Are all ULXs created equal? The globular cluster ULX in the S0 galaxy NGC 1380

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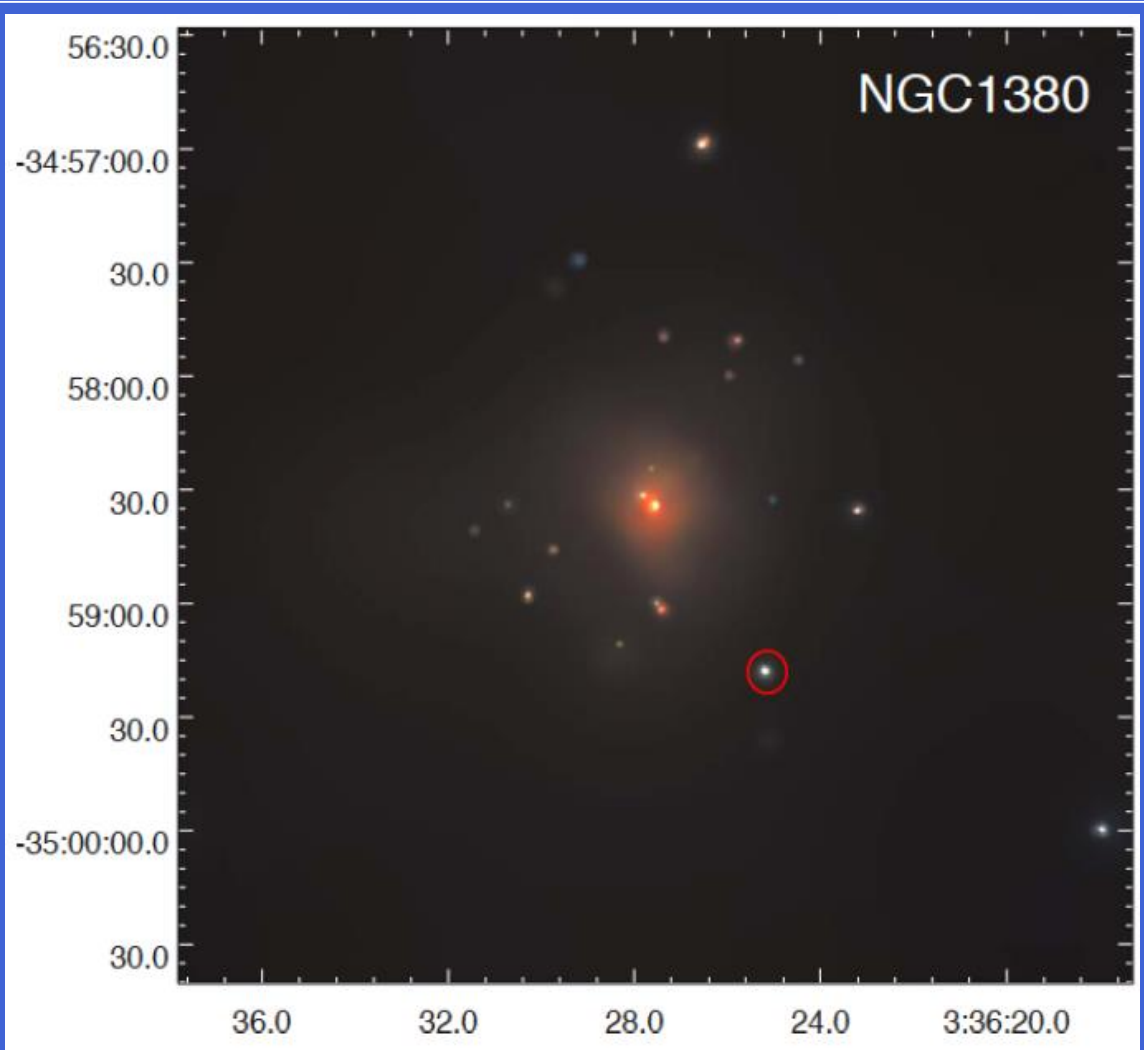
NGC 1380 ULX 1

We want to produce a physical description of NGC 1380 ULX 1



Chandra image of NGC 1380

Our ULX:

- Located in globular cluster, as part of NGC 1380 galaxy
- Classified as a ULX based on work done by Danley Hsu, a CSS alumnus
- GC association, large variability, and atypically hard spectrum make the ULX a good candidate for study

What is a ULX?

