Georgia Tech College of Sciences
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To the Scientific Council,

Below is my review of the doctoral dissertation of **Dominik Gronkiewicz** entitled "*Warm Coronae for Magnetically Supported Disks in Accreting Black Holes*". The dissertation contains four chapters: an Introduction and three chapters which reprint refereed papers containing Mr. Gronkiewicz's contributions to the field. The dissertation presents a new and elegant numerical solution to the radiative transfer, thermal equilibrium and hydrostatic balance equations in a magnetically supported accretion disk. These solutions naturally produce both a warm and hot corona at the disk surface, and give a clear theoretical explanation for the soft excess seen in the X-ray spectra of accreting black holes. Thus, the dissertation provides an original solution to a scientific problem.

Chapter 1. Introduction: In this Chapter, Mr. Gronkiewicz provides a thorough overview of both observational and theoretical results in astrophysics related to the X-ray emission of accretion disks around black holes and the problem of the soft excess. Mr. Gronkiewicz describes the different models proposed in the literature to explain the soft excess, and goes over their strengths and weaknesses. He then reviews recent analytical and numerical models of the role of magnetic fields in accretion physics, and provides a quick introduction to the thermal instability in photoionized plasmas. The Chapter is quite comprehensive and does a good job in providing a reader the important information needed to follow the three papers that comprise the remainder of the thesis. It is clear that that Mr. Gronkiewicz has strong general theoretical knowledge in high-energy astrophysics. I have two questions for Mr. Gronkiewicz from this Chapter:

1. Why is it important to understand the soft excess? How would you argue for, say, financial support, to study the soft excess?

2. X-ray reverberation measurements are a critical new method to explore the inner accretion flow around black holes. How can reverberation signals be used to understand warm corona models?

Chapter 2. Paper 1. Gronkiewicz & Różańska, 2020, *Warm and thick corona for a magnetically supported accretion disk in galactic black hole binaries,* A&A, 633, A35: This Chapter describes the basic equations used by Mr. Gronkiewicz to develop his model of a warm corona. The Appendix of the paper also gives the details on the numerical method to solve the equations. The paper provides a comprehensive description of the model solutions and the dependence on the key parameters. Because

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of the novel numerical method, Mr. Gronkiewicz is able to calculate models very quickly and the paper shows how the warm corona model changes as a function of radius along the disk and the overall accretion rate. The major limitation of the paper is that it challenging to compare the theoretical quantities computed to observational results. I have 1 question from this Chapter:

1. The model described here is focused on galactic black hole binaries, but the motivation is not clear. Is the model designed for binaries in the low-hard state, or in the high-soft state? If the former, what would be the implications of a truncated disk? If the latter, would the thermal emission from the disk overwhelm any warm corona?

Chapter 3. Paper 2. Gronkiewicz, Różańska, Petrucci & Belmont, 2023, *Thermal instability as a constraint for warm X-ray coronas in active galactic nuclei*, A&A, 675, A198: This paper updates Mr. Gronkiewicz's warm corona model from Paper 1 and applies it to the soft excesses observed in active galactic nuclei (AGNs). The main differences in the model compared to Paper 1 are a new assumption on how the magnetic parameters are related and implementation of a magnetic quenching criterion. As in the previous Chapter, the results show how the warm corona properties in AGN depend on disk radius, magnetic viscosity and accretion rate. However, this Chapter is able to provide a simple comparison to data by comparing the optical depth and average temperature of the corona to a compilation of data from the literature. In general, the agreement is fair for a range of reasonable model parameters. The calculations had to deal with additional numerical issues, in particular the thermal instability. This leads to my question from this Chapter:

1. The implications of the thermal instability on the properties of the warm corona are not clearly described. Given that photoionization/recombination is not included in the calculation, what role do you expect the thermal instability to play in a more realistic calculation of a warm corona?

Chapter 4. Paper 3. Petrucci, Gronkiewicz, Różańska, et al., 2020, *Radiation spectra of warm and optically thick coronae in AGNs*, A&A, 634, A85: This chapter presents calculations of the ionization and thermal properties of a heated constant density gas at the surface of an illuminated accretion disk. The codes TITAN and NOAR are used to calculate grids of warm corona models to determine the range of parameters that could lead to gas temperatures consistent with observations. The paper also confirmed that the spectra emitted by this warm corona would not display any absorption lines. This paper complements the other papers in the dissertation by showing that a heated layer on the surface of the accretion disk could produce spectra similar to what is observed in AGNs. The heating process in this paper is not specified

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but could be plausibly connected to the magnetic processes used in the other papers. Therefore, my question on this Chapter is:

1. Is it possible to do a limited self-consistent calculation where the magnetically supported accretion disk model is connected to the spectral simulation to produce X-ray spectra that can be compared to observations?

To conclude, the dissertation by Mr. Gronkiewicz clearly demonstrates the impact of his work on the field of high-energy astrophysics and his ability to independently conduct scientific work. Overall, I consider the doctoral thesis of Dominik Gronkiewicz to be a valuable contribution and to meet the criteria prescribed by the law for a doctoral dissertation. Therefore, I request that this dissertation be admitted to a public defense.

Sincerely,

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