UNLV | Department of PHYSICS & ASTRONOMY

UNIVERSITY OF NEVADA, LAS VEGAS

August 28, 2017

Prof. Dr. Piotr Życki
NCAC Director
Prof. Dr. Ryszard Szczerba
Chair of the Science Council
NCAC
Warsaw, Poland

RE: Report on the PhD thesis entitled *"MHD Simulations of Time Varying Astrophysical Flows"* by Mr. Varadarajan Parthasarathy.

Dear Profs. Życki and Szczerba,

The thesis submitted by Mr. Parthasarathy presents results for various numerical simulations of astrophysical flows with the main focus on accretion flows in compact objects. Generally, the subject of this work is related to computational astrophysics perhaps the fastest growing area in theoretical astrophysics. To make progress and be successful in this area one has to combine skills and experience in several fields that include: mathematics, numerical methods, physics, and compute science. In addition, one has to be not only creative but also perseverant. Moreover, to be relevant to astrophysics, one has to be able to design, carry out and analyze a set of well controlled numerical simulations that can provide us with some meaningful insights to a given astronomical problem, in this case, the puzzling origin and nature of quasi-periodic oscillations. After a careful review of the thesis, I came to the conclusion that Mr. Parthasarathy has produced several significant and important results and has done a good job describing his work.

The thesis (chapters 2 and 3 are based on two papers published in MNRAS) clearly demonstrates creativity and productivity of the candidate. It also shows progress and development in the candidate's work: starting with a simplified approach to study accretion flows in chapter 2 (inviscid 2-D flows) and then moving on to a more complete approach in chapter 3 (ideal MHD flows) and in chapter 4 (viscous and resistive flows). In addition, the thesis shows the canditate's ability to grow and improve his technical skills, that is, he started as a user of a public code (work in chapters 2-4 is based on results from simulations using PLUTO) and became a code developer (chapter 5 presents results based on simulations using PIERNIK with the candidate's implementation of a approximate Riemann solver).

It is also worth noting that the thesis shows another important quality of the candidate: ability to work with others (not only with the advisor) and willingness and ability to connect the results from numerical simulations with theoretical work (e.g., results obtained by O. Blaes, see chapter 2) and observations (e.g., chapter 3). As always it is

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important to be able to critically and carefully assess our own work. The candidate impresses also in this respect, e.g., comparing his results from simulation of perturbed and unperturbed tori, he concluded that three modes of torus oscillations are of numerical origin (namely, the R, B, and + modes).

In summary, this thesis satisfies the customary requirements of a Ph.D. thesis and I recommend the candidate to be permitted to publically defend his thesis.

Sincerely yours,

Daniel Proga
Professor
dproga@physics.unlv.edu

P.S.

I have a few comments that the candidate could consider addressing if it were decided to revise the thesis or if the candidate decides to publish results from chapter 3 and 4.

1) chapter 1.
   a) use consistently either singular or plural first person pronouns. It will help to identify parts of the work that have been done primarily by the candidate
   b) provide formal definitions of the following terms: quasi-periodic patterns, high-frequency QPOs (clarify their relation to the upper and lower kHz QPOs that are discussed in chapter 3).
   c) it will be helpful to explicitly state that one of the differences in the setup of the simulations between simulations presented in chapter 2 and 3 is a use of a smaller inner radius of the initial torus in chapter 3.
   d) chapter 3 presents results from simulations using PLUTO with the HLL Riemann solver (as stated on page 42). It could be helpful to describe the similarities and differences between the implementation of this solver in PLUTO and in PIERNIK. (perhaps very briefly in chapter 1 but elaborate more in chapter 4).

2) chapter 4.
   a) it would be helpful to clarify what is meant by the following statement " We successfully simulate a thin accretion disk around millisecond pulsar ... (the bottom of page 37). Is it simply the fact that the candidate managed to setup the simulations and run the code over a relatively long time?

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b) section 4.2, the first paragraph states that "The precise location of the truncation radius is still an open issue ..." and then "It is a general consensus that the inner radius of the disk may not differ very much from the Alfven radius ...". My understating of this text is that 'it is a general consensus that the truncation radius is the same as the Alfven radius". Is this correct?

c) Section 4.3, the author wrote that "the heating terms in eq. 4.2 are omitted in our simulations". This means that there is no viscous and Ohmic heating. Therefore, the author should clarify why the disk that is modeled here is referred to as 'viscous'.

d) Figure 4.3, I understand that the quantity plotted along the y-axis is in units of time (Jdot over J). If so, are the units along the x- and y-axes the same?

3) Chapter 5

a) make a qualitative comparison between different numerical methods. Ideally, it would be the best to compare results from approximate Riemann solvers with those from an exact Riemann solver at least for 1-D Sod and Ryu-Jones tests.

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