UNIVERSITÄT BIELEFELD

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Report on Dissertation by Paweł Drozda

31.07.2025

Dear Members of the Scientific Council of the Center for Theoretical Physics of the Polish Academy of Sciences,

I was appointed as a reviewer of the doctoral dissertation of Paweł Drozda, entitled „Higher Order Statistics of the Large Scale Structure". In the following report, I provide a detailed evaluation of the PhD thesis with regards to demonstration of general knowledge, independent scientific work and originality. I also provide a peer-review style assessment of strengths and weaknesses. I conclude with the unequivocal statement that the candidate meets the standard European Ph.D. criteria.

General theoretical knowledge of the applicant

The thesis has a logical structure, a concise and accessible introduction of the relevant basics and a good progression to the research results. The introduction provides a motivational bridge from the quest to understand the Universe to the most fundamental questions and the status of cosmology as an empirical precision science. The thesis reflects a good working knowledge of the research field and presents key background theoretical knowledge underlying the thesis work.

Demonstration of independent scientific work

The thesis clearly demonstrates the ability of the candidate to carry out scientific work independently, as evidenced by the presentation of original results including a description of the analysis steps, creation of scientific plots and their description. The candidate clearly demonstrated that he extracted the necessary summary statistics from the existing simulations, performed the data analysis and interpreted the results, the latter in exchange with the supervision team.

Demonstration of originality

Overall the thesis contains a significant number of original results focused on exploring which clustering statistics can capture signatures of extended gravity models, with increasing realism from dark matter to dark matter halos and the galaxies they inhabit. The demonstration of originality cannot only be inferred from the thesis itself, but also from the appeareance in peer-reviewed articles. The research on angular clustering in extended gravity models is already published in Phys Rev D. The work on real- and redshift-space clustering is expected to be accepted soon, and the last paper on shape-dependent clustering with the ellipsoidal correlation function has been submitted for publication.

Strengths and weaknesses

The written presentation of the two introductory chapters is overall in good shape, but could be improved language wise, as might be expected for a non-native English speaker, which would also help with the overall flow of the thesis.

The first science chapter presents a novel analysis of the impact of extended gravity in a projected setting and a nice comparison of the effects for dark matter, halos and HOD-galaxies. It is interesting to identify the redshift range and scales where there is most sensitivity resides, which can inform strategies for probing gravity with galaxy surveys. The work has a few limitations which

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are pointed out in the text, the low number density of tracers mean the level of shot noise is not representative of current photometric surveys, which have at least one order of magnitude higher density. As mentioned in the conclusion, the choice of a constant selection function and fixed redshift thickness (rather than volume) might be suboptimal.
The second science chapter contains a valuable analysis of the potentially detectable signal indicating a deviation from General Relativity in redshift space. A highlight of this part is the discussion on the impact of redshift-space distortions on the halo and HOD galaxy populations, which show different behaviour that is also studied in the split between central and satellite galaxies. It would have been nice to discuss the precise input for the HOD and potentially investigate a change in HOD parameters to see how representative the behaviour seen for the galaxy sample dominated by centrals is.
The third science chapter presents an investigation which ellipsoid configurations enhance the signal associated with the anisotropic averaged two- and three-point correlation functions corresponding to a variance and skewness depending on the two ellipsoid radii. This is an idea very similar to so-called 2D kNN statistics, which instead of considering the one-point distribution of the density as a function of scale consider the distribution of distances of the k-th nearest neighbour, which is sadly not mentioned. The dependence on different growth rates is investigated with MG-COLA but run for LCDM cosmologies. It would have been nice to describe those approximate simulations in more detail and provide a link to how those changed LCDM models affecting fsigma8 might or might not resemble signals in extended gravity.
The conclusion provides a brief summary of the results, but could have benefitted from tying the research results back into the larger context of probing extended gravity with galaxy surveys.

Overall verdict
I conclude that the presented dissertation meets the formal requirements for a Ph.D. thesis and recommend admission of the Candidate to the subsequent stages of the procedure, including the public defense.

Yours sincerely,

Cora Uhlemann

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Konkluzja recenzji rozprawy doktorskiej
(Conclusion of dissertation review)

„Higher Order Statistics of the Large Scale Structure"

Tytuł rozprawy *(Dissertation title)*: .....

Paweł Drozda

Autor rozprawy *(Author of the dissertation)*: .....

[x] Pozytywna ocena *(Positive conclusion)*:

Stwierdzam, że przedstawiona mi do recenzji rozprawa spełnia wszystkie wymagania ustawowe i zwyczajowe stawiane rozprawom doktorskim i wnoszę o dopuszczenie jej do dalszych etapów postępowania doktorskiego, uwzględniając publiczną obronę.

*(I conclude that the presented dissertation meets the formal and customary requirements for doctoral dissertations and I recommend its admission to subsequent stages of the procedure, including the public defense.)**

[ ] Ocena negatywna *(negative conclusion)*

Stwierdzam, że przedstawiona mi do recenzji rozprawa nie spełnia wszystkich wymagań ustawowych i zwyczajowych stawianych rozprawom doktorskim i dlatego nie rekomenduję dopuszczenia jej do dalszych etapów postępowania doktorskiego.

*(I conclude that the presented dissertation does not meet the formal and customary requirements for doctoral dissertations and therefore I do not recommend its admission to subsequent stages of the doctoral procedure.)**

Uzasadnienie powyższej oceny znajduje się w raporcie będącym załącznikiem 1.
(The justification of the above assessment can be found in the detailed report in the attachment 1.)

01.08.2025.....
Data i podpis
(Date and signature)

Załącznik 1: Recenzja rozprawy doktorskiej
(Attachment 1: Review of the dissertation)

Zaznacz ocenę (Please tick the box with your conclusion)