# LONG-TERM X-RAY VARIABILITY IN ACTIVE GALACTIC NUCLEI 2MASX J20082452-444095: STUDYING ACCRETION ONTO AN INTERMEDIATE MASS BLACK HOLE


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## Objective

While all Active Galactic Nuclei (AGN) commonly vary in X-ray emission on short time scales, it has been noted by several papers that this flux variability seems to be inversely correlated with the mass of the black hole (e.g., Lu & Yu 2001[4]; Papadakis 2004[8]; McHardy et al. 2006[5]). This correlation implies that black holes with greater variability are less massive (~$10^6 M_\odot$). Therefore, if X-ray variability is great and the black hole is accreting near its Eddington limit, it can be inferred that this is a growing black hole[3]. Our research focuses on a dataset of the AGN 2MASX J20082452-444095 that spans several years (2011-2019) and was collected with the X-ray telescope onboard the Swift satellite. We study the long-term X-ray variability of J2008 in order to understand the growth rate of its central black hole.

## Introduction

### About AGN

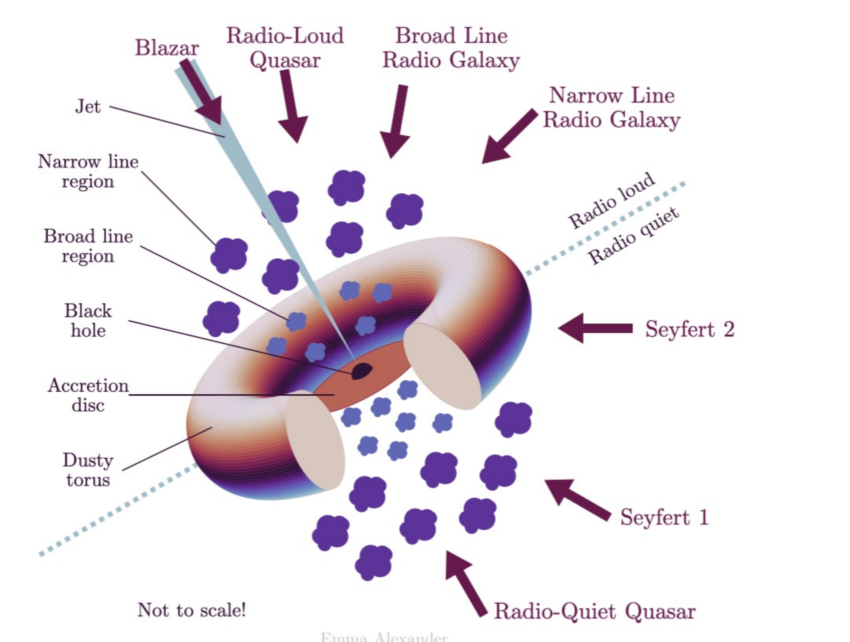


**Image 1:** A model of an AGN that displays the Unified Model, the theory that the classification of an AGN depends on the angle at which the observer views the object and whether or not the AGN produces a jet [10].

AGN are found at the center of galaxies and are objects of incredibly high energy densities. They can radiate across the entire electromagnetic spectrum, though they often peak in the optical-ultraviolet waveband. As seen in **image 1**[10], AGN are typically modeled as supermassive black holes with accretion disks surrounding them. The accretion disk, containing gas and dust trapped in the black hole's gravitational well, can launch relativistic jets that accelerate particles away from the central black hole and emit radiation in all wavebands[9]. This presentation focuses on the Seyfert type I galaxy, 2MASX J20082452-444095 (J2008-44).

### About Seyfert Galaxies

The difference between Seyfert I and Seyfert II galaxies depends on whether or not the dusty clouds of the torus interfere with the viewer's line of sight. Spectral emission lines are present in both Seyfert I and Seyfert II galaxies, but in Seyfert II galaxies, some of the emission lines are obscured by the presence of the torus. Therefore, Seyfert II galaxies can typically be classified based on their lack of broad emission lines. Broad line emission suggests that the gas of the spectral emission lines is highly excited and moving at a speed of over 1000 km/s[11].

