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Evaluation of the PhD thesis of Yulian Honchar

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To whom it may concern,

I have read the thesis entitled "*Scaling properties of phase transitions above the upper critical dimension and the description of DNA denaturation*" prepared by Y. Honchar and herewidth provide my report. The thesis is based on the following works:

- Y. Honchar, C. von Ferber, Y. Holovatch, *Variety of scaling laws for DNA thermal denaturation*, Physica A: Statistical Mechanics and its Applications **573**: P125917 (2021).
- Y. Holovatch, C. von Ferber, Y. Honchar, *DNA thermal denaturation by polymer field theory approach: effects of the environment*, Condensed Matter Physics **24**: P33603 (2021).
- Y. Honchar, B. Berche, Y. Holovatch, R. Kenna, *When correlations exceeed system size: finite size scaling in free boundary conditions above the upper critical dimension*, arXiv:2311.11721.

The thesis is concerned with scaling properties of critical phenomena and more particularly in the five dimensional Ising model and the Poland Scheraga model of DNA denaturation.

In an introductory overview, the candidate motivates the research topic very briefly and explains how their work relates to the academic environment in which it was carried out. Furthermore methodology and scientific novelty are outlined as well as the contributions of the candidate to the aforementioned works.

In **Chapter 1**, the author reviews relevant literature of scaling theories and polymer physics. In terms of the scaling, the usual hyperscaling relations and the homogeneity hypothesis are discussed and the author then focuses on finite size scaling, the definition of pseudo-criticality and the introduction of the Q scaling theory. At a similar level of depth, the application of scaling theories to polymer physics is discussed. Models containing random walks and self-avoiding walks are introduced, as well as relevant scaling and star exponents. This chapter has room for some improvements: Although it is supposed to act as an introduction it rushes through many non-trivial concepts without properly introducing them. While I was able to follow sections 1.1. and 1.2. since it aligns with my background, section 1.3. was not easily accessible to me:

- a lot of jargon is used in this section.
- there are mistakes in Figures 1.1 (ϕ vs φ) and 1.2 (V1, V3 missing)
- variables are not introduced (e.g. $\tilde{z}$ in Eq. (1.28), ...)

There are also a large number of orthographic, grammatical and typesetting errors in the text that hinder the accessiblity of the manuscript. Unfortunately, this is true throughout the remainder of the manuscript.

In **Chapter 2**, the author presents their numerical results on the FSS in the five-dimensional Ising model with free boundary conditions. Simulating high-dimensional systems is challenging due to large boundary effects as the author acknowledges. However, the results are impressive in terms of breadth and quality. After the Wolff algorithm and data analysis methods are introduced, the pseudocritical point T_L and its FSS is determined. This is followed by a scaling analysis of the magnetisation, magnetic susceptibility, internal energy and heat capacity at pseudocriticality and at criticality. Several of the results are found to be consistent with either Q scaling or Gaussian scaling however, some (e.g. the internal energy at pseudocriticality) are not. It would have been interesting to see a more in-depth discussion of this. Nevertheless, I judge these results of **high scientific quality** but their presentation could be improved. In the current form there is little context given and the chapter is a sequence of plots and their description.

In **Chapter 3**, the author aims at substantiating their findings from Chapter 2 by analysing Fourier modes and Lee-Yang zeros. The partition function zeroes hint at G scaling at criticality and Q scaling at pseudocriticality. These results are interesting and methodically appealing since they do not require extensive system sizes to arrive at rather precise conclusions about the scaling behaviour. Therefore, I judge these contributions as **very valuable to the field** and debate around FSS above the upper critical dimension.

In **Chapter 4**, the author analyses the denaturation of DNA. They use a model in which three chains are attached to each other and each chain is either modeled by a random walk or a self-avoiding walk. The main result of this chapter seems to be the new scaling relations for the loop closure exponents. I deem this result **important and correct**, however I find this part of the thesis the least accessible.

Additionally, the author provides brief summaries at the beginning of the thesis in Ukranian and English as well as conclusions at the end of the manuscript.

There are some issues with the manuscript in its current form, however they are not related to the scientific quality of the work. I judge the overall scientific work of high theoretical and numerical quality and therefore I support the defence of this thesis.

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Sascha Wald
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