# From Einstein to Chandra: An Exploration of Highly Variable AGN

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## Introduction/Background

- It is widely accepted that most (and perhaps all) galaxies host a supermassive black hole at their centers. Some of these black holes are actively accreting material, which produces radiation. Such objects are called active galactic nuclei (AGN).
- X-ray emission is directly linked to black hole accretion; thus black hole accretion can be studied with orbiting X-ray telescopes such as the *Einstein Observatory* (launched 1978), *ROSAT Observatory* (launched 1990), and *Chandra X-Ray Observatory* (launched 1999).
- Dramatic, long-term changes in an AGN's X-ray luminosity could reflect a change in the way its black hole is being fueled.
- However, the durations of accretion episodes in AGNs are long compared to the history of X-ray astronomy, so dramatically variable AGN are rare.
- Here, we present two examples detected by *Einstein*, *ROSAT*, and *Chandra*.

**Top: Einstein Observatory, ROSAT Observatory**
**Bottom: XMM-Newton Observatory, Chandra Observatory**

## Methods/Design

- We have cross-correlated catalogs of sources detected by the *Einstein, ROSAT,* and *Chandra* over the past ~ 4 decades.
- We examine each source's "light curve" (i.e., its brightness vs. time).
- If a source varied significantly (by a factor of > 6), additional data such as optical images and spectra are obtained.

## Results

**J111521.2+404322**

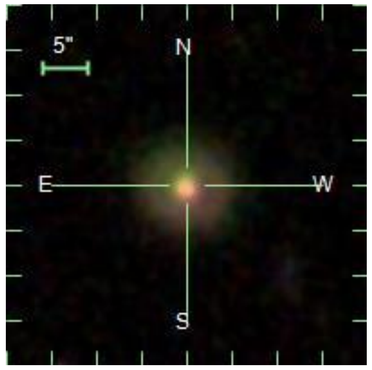


**Figure 1:** Optical image of the galaxy J1115+4043.

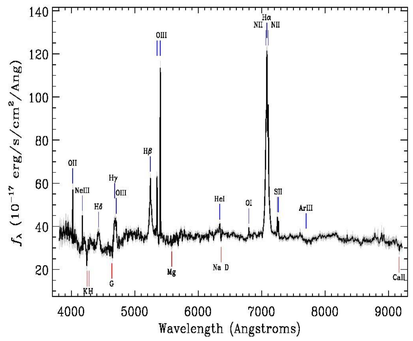


**Figure 2:** The optical spectrum of J1115+4043 reveals strong, broad emission lines that are characteristic of AGNs.

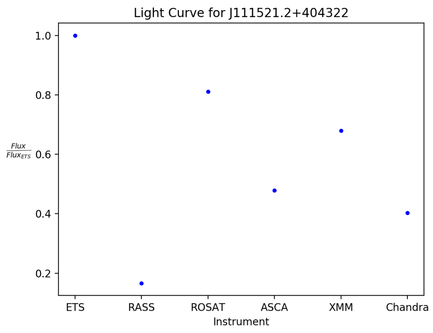


**Figure 3:** The light curve for J1115+4043 ordered by date of the observation shows the AGN varying in brightness.

**J180115.2+662401**

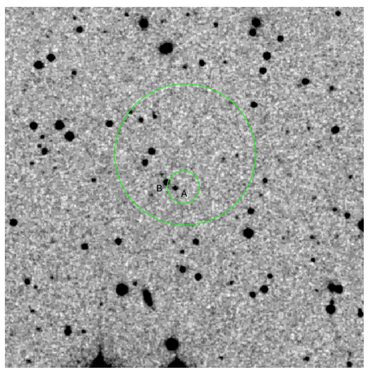

**Figure 4:** The optical field around J1801+6624 (object A) is shown with the *Einstein* (large) and *ROSAT* (small) position error circles.

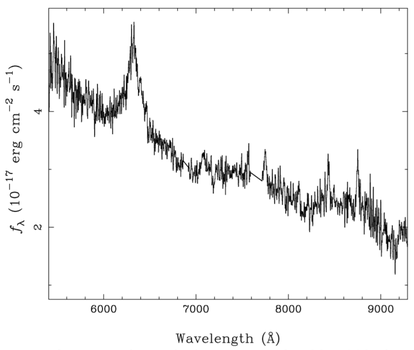


**Figure 5:** The optical spectrum of J1801+6624 is a powerful type of AGN known as a *quasar*.

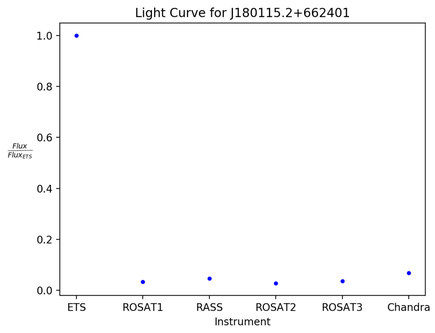


**Figure 6:** The light curve for J1801+6624 shows an initial decrease in brightness, followed by a consistent flux.

## Conclusions

- Figure 3 shows J1115+4043 to have a drastic decrease from its ETS to RASS observation. It then varies in brightness throughout the following observations, but J1115+4043 neither returns to its original brightness nor continue to decrease beyond the brightness detected with RASS.
- J1801+6624 experiences a decrease in luminosity from its ETS detection to its following detection in ROSAT. Rather than vary throughout its following observations, however, J1801+6624 has kept a constant brightness throughout.
- While we are yet to observe a black hole completely enter or exit its accretion phase, we have found multiple AGNs that vary in their accretion rates.
- For the AGNs that we found to be highly variable, we have found that it is more common for an AGN's accretion rate to decrease rather than increase.
- J1115+4043 and J1801+6624 prove to be great examples of what we are likely to find when looking for variable AGN within larger samples.

## Future Work

- Continue to cross correlate other X – ray observatories' data with the *Chandra* Source Catalog
- Find optical data for variable sources in catalogs such as the Sloan Digital Sky Survey
- Conduct up-to-date optical and X - ray observations for variable sources

## Acknowledgements

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