## Methods

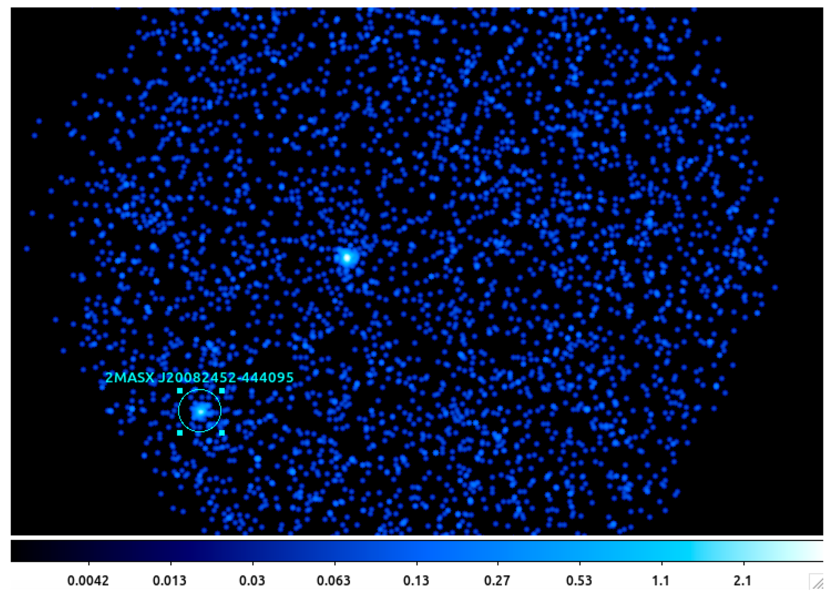


**Image 5:** A 2013 observation of 2MASX J20082452-444095 (circled in cyan). OBSID: 00032492007

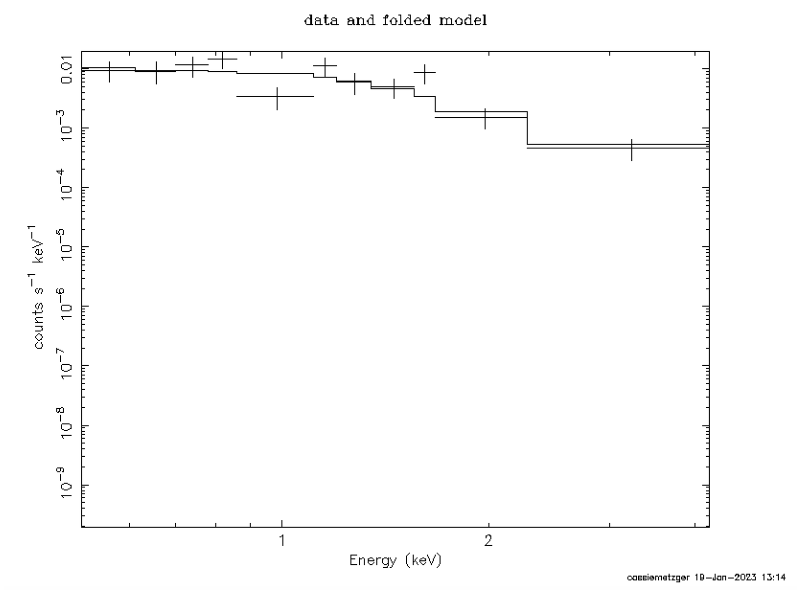


**Figure 1:** An example of the spectra received from the analysis described and the power law + blackbody fit. Groupings of 8 counts per bin. OBSID: 00032492007

### Literature

J2008-44 appeared in one of the images of a high-redshift blazar that we were studying. Previous studies of the X-ray variability of J2008-44 revealed a rapidly accreting black hole with mass 1.8 x $10^6$ $M_\odot$ (Kamizasa et al., 2012[3]) following the expression:

$$M_{BH} = 10^{5.76\pm0.13}(\sigma^2_{NXS,0.5-10})^{-0.64\pm0.04} M_\odot$$

Later studies of line emission confirmed the previous mass estimates (Ho & Kim, 2016[4]) and classified the object as a Seyfert I galaxy. Finally, the authors made the assessment that J2008 had a unique $O_{III}$ profile with peaks at λ4959 and λ5007. Normally, the two peaks are comparable in width, but the peaks of J2008-44 are 175 km $s^{-1}$ and 870 km $s^{-1}$, with the second peak (λ5007) blue shifted by 381 km $s^{-1}$.

