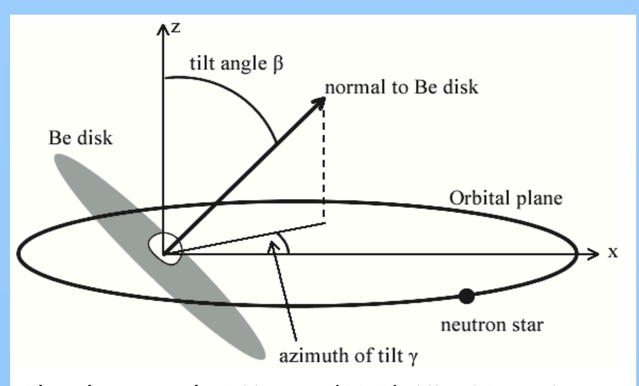
Not just normal or giant

A new look at Be X-ray binary outbursts

Be X-ray binaries

Binary systems composed of a compact object (mostly neutron star) accreting material from a Be star – a rapidly rotating, late O or B star with Balmer Hα emission lines, created in a decretion disk around the massive star.

Orbits tend to be eccentric, with periods of typically tens to hundreds of days, some much longer. **Most BeXRB are X-ray transients.**



Okazaki, Hayasaki & Moritani (2013), MNRAS 65, 41

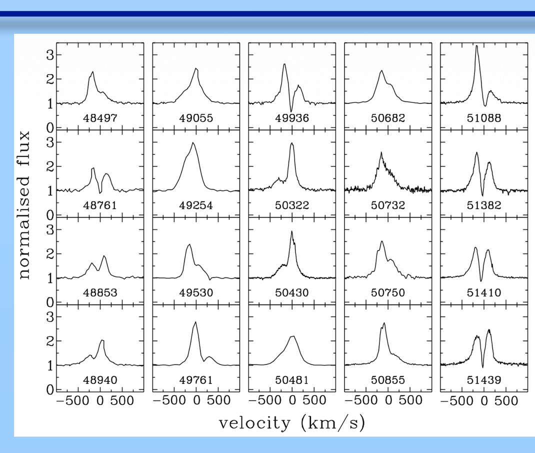
Beyond X-rays

Most BeXB show asymmetric, split Hα profiles with long-term variations of relative peak strengths.

