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DEPARTMENT OF PHYSICS SANTA BARBARA, CALIFORNIA 93106-9530

September 9, 2020

Professor Bronek Rudak
Chair of the Scientific Council
Centrum Astronomiczne Im. Mikołoja Kopernika
Polskiej Akademii Nauk
Bartycka 18, 00-716 Warszawa
Poland

Dear Professor Rudak and Members of the Scientific Council:

What follows is my review of the Ph.D. thesis of Deepika Bollimpalli, entitled *Temporal Variability Processes in Discs and Shells around Compact Objects.* I should say at the outset that I find this to be a very impressive body of work. In particular, the sheer breadth of theoretical research, from simulating dwarf nova-type outbursts to analytical calculations of neutron star atmosphere oscillations to analysis of general relativistic MHD simulations, is astonishing! Furthermore, the close attention of applications of this work to observations and/or using the theory to provide observational constraints is representative of the very best sort of theoretical work within astrophysics.

I found the introduction to be a thorough and in-depth overview of the types of astronomical sources to which the thesis applies. I could quibble with microscopic details (e.g. “force” before equation 1.3 on page 7 should be “acceleration”), but that would be the height of nitpicking!

Chapters 2-5 of the thesis have already been independently refereed by the journals in which they have been published, but I nevertheless offer the following comments and questions:

Chapter 2 is an extremely interesting application of the disk instability model (DIM) machinery to understanding so-called combination outbursts. I personally learned a lot of phenomenology from reading this chapter. Having done some work on dwarf novae myself, I am somewhat familiar with the DIM lightcurve code that is used here, and it is very challenging to explain how it works. I thought this was well done here.

Chapters 3 and 4: This explores a fascinating general relativistic effect which, I confess, I have always been dubious about. But these chapters have convinced me that this could be of real importance. The mode analysis of these levitating atmospheres is very cute, and the potential applications to measuring masses, radii, and distances of neutron stars is interesting. I was surprised, however, that the only comparisons to other methods were related to Chandra observations. I was under the (perhaps mistaken) impression that NICER was supposed to do an

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excellent job here, and was therefore surprised that the prospects with this mission were not discussed at all as a point of comparison.

Chapter 5: This is very challenging work, particularly as fluctuations in accretion rate do not necessarily correspond to fluctuations in light output, as clearly acknowledged in the thesis itself. Moreover the simulations themselves, done with three different codes, and even done with the same code, show considerable disparities in their behavior. Given all this, I believe that this was about as thorough a job as could be done. In fact, I am extraordinarily impressed that it was possible to get meaningful results at all, and that the results proved to be so interesting! I do have some questions, though:

-Given the disparities, and the fact that simulations A and R appear to "show many interesting points of overlap with observation", can one use the observations to say that something about the other simulations must not be happening in Nature?

-Would the rms-mean relations shown in Fig. 14 still have been obtained if they had just taken the raw accretion rate variations without filtering power to be just that below the viscous frequency? I.e. was this necessary? And I take it that this filtering was not done when computing the distributions show in Fig. 15? The reason I ask is that I thought that rms-flux went hand-in-hand with lognormal distributions.

-When one accounts for radial emissivity profiles in different photon energy bands, do the frequency-dependent lags that one then gets become more consistent with communication on the viscous time scale, or are the lags still much faster than that? (I may have missed this – if so, I apologize.)

I do not think that these items need to be addressed by any revisions of the thesis itself.

Summing up, I consider the doctoral thesis of Deepika Bollimpalli 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,

Omer Blaes

Omer Blaes
Professor of Physics