### Procedure

To gain a better understanding of the nucleus of J2008-44, we aimed to produce a light curve displaying the observed X-ray flux from May 2011- October 2019. For 33 observations, We utilized `PyXspec` with Cash-statistics to fit the X-ray spectrum from 0.5 – 10 keV with a combined power law and black-body model. We consider Galactic foreground absorption in the model. Five observations were excluded from the final light curve because the spectra had an insufficient amount of photons. From the fits, we can determine the flux of J2008-44 for each observation.

With the acquired flux distribution, we use the fractional variability ($F_{var}$) in order to express the variability of J2008-44.

$$F_{var} = \sqrt{\frac{S^2 - \overline{\sigma^2_{err}}}{x^2}}$$

$S$ is the variance expressing the deviation of the measured fluxes from their arithmetic mean, $\bar{x}$. $\overline{\sigma^2_{err}}$ is the average from all flux measurement errors squared [12].

## Results

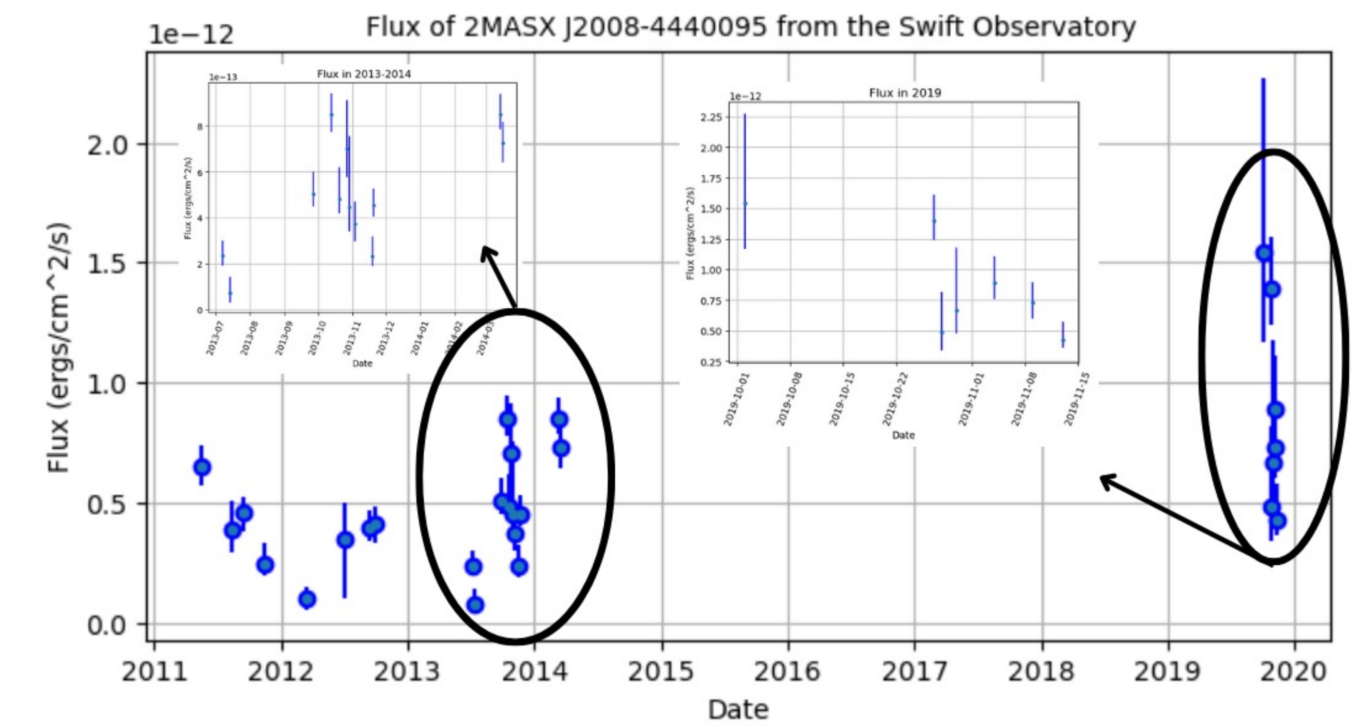


**Figure 2:** A light curve of 2MASX J2008-4440095 from 2011- 2019.

The figure above displays the flux of J2008 received by the Swift telescope from 2011- 2019. $F_{var}$ was calculated to be 0.6014 with an error ($\sigma_{err}$) of 0.091.

This means that J2008 is significantly variable because the error margins of the measure of variability do not intersect with 0, meaning that there is always some variability present.

$$0.6014 \,{}^{+}/_{-}\, 0.091 \neq 0$$

