LABORATOIRE DE PHYSIQUE THÉORIQUE
DE LA MATIÈRE CONDENSÉE
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**Official referee's report**

on the thesis by Krasnytska Mariana Bohdanivna
"Collective behavior on complex networks: fundamental aspects and applications"
submitted for the degree of Doctor of sciences in physics and mathematics
in specialization 01 .04.02 - Theoretical Physics

The thesis explores the collective behavior of complex systems, focusing on phase transitions in magnets with nontrivial architecture, ordering phenomena in classical statistical models, and their modifications on complex networks. Traditional approaches often fail to capture the complexity of real-world systems, requiring the development of generalized spin models to study new mechanisms of ordering and phase transitions. Two key modifications are proposed: (1) in the Potts model *invisible states* are introduced, which makes possible to control the nature of phase transition (the first or the second order); (2) the Ising model is modified to consist of spins with *variable length*, which allows to study the effects of disorder and heterogeneity both in magnets and in the models of social systems.

For the Potts model with invisible states, it was found that the introduction of non-interacting states changes the order of the phase transition, characterized by two marginal dimensions. On scale-free networks, the interplay between topology and entropy leads to three distinct critical regions, and demonstrates that structural and entropic effects act independently. A novel percolation transition mechanism was identified, which turned out to be different from classical and explosive percolation.

The Ising model with variable spin length was analyzed on complete graphs, on Erdős–Rényi networks, as well as on scale-free networks. It was shown that both local spin intensity and network topology equally influence the nature of the phase transitions. Two new universality classes for logarithmic corrections to scaling were discovered, providing new insights into the scaling behavior. This modified Ising model allows to study disorder-driven phase transitions, demonstrating that structural disorder alone, without non-magnetic dilution, is sufficient to alter critical behavior. Monte Carlo simulations confirmed that both the critical exponents and corrections to scaling well match with those of the site-diluted Ising model.

The final part of the thesis is devoted to very interesting statistical physics techniques in which one performs the analysis of the partition function zeros in the complex temperature plane. In terms of this approach the Author investigates the structure the phase diagram of the three-state spin model, where, in particular, it was possible to identify the crossover behavior between critical and tricritical regimes. Besides, using complex networks the Author performs quite impressive statistical study of the scientific collaboration and semantic networks, leading to a generative model that explains the formation of interdisciplinary knowledge. These findings contribute to a deeper understanding of disordered magnets, phase transitions, and networked systems, with applications in materials science, statistical physics, and social dynamics.

The thesis is clearly written and contains many interesting results. Nevertheless, I have several minor remarks:

- It would be useful to include simulations for the proposed modified Ising model on a network, or at least to provide a comparison with existing real-world database results.
- For the Potts model with invisible states, a more detailed investigation of the percolation limit is recommended, along with a comparison to other models of explosive percolation.
- A comparison of effective exponents obtained from finite-size partition function zeros analysis for the Blume-Capel model with effective exponents derived from other approaches would be quite valuable. Besides, an estimation of computational time requirements and potential savings, would strengthen the practical relevance of the findings.
- Bibliography formatting needs correction—some entries are missing author names, in particular for thesis and papers in Ukrainian.

The main results presented in this dissertation are fully documented in 12 papers published in reputable scientific journals indexed in Scopus and WoS databases. All findings are original, with no instances of plagiarism, ensuring the integrity and authenticity of the research. These works have also been presented at numerous international conferences. The abstract of this dissertation effectively summarizes its content and comprehensively reflects the obtained results. The dissertation by Krasnytska Mariana fully meets the requirements of the procedure for awarding scientific degrees, as approved by the resolution of the Cabinet of Ministers of Ukraine on November 17, 2021, No. 1197, concerning habilitation dissertations.

Krasnytska Mariana Bohdanivna is a well-respected researcher with a strong presence in the scientific community. She successfully defended her PhD through an international co-tutelle program in France and has maintained active collaborations with colleagues abroad since completing her doctorate. Certainly, she deserves to be awarded the degree of Doctor of Sciences in Physics and Mathematics in specialization 01.04.02 - Theoretical Physics.

Doctor of Sciences in Physics and Mathematics,
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