- Ultra-luminous X-ray source (ULX)
- Source that emits strongly in X-ray range
  - ▷ Not so much visible light!

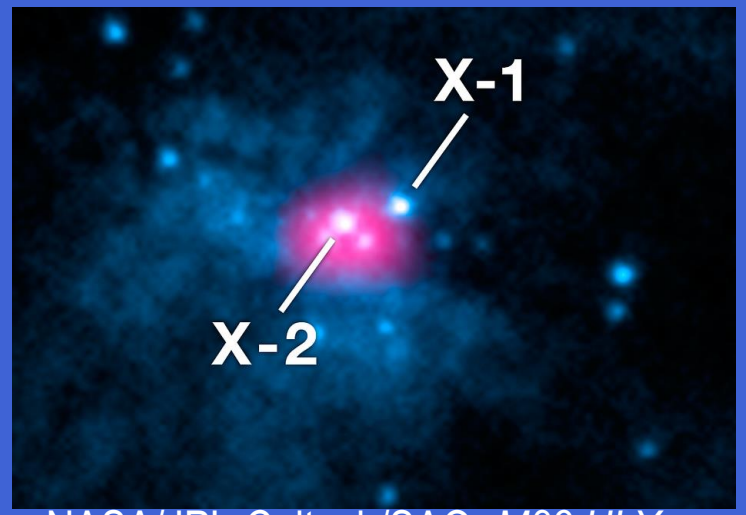
- Typical power output of a ULX: > 10^{39} erg/s
  - ▷ Reference: $L_{\odot} = 3.8 \times 10^{33}$ erg/s

- More power output than stars
- Less power output than AGNs

X-rays:
0.01 – 10 nm
10^{16} – 10^{19} Hz

Pretty high energy!

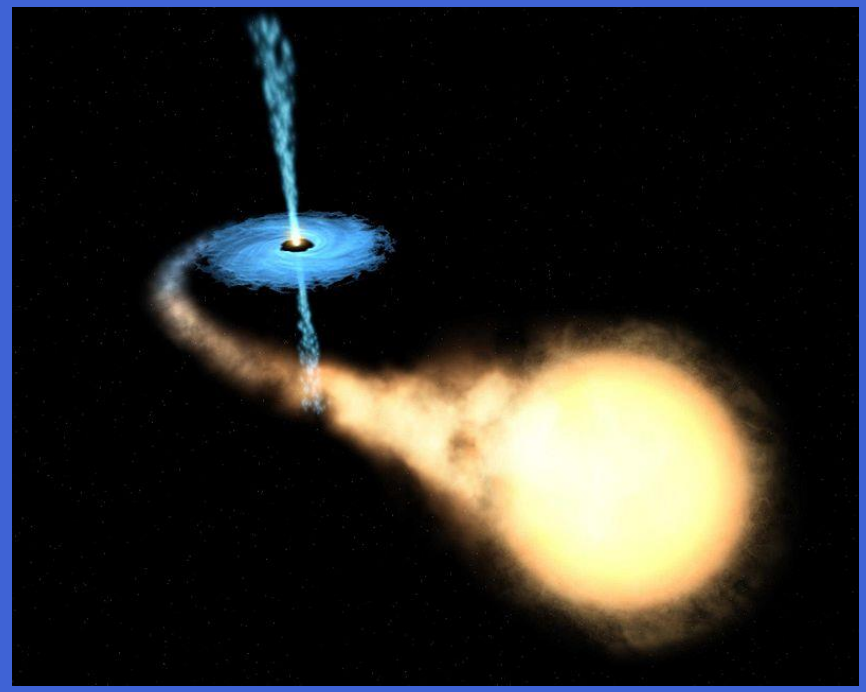
10^{39} erg/s = 10^{32} Watts



NASA/JPL-Caltech/SAO: *M82 ULXs*

Maybe a black hole?

