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АСТРОНОМСКА
ОПСЕРВАТОРИЈА

Review of the doctoral disseration:
"Morphology of Circumnuclear Accreting Gas in Active Galactic Nuclei"
by Tathagata Saha

The doctoral dissertation of Tathagata Saha consists of five chapters: three of them (2, 3, 4) corresponding to a different research project, enclosed by Introduction and Conclusions (#1 and 5). Chapter 2 is a paper published in a peer-reviewed journal, chapter 3 is submitted and under review, while chapter 4 appears to present a work in progress. These three chapters are not directly linked, but share a common theme: using different aspects of (mostly) X-ray reprocessing to study the circumnuclear material in the active galactic nuclei (AGN).

The first chapter provides a comprehensive introduction into the phenomena of AGN: a brief historical overview, the dominant physical processes that power the AGNs, substructures, classifications, with particular attention to X-ray spectral properties. The fifth chapter is summarizing the main findings of each of the three research projects.

The entire chapter 2 represents a paper published in a peer-reviewed journal: Monthly Notices of the Royal Astronomical Society in 2022 Volume 509, page 5485.
The aim of this project was to asses the reliability of the so-called "torus" X-ray spectral models in the studies of obscured AGNs. A number of such models are present in the literature, assuming different geometries and morphologies. The question arises if, given the data quality of the current X-ray instruments, various model parameters obtained from a spectral fit are adequately constrained, such as, the intrinsic photon index and parameters determining the torus morphology. To this end, XMM-Newton and NuSTAR synthetic data were simulate based on six different models. The Bayesian Nested Sampling method was employed to analyze the simulated datasets. If was found that, for exposure times and fluxes typical of nearby Compton-thick AGN, several torus parameters remain unconstrained. Moreover, distinction between different models is only feasible for high intrinsic flux values. The results of this research project are valuable for the community as they emphasize important caveats and limitations in the modeling of the X-ray spectra reprocessed by the circnumnuclear material in AGN.

The chapter 3 represents a paper submitted to the peer-review journal (Astronomy & Astrophysics) and is still under review, at the moment of writing this report. A pre-print version is publicly available via arXiv service. In the focus of this chapter is a comprehensive multi-wavelength campaign of a transient AGN exhibiting flaring and changing-look behavior. The aim was to investigate the flaring mechanism and examine the time-dependent responses of the disk, corona, BLR, and torus. The Zwicky Transient Facility detected a transient flaring event in the type-1.9 AGN lasting over $\sim$ 40 days. The event was, with some delay, also observed by the SRG/eROSITA in X-rays. A three-year, multiwavelength follow-up campaign was carried out to monitor the source's spectral and temporal evolution, involving optical spectroscopic monitoring by various ground-based facilities, and X-ray and UV observations by space-based observatories. These observations revealed a changing-look event, with the source transitioning from type 1.9 to 1, marked by the appearance of a double-peaked broad Hβ line and a blue continuum. The X-ray emission displayed significant flux variation, without spectral evolution, and no evidence of a soft X-ray excess. Post-event, the optical continuum transformed back to a galaxy-dominated spectrum. Further study revealed no apparent signatures of a tidal disruption event. Consequently, it is suggested that the extreme multi-wavelength variability is triggered by an instability in the inner accretion disk. Extreme variability, changing-look AGNs and potential tidal disruption events represent a laboratory for understanding the accretion physics in environment of supermassive black holes, and case studies such as this one are very valuable contribution.

The chapter 4 presents development and testing of a pipeline for detecting changing AGN obscuration events in the eROSITA archive based on the X-ray hardness ratio. The pipeline was tested using eROSITA instrument response and simple models of obscured AGNs. The findings indicate that the detection of changes in line of sight absorption is feasible only in nearby Compton-thin and mildly obscured sources with a flux exceeding 1 mCrab in the 2–10 keV band. The pipeline is expected to be able to detect bright changing obscuration events both in the eROSITA archive and for real-time identification when eROSITA scans resume. Collection of a large number of such events would provide a way to statistically derive constraints on the torus cloud distribution and their properties. Furthermore, upon future real-time detections, this pipeline can potentially generate alert triggers for follow-up campaigns of the occultation events in progress. This chapter leaves an impression of a work in progress, as what would be the main expected result – the actual application on the eROSITA archive – is discussed only in a context of a future work. However, it is still a worthwhile addition to the thesis, and, if the work is continued, I expect that it will lead to another paper in a peer-reviewed journal.

Summing up, I consider the doctoral thesis of Tathagata Saha to be a valuable contribution and to meet the criteria prescribed by the law for a doctoral dissertation. It presents original work and demonstrates candidate's ability to conduct independent scientific research. Therefore, I request that this dissertation be admitted to a public defense.

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