## Interpretation of Results & Conclusion

We conclude that J2008 appears to show long term changes in its variability. This leads us to believe that J2008 has a changing accretion flow as the accretion flow of an AGN is what produces its electromagnetic emissions. J2008's accretion flow may appear "clumpy" and irregular in concentration.

## X-ray Astronomy

The Neil Gehrels Swift Observatory resides in a low-Earth orbit and functions as a multi-wavelength observatory. As payload, Swift contains 3 instruments, each designed to observe a different waveband: the Burst Alert Telescope (15– 150 keV), the UV/Optical Telescope (170 - 600 nm), and the X-ray Telescope (0.3 – 10 keV)[6]. We utilized the Swift/XRT in order to collect data on the X-ray emission of J2008-44. Unlike an optical telescope, an X-ray telescope won't work through simple reflection. The photons are too energetic and would pass directly through the mirrors that the optical photons would reflect off of. In X-ray telescopes, the high energy photons enter a hemisphere of wafer-thin mirrors. A photon's trajectory then changes as it **grazes** off one of the mirrors like a "stone skipping on water.[7]"

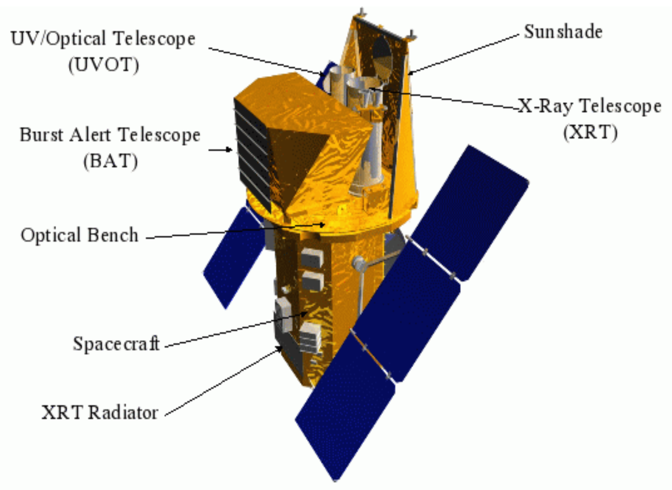


**Image 3:** The instruments aboard the Swift telescope[1]

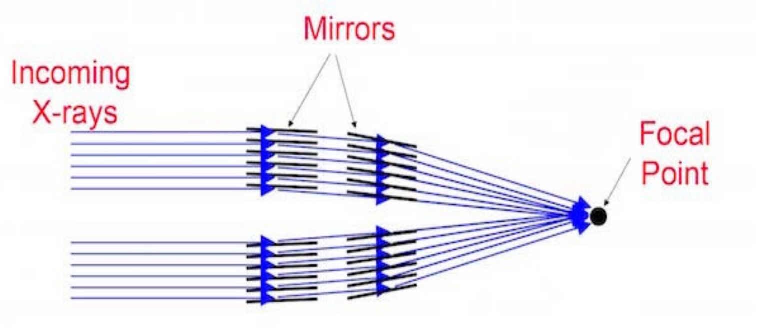


**Image 4:** X-ray photons entering an X-ray telescope and meeting at a focal point[7]

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