OTOC as the chaos indicator is exemplified on the u(3) model. The possible quantum-classical correspondence between the time development of OTOC and the classical Lyapunov exponent is discussed in the Dicke or Lipkin-Meshkov-Glick model.

The last part of the introduction is dedicated to the systems described by non-hermitian Hamiltonians. The spectrum of non-hermitian operators allows for specific degeneracy of energy levels that occurs for critical values of coupling parameters. The spectral points corresponding to this kind of degeneracy are called exceptional points. The chapter provides introductory backup for the works presented in the appendices F and G and J. There is discussed QPT of the first and second type in the proximity of the exceptional points, there are analyzed open systems where the coupling

of the closed system to the continuum is provided by random matrices, there are investigated complex densities of continuum states in the context of resonant tunneling. Does PT-symmetry or pseudo-hermiticity play any prominent role in these processes?

The work is well written and the presentation can be followed even by a non-expert in the field. In my opinion, it meets all the requirements for the habilitation thesis, both from the formal and scientific point of view. If pushed to express some discontent, I would mention the ordering of the appendices. It would be more intuitive to order them as they appear mentioned in the introductory text.

The analysis of plagiarism resulted in 31% in total. As much as the number can appear rather large at first sight, the breakdown of the analysis shows that it mostly accumulated from rather marginal overlaps (1%-4%) with the works presented in the thesis. Therefore, I do not consider the result of this analysis as either surprising or disturbing.

Dr. Pavel Stránský displays a wide and impressive palette of expertise in diverse topics related to the research area that forms the main theme of the thesis. I find the scientific achievements of Dr. Pavel Stránský displayed in the thesis as remarkable. The quality of his scientific work is testified by his papers that were either included in the thesis or mentioned in the references. Two of the presented papers were published in Physical Review Letters. The scientific contribution of the papers can be documented by the number of citations they have collected (e.g. the paper in Appendix H from 2019 has over 100 cites).

In Conclusion, I strongly recommend accepting the thesis and to award Dr. Pavel Stránský the degree associate professor.

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