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From: *Professor John Miller*

Examiner's report on the Doctoral thesis of Debora Lančová

"Computer modelling of accretion processes in binary systems
with black holes and neutron stars"

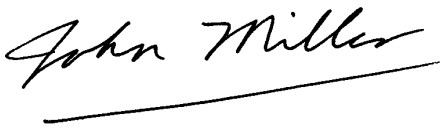
This thesis is concerned with close binary systems where one of the components is a stellar-mass compact object (a black hole or a neutron star) and the other is an ordinary star from which it is accreting material. Due to the orbital angular momentum in the system, the accreted matter typically forms a high-density rotating disk around the compact object with viscous stresses in the disk then causing sufficient heating to produce substantial emission of X-rays. Some of these X-ray binaries are among the brightest sources in our Galaxy and they have attracted a lot of interest both among observational astronomers and among theorists who make models of them to confront with the observations in order to gain understanding of the mechanisms involved and of the values of the system parameters. In recent years, with advances in high-performance computing and associated numerical techniques, it has become possible to make much more sophisticated models than before and this is the topic of the present thesis. While many aspects are discussed in this thesis, the major contribution of the work is in the introduction of the new class of "puffy disk" models which has been discovered by the candidate and her colleagues with the aid of sophisticated 3D GRRMHD simulations. In my view, this is very exciting work and is an important step forward.

The thesis materials presented for evaluation consist of reprints of six papers on which the candidate is an author (comprising Part 2 of the thesis), prefaced by a systematic extended introduction (in Part 1 of the thesis), which puts the original work in context. Four of the papers presented have been published in refereed journals and the other two are articles in proceedings. She is first author of the journal article announcing the puffy disk model and also on one of the proceedings articles. She has also authored several other articles and has given 21 presentations at international conferences and invited seminars.

In the following, I will mention my opinion of the work in the papers together with my comments on the chapters of Part 1 to which they relate. Part 1 starts with a review of the various types of accretion onto compact objects and its modes of variability (Chapter 1) and then proceeds on to a review of the basic physics of accretion disks and analytical models for them (Chapter 2). Both of these reviews are very nicely done. Chapter 3 then presents the background methodology used for making the GRRMHD simulations. Chapter 4 contains an extremely interesting account of the puffy disk calculations, including many further details additional to what appeared in the corresponding published paper (Paper 1) which had been published four years earlier. Chapter 4 also relates to Papers 2 and 3, concerning observational properties of the puffy disks. The picture of the puffy disk model which emerges makes perfect sense to me as a step beyond the earlier thin and slim disk models. The extra effects of radiation, magnetic fields, turbulence, etc., which are now included, are all things which ought to be there in a more complete picture and it is clear that one should also then expect to have an extended puffy region of hot material above and below the

core part of the disk. Finally, Chapter 5 then deals with the modelling of high-frequency quasi-periodic oscillations (QPOs) appearing in the X-ray signals, which has been another area of work to which the candidate has contributed (related to Papers 4 – 6). This is also an interesting area for the interpretation of observations. The effects on QPO frequencies of pressure forces and oblateness of the compact object are investigated, with interesting results, and a simple analytic formula is derived linking these frequencies to the mass and spin of the compact object in the case of the cusp torus model.

I have looked in some detail at each of the attached papers (many of which were already familiar to me) and I have a number of questions arising, which I would like to ask the candidate at the time of the thesis defense but, to summarise: I liked the thesis very much and think that it makes a very significant contribution which certainly merits award of the Doctorate. I am looking forward to hearing the candidate's presentation of her work on 21 September.



Oxford, 16 September 2023