- Black holes show up as luminous as they accrete material
  - ▷ Material comes from a companion object in mutual orbit with the black hole
- Two mass regimes for black holes
  - ▷ StMBH: ~ mass of Sun (1 $M_\odot$)
  - ▷ SMBH: ~ > 1000 $M_\odot$



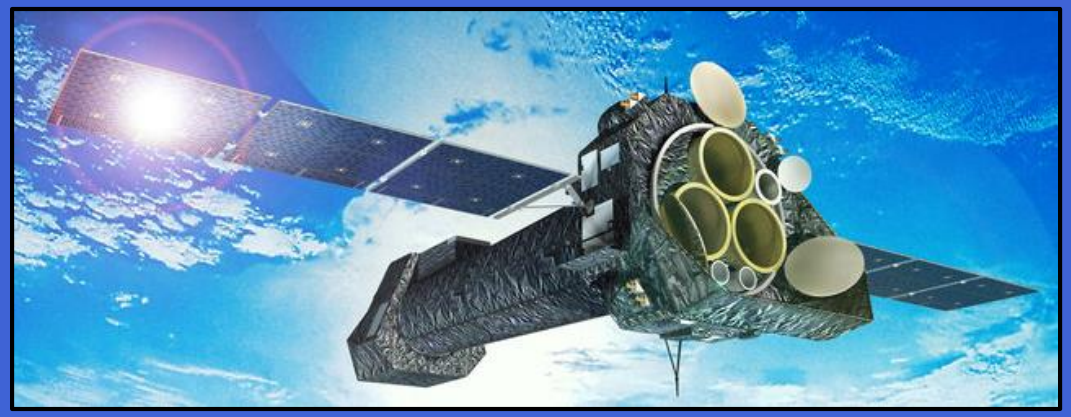
Artist depiction of accreting StMBH.
See "Accretion disc" *Wikipedia* article.

Working idea:

Perhaps some ULXs are intermediate mass black holes (IMBHs) that are accreting material from a companion object

Our observation

- Use X-ray telescope
  XMM-Newton
- ~ 1 day total exposure time
- Data: Photons hit telescope, recorded as “counts”
  - ∝ to energy



