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Konkluzja recenzji rozprawy doktorskiej
(Conclusion of dissertation review)

„LIGHT ECHO STUDIES IN ACTIVE GALACTIC NUCLEI AND THEIR APPLICATION FOR DISTANCE MEASUREMENT"

Tytuł rozprawy *(Dissertation title)*: ....

Vikram Kumar Jaiswal

Autor rozprawy *(Author of the dissertation)*: ....

[X] Pozytywna ocena *(Positive conclusion)*:
Stwierdzam, że przedstawiona mi do recenzji rozprawa spełnia wszystkie wymagania ustawowe i zwyczajowe stawiane rozprawom doktorskim i wnoszę o dopuszczenie jej do dalszych etapów postępowania doktorskiego, uwzględniając publiczną obronę.
*(I conclude that the presented dissertation meets the formal and customary requirements for doctoral dissertations and I recommend its admission to subsequent stages of the procedure, including the public defense.)**

[ ] Ocena negatywna *(negative conclusion)*
Stwierdzam, że przedstawiona mi do recenzji rozprawa nie spełnia wszystkich wymagań ustawowych i zwyczajowych stawianych rozprawom doktorskim i dlatego nie rekomenduję dopuszczenia jej do dalszych etapów postępowania doktorskiego.
*(I conclude that the presented dissertation does not meet the formal and customary requirements for doctoral dissertations and therefore I do not recommend its admission to subsequent stages of the doctoral procedure.)**

Uzasadnienie powyższej oceny znajduje się w raporcie będącym załącznikiem 1.
(The justification of the above assessment can be found in the detailed report in the attachment 1.)

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Załącznik 1: Recenzja rozprawy doktorskiej
(Attachment 1: Review of the dissertation)

**Zaznacz ocenę (Please tick the box with your conclusion)*

Review report on the thesis entitled **"Light Echo Studies in Active Galactic Nuclei and their Application for Distance Measurement"** submitted for the degree of PhD by **Vikram Kumar Jaiswal**.

I will start with my conclusion – the work compiled in this thesis is easily of sufficient quality and substance to meet the requirements of a PhD. Of the three main chapters of the thesis, two are already published in a leading journal (Astronomy & Astrophysics), and the third has been submitted for review. I expect that third article will have no problem being accepted for publication after minor revisions.

The thesis explores interesting aspects of reverberation mapping – Paper I looks at the expected signal for continuum lags from the BLR under various different scenarios. Paper 2 develops this further to test the FRADO model and actually fit the observed continuum lags in NGC 5548. Particularly interesting is that the inclusion of the FRADO model in addition to just a disk recovers a much improved value of H_0. Finally, Paper 3 explores how the reverberation signal from the accretion disk would change with an extended corona. Each of these studies in novel, and an important contribution to this area of AGN studies.

The thesis is generally well written, and comprehensive, though there are one or two spots in the introductory material that I think could be expanded on a little further. Below I provide specific comments in order that they appear in the thesis. I highlight the most substantial comment in red.

Pg 29: the diffraction limit is not the practical limit from the ground – atmospheric seeing or adaptive optics limitations are.

Pg 31, Section 2.2.2, 2.2.3, 2.2.4: I think these sections belabor the point about the inability to spatially resolve the different structures from the ground, especially since the diffraction limit is not the problem – from the ground atmospheric seeing and adaptive optics limitations are what limit the angular resolution.

Fig 2.1: This figure is from Cackett, Bentz & Kara (2021) not Cackett et al, (2020)

Fig 2.3: This is also directly from Cackett, Bentz & Kara (2021), using data from Fausnaugh et al (2016).

Pg 44: The broader response with wavelength is also just a geometrical effect – we see the near side first and the far side last. As you go to larger radii the difference in lag between the near side emission and the far side emission increases.

Pg 45: Sergeev et al. (2005) were the first to show that lags are longer than predicted for their observed luminosity, noting about a one magnitude difference.

Pg 46: Another model proposed for the longer than expected lags is obscuration – in Lewin et al (2025) they find that the difference between predicted and observed lags is largest for those objects with large X-ray obscuration.

Pg 46: In introducing emission from the BLR as a possible solution to the disk size problem there should be a substantial discussion about the current literature in this area, especially since the work in this thesis focuses on this topic. For instance, theoretically there has been a lot of work starting with Korista & Goad (2001) but also including Lawther et al. (2018), Korista & Goad (2019), Netzer (2022), Netzer et al. (2024) among others. Observationally there are a number of key indicators that the BLR may be important – for instance, the observation that the u-band lags frequently lie substantially above the trend extrapolated from other wavelengths (e.g. Edelson et al 2019, but many others too), and when the lags are resolved spectroscopically in NGC 4593 this is a broad feature at the Balmer jump (Cackett et al. 2018). Moreover, advanced analysis techniques also indicate emission from further out (e.g., Chelouche et al 2019, Cackett et al. 2022). While many of these papers are referred to briefly in later chapters, I think it is important to provide a detailed summary of this prior work in the Introduction to the thesis.

Pg 52: Li et al. were not the first to introduce the Bayesian/MCMC approach to fitting BLR reverberation data. See Pancoast et al. (2011) and associated papers.

Section 3.5: It would be good here to discuss previous efforts to use continuum RM to measure H_0, for instance, Collier et al (1999) and Cackett et al (2007).

Paper I: I think the dependence of the measured delay on the response function (Fig 15) may simply indicate that the ICCF method is too simplistic for separating out more complex delay distributions. I think more complex analysis approaches, such as those that fit the light curves, or a lag-frequency analysis, are more powerful for separating signals that are occurring on different timescales.

Paper 2: How do the lags from this model compare with the work of Korista & Goad (2019)? I know Section 6.5 touches on this very briefly, but a deeper comparison between the two approaches would be useful.

Paper 2: I think I misunderstood or missed something – is the UV/optical Fe II complex included in the SED modeling? Does that come directly out of the CLOUDY modeling?

Paper 2: The text notes that model C does the best job at fitting the lags, but this does not appear to be quantified? Does a simple chi-squared (or similar) justify this claim?

Paper 2: I want to complement specifically that the paper is nicely open about the shortcomings of the model – that's refreshing to see!

Paper 3, Introduction: I think your work in Paper 2 nicely implies that the larger corona heights from the Kammoun et al work are simply needed to get longer lags, which can alternatively be accounted for by the BLR. That said, it is still worth testing the implications of a larger height.

Paper 3, section 2.2: Are the upper & lower pulses simultaneous? If so, how do they know about each other? The fastest a signal can travel is the speed of light. What's the effect of different assumptions about the speed of propagation of the impulse from the upper to lower corona or vice versa. See, for example, the investigation on this by Wilkins et al. (2016) for the case of X-ray reverberation.

Paper 3: Was any measurement noise added to the sampled light curves? Typically, we only get about 1% photometric uncertainty, at best. If it is not included, then the hopes of recovering the signal are even worse.

Paper 3: As with my comment on Paper 2, I think that ICCF may be a real limitation here. I think light curve fitting techniques, such as MEMECHO, or PyROA, could be used to more successfully test whether a 2 corona model can be distinguished from a 1 corona model.