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Subject: Report on PhD thesis of Ananda Deepika Bollimpalli

Dear Committee,

This thesis focuses on variable phenomena that occur on the surface or in the accretion disks surrounding compact objects (white dwarfs, neutron stars and black hole). The work is theoretical, but with connections to a number of observed phenomena that are not yet fully explained. The studies are thus well-motivated.

The first paper in the thesis concentrates on Symbiotic Star systems, where the accretor is a white dwarf. These systems exhibit regular outbursts (where emission brightens substantially), but the cause is unclear. Possible mechanisms include accretion disk instabilities, thermonuclear burning on the surface of the white dwarf, or a combination of both. These are challenging systems to simulate (due to factors including their large size, and irradiation of the disk), and the interplay between accretion and thermonuclear burning is complex. This paper applies a thermal-viscous disk instability model to test scenarios that have been proposed for two specific and well-observed binary systems. The results show that the recurrent nova events in RS Ophiuchi are likely triggered by accretion-disk instabilities. The combination nova event from Z Andromedae, by contrast, most likely did not involve a disk instability, but rather a mass transfer enhancement from the companion, leading to an increase in nuclear burning. The simulations and analysis choices are clearly explained and justified, and the results have important implications for our understanding of these complicated systems.

The second and third papers turn to a different topic, that of radial oscillations in optically thin neutron star atmospheres being supported by radiation pressure at luminosities close to the Eddington limit. There are a number of instances where such a situation might arise: in accreting neutron stars undergoing thermonuclear X-ray bursts; or in Ultra-luminous X-ray sources, some of which are known to harbour high magnetic field stars accreting at very high rates. The first paper employs a Newtonian formalism to compute oscillation frequencies, the second a relativistic one. The calculations themselves (including assumptions) are well-explained, and the results are clear and well-presented.

The connection to the observed phenomenon of thermonuclear burst oscillations I find more of a stretch, however. Some of the potential shortcomings in the model (e.g.

optically thin rather than thick atmospheres) are acknowledged. Others are not: the link between burst oscillation frequency and the neutron star spin, which is very well-established for all burst oscillation sources, is not explored[1]; as is the fact that burst oscillations tend to disappear in the standard X-ray band during episodes of photospheric radius expansion (precisely the point when the atmosphere is presumably levitating and the model applies).

That said, while I question whether radial oscillations might be responsible for thermonuclear burst oscillations, I think the models developed are nonetheless very interesting, because they point to something that might be occurring in the peak of thermonuclear bursts, when emission has dropped into the soft X-ray or even UV band. There has not yet been sufficient instrumental capability to search for high time resolution phenomena in this band, but this would come with large-area broadband X-ray observatories like STROBE-X. If radiation-supported radial oscillations during burst peak could be detected, then the possibility of using this phenomenon to provide a new constraint on neutron star mass and radius becomes very interesting. Measuring neutron star mass and radius is a primary science goal for the mission, and this technique could provide a valuable cross-check for stars where other independent techniques can also be used, reducing systematics. So I think these two papers, and the theoretical model and ideas developed within them, are very exciting. I would certainly encourage the candidate to explore this further, and the application to ULXs!

The final paper in the thesis switches to black hole accretion, in particular the broadband X-ray variability observed from these systems. This study aims to test a very popular model, that of inward propagating fluctuations in accretion rate, focusing in particular on the implications for variability across timescales of milliseconds to seconds. This is done using GRMHD simulations of black hole accretion disks that are run for a sufficiently long duration to explore this range of timescales. It also – importantly – tests the sensitivity of the results to initial conditions (a known risk in this type of work). It is very nice to see rigorous studies of this kind attempting to test what has been until now quite a phenomenological model – and also to see the findings compared to the very large body of observations that exist. This is without doubt a major and important contribution to the literature in this field.

Overall this was a creative, rigorous and wide-ranging thesis and I was impressed by both breadth and depth. Summing up, I consider the doctoral thesis of Ananda 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.

Yours sincerely,

Professor Anna L. Watts

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[1] This is true also or non-pulsars: 4U 1636-536 seems to be included in the text as an accretion-powered pulsar, but it is not – it has burst oscillations during both normal X-ray bursts and superbursts.