ESA - D. Dukros: Artist rendering of XMM-Newton

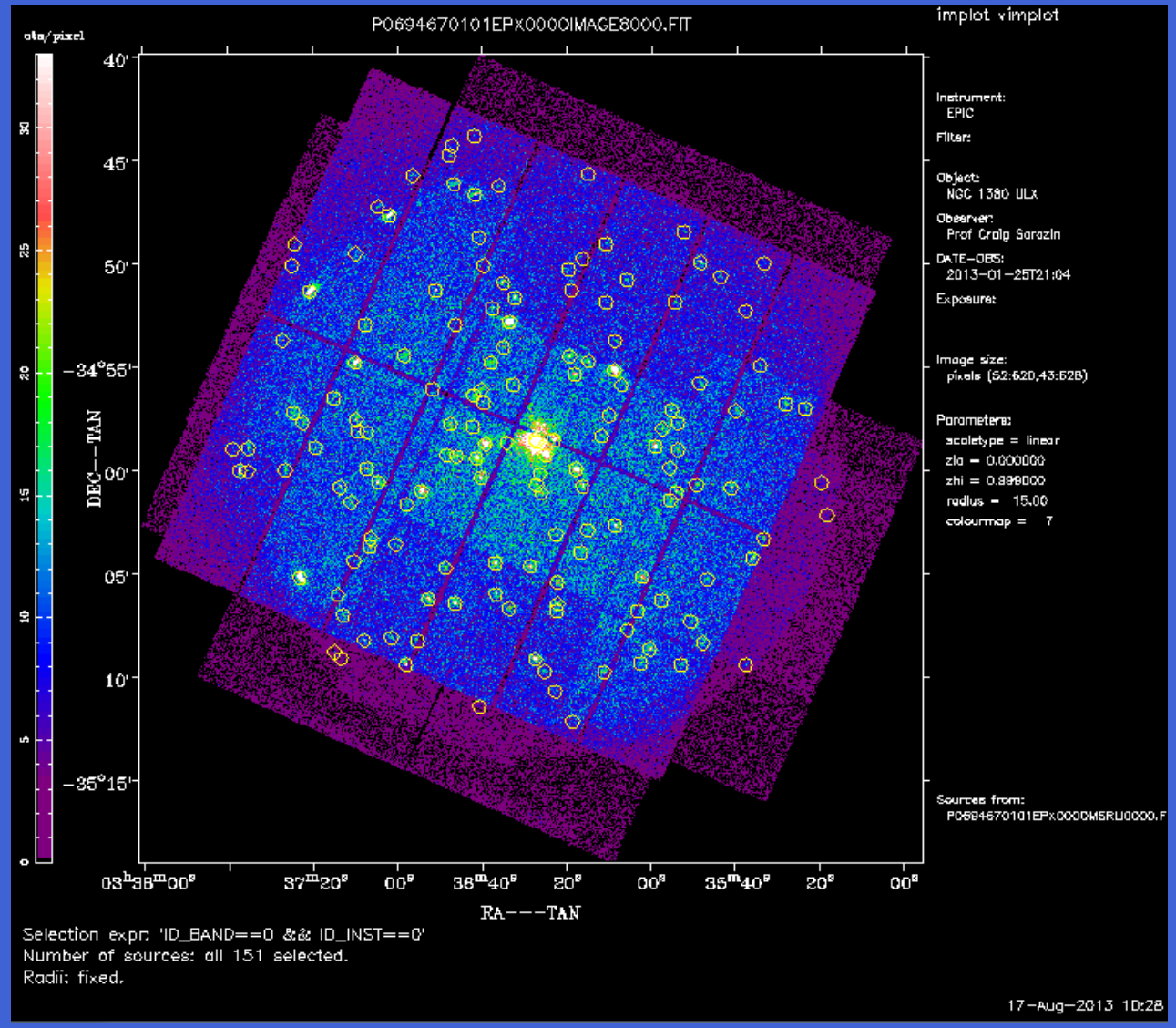


Image from our observation

Data analysis

- Is the ULX an intermediate mass black hole?

Need to find ULX's mass

- Can't directly measure mass (Unless you have a giant scale I can borrow!)
- Must calculate it from information that we <u>can</u> use the data to find

[1] Temperature of the accretion disk

[2] Luminosity of the ULX

[3] Orbital period of the ULX

Obtain using →

Spectral fitting

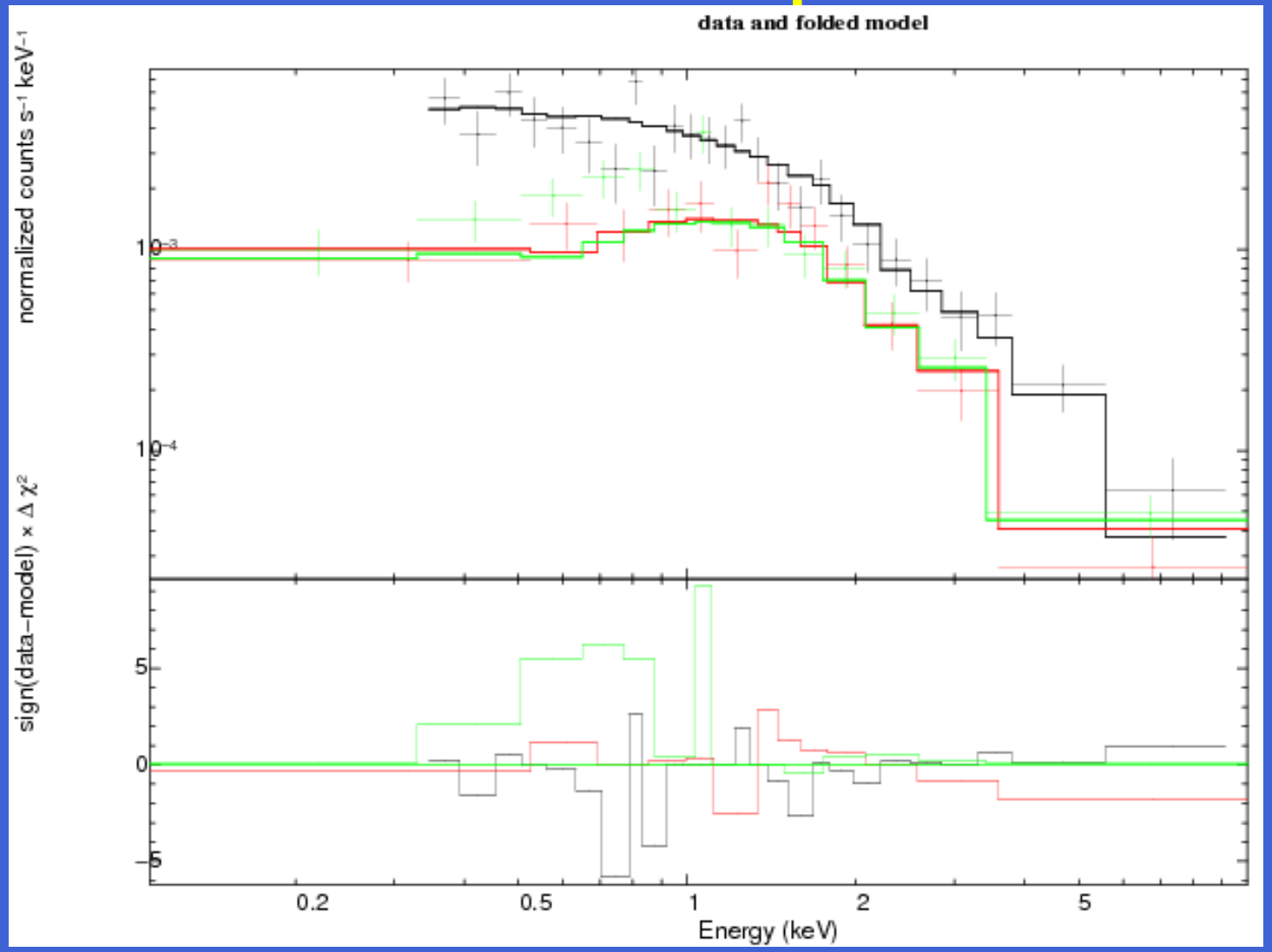
Timing analysis

Periodicity maybe caused by a companion object coming in the way of our line of sight to the ULX

Part 1: Spectral fitting

- Use “counts” data to generate an energy spectrum for the ULX
  - This basically tells us how many counts we have for any given energy
- Plot spectra on counts vs. energy, then fit models to the data
- Choose models that are of physical interest
  - ▷ Power-law model → blackbody radiation → black hole
  - ▷ Disk blackbody model → accretion disk
- χ^2 statistical test to determine which models are best

Figure: Disk blackbody + power-law spectral fit



The parameterization of this model fit tells us a lot about the ULX. Namely,

T_{inner} **(temperature)**

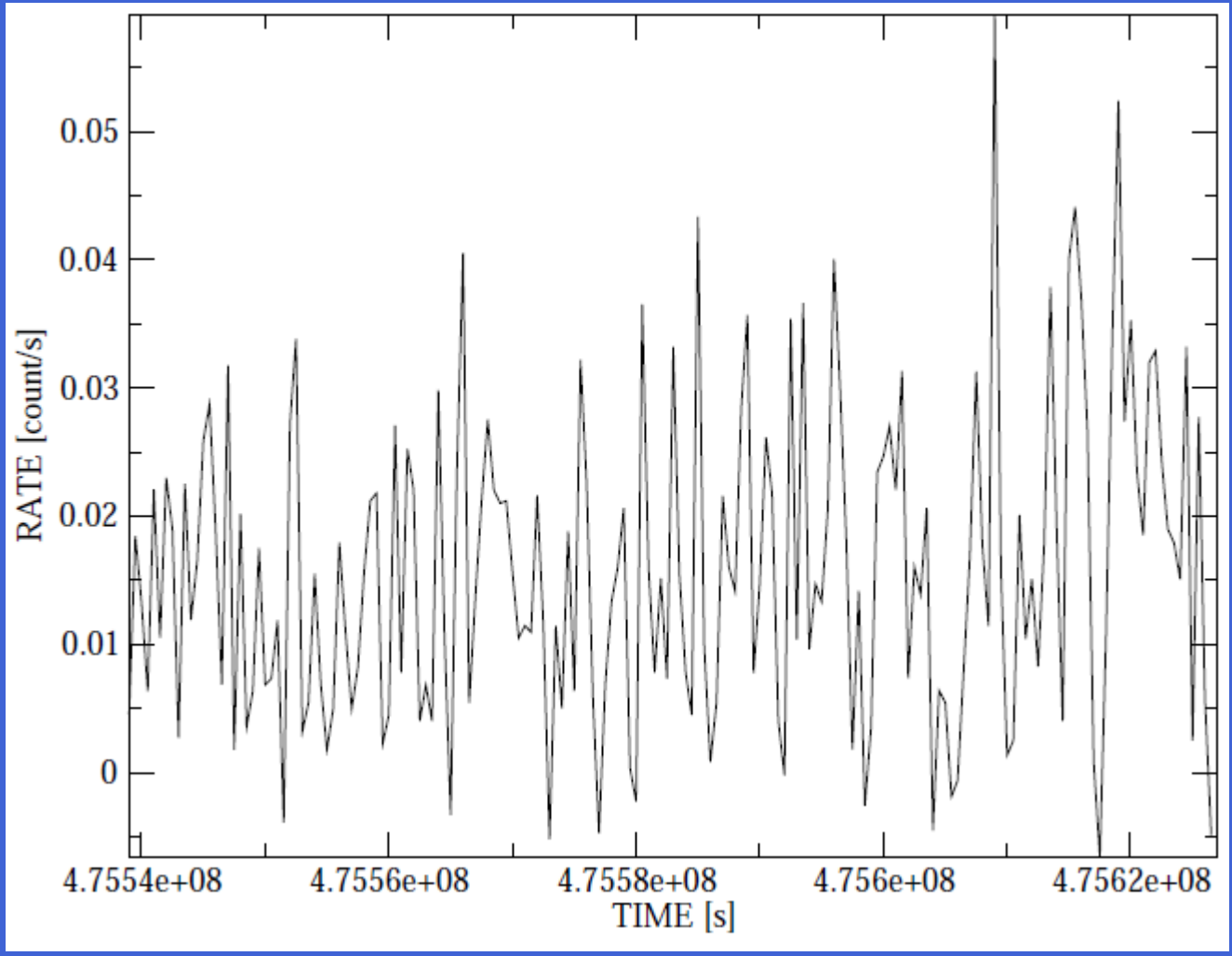
and

L_{ULX} **(luminosity)**

Now, we also want to know if the ULX may be in orbit with a companion . . .

Part 2: Timing analysis

- Next, we study the count rate of the ULX as a function of time
  - Use searching routine to find periodicity associated with the count rate



Best period:
2.1 kiloseconds

Of course, not quite that simple. Maybe this is an orbital period, but it could also be related to other kinds of interference

Some results

- Combining what we found from spectral fitting and timing analysis, we can write the following for the ULX:

$T_{inner} = 1.23$ keV $= 1.43 \times 10^7$ ºC

$L_{ULX} = 2.00 \times 10^{39}$ erg/s

$T = 2.1$ ks

- This is not a definitive parameterization, but rather a summary of what our analysis seems to indicate

A fun story that may or may not be true

$a = 6 \times 10^5$ km

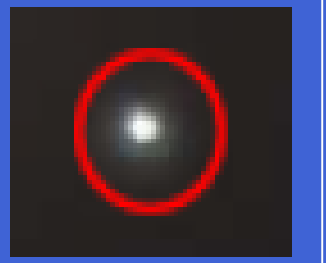
$M_{ULX} = 13.1\ M_\odot$

$M_{companion} = 0.2\ M_\odot$

- Relatively small a
- $M_{companion}$ in WD range
- M_{ULX} in StMBH range

Maybe . . . →

ULX is accreting heavy material from white dwarf, resulting in high luminosity

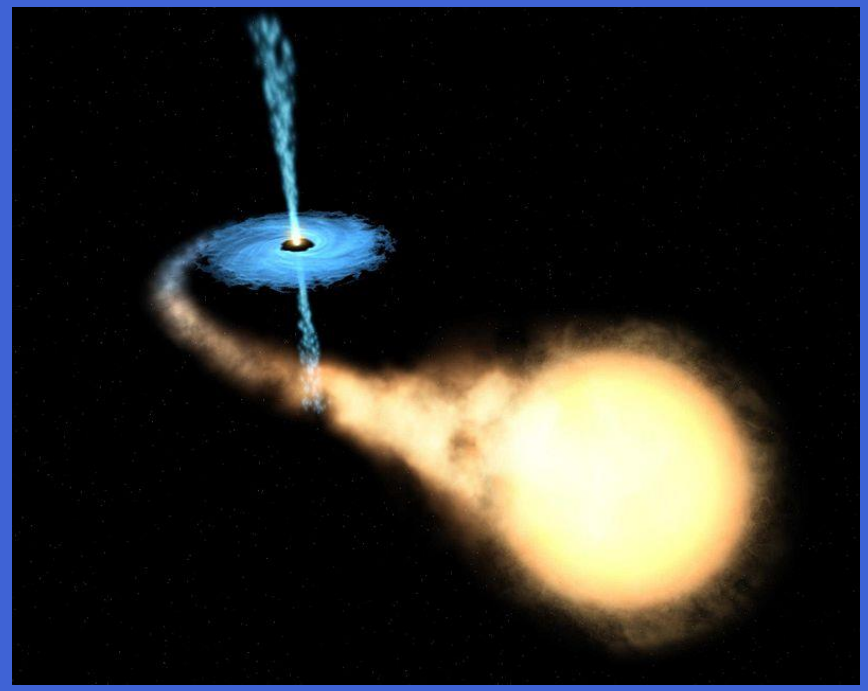


Our ULX

- What we observe to be a point of light is actually two objects orbiting each other, a black hole and a white dwarf
- The black hole provides the X-ray light
- The white dwarf causes a decrease in X-ray flux each time it passes through our line of sight to the black hole → periodicity

Future

- Maybe we'll continue with the timing analysis
- Use *Chandra* data to account for other point sources and ISM gas emission in the exposure
- Determine temperature and abundance of the diffuse gas in NGC 1380
- Other explanations for ULX still possible?



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