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Reviewer report for PhD-thesis of Saikruba Krishnan

Saikruba Krishnan's thesis consists of three parts:

1. A general introduction into the topic of Active Galactic Nuclei (AGN).

2. A first scientific project, assessing the significance of the detections of quasi-period oscillations in the (red-noise dominated) power spectra of light curves of AGN.

3. A second scientific project analyzing the photometric and spectral changes of the AGN nick-named J0408 as witnessed by X-ray telescopes and ground-based follow-up.

In the following I will review these three parts first separately, and then come to an overview assessment.

1. The introductory chapter is a well-written, 18-page introduction to the topic of AGN, presenting all background material necessary. It is in size, depth and scope very well matched for a PhD thesis. I found only few places where the text would profit from corrections:

- In the historical part, the detection of the massive black hole in the Galactic Center is described briefly, and lacks recent references. Further, the scientific role the Event-Horizon-

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Telesope-images from M87 and Sgr A* are overstated, as they are not en-par with the robust infrared work on stellar orbits.
- The technique of reverberation mapping is mentioned without further explanation. This is fine for the context of the expected readers, yet it does not match the general level of explanations in the chapter.

2. The second part presents the first scientific project and is entitled “Detection of periodic signals using statistical tools”. It is based purely on simulations and tries to answer the question, under which conditions detections using the “Auto-Correlation Function” method and “Phase Dispersion Minimization” method can be considered as significant. Both tools have been used in many studies of AGN observations, but lacked a proper assessment, how reliable the reported quasi-periodic signals are. The issue is that the quasi-periodic signals are super-imposed on top of a noise background, which for such data typically is a red power-law. Perhaps somewhat surprisingly, many quasi-periodic looking parts of light curves actually can be created from pure red-noise spectra. Saikruba Krishnan has conducted a large set of simulations addressing the question systematically: In a first step, pure red-noise spectra are analyzed, which then allows defining, at what level a true quasi-periodic signal can be called significant. The work is rigorous and original, and the main result is that indeed many detections of quasi-periodicity in the literature might have suffered from insufficient consideration of the background noise. It is important to simulate the own data in order to be able to take this into account. My main comments would be on the presentation:
- It would be very instructive to accompany the text with many more figures – showing for example light curve examples, correlation functions etc. These are all (of course) intermediate products of the simulations, yet it would help the reader to be able to see what different parameter sets mean throughout, from how data would look like all the way to how the corresponding measurable would look like.
- The text is very dense in numbers, and thus hard to grasp. I suppose it would be better to try to place numbers into tables (even if just small ones), and have a more fluid text. In this way, the meaning of the numbers would be concentrated in the text, while the numerical evidence would rest on figures and tables.
The above shortcoming does not affect the scientific merit of the investigation; it is just not presented in an ideal form. In terms of completeness, I wonder why not more tools have been investigated – in particular the standard technique of looking for peaks in periodograms is not part of the research. This is somewhat surprising, since the author seems to be well aware of

the tool and literature, but seems to ignore it. Another point I would raise, rather as a question: Why would the addition of Poisson noise make a true difference? It hampers true detections, but also the red-noise-only light curved would be affected in the same way; so I wonder why this is presented as true limitation of the work.

3. The third presents the second scientific project. It is entitled “An X-ray flaring event and a variable soft X-ray excess detected with eROSITA”. The text presents the instruments used to obtain the data, the data and the reduction chain. The goal is trying to understand, what has happened in this AGN during the episode of increased brightness. Saikruba Krishnan was able to show that standard Comptonization models as available from the reduction software can describe the X-ray data. The picture complicates with the addition of optical data, and she discusses the so-called FRADO model. Overall, the optical data are not strong enough to be conclusive.
This part of the thesis is a classical X-ray analysis, using modern instruments and data. Saikruba Krishnan clearly knows how to reduce, analyze and fit such data, i.e. I have no general comments here, just very small details below the scope of this report. In the interpretation, for the non-X-ray astronomers, I think the addition of schematic view graphs, how the physical model used actually looks would be very valuable, i.e. how does “thermal Comptonization in the AGNSED model” actually look like; what is happening? Overall, the text would profit from sharpening. Lead questions could be “Did we observe an event similar to what is observed in changing-look AGN?”, or “Did we see a temporal increase in accretion rate?” Such questions would help to put the model effort into a physical context.

Perhaps a bit unusual in this thesis is that it consists of two very independent parts, which almost have no overlap, except for the fact that they deal with AGN. But given that indeed there is no overlap, I find it more convincing not to attempt to put both parts into a single interpretation. It is better to have them as independent parts. In wonder, however, why the tools presented in the first project have not been employed on real data. I would expect that this would be a relatively easy project, in which one would be able to earn the fruits for which the previous hard work was done? This would have, as the second project does, also added some real data into the thesis. But I understand that the analysis of X-ray data is also timely and urgent; and perhaps future publications are planned to look at the quasi-periodic signals of AGN. I would recommend so.

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Summing up, I consider the doctoral thesis of Saikruba Krishnan 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.

Stefan Gillessen, Garching, 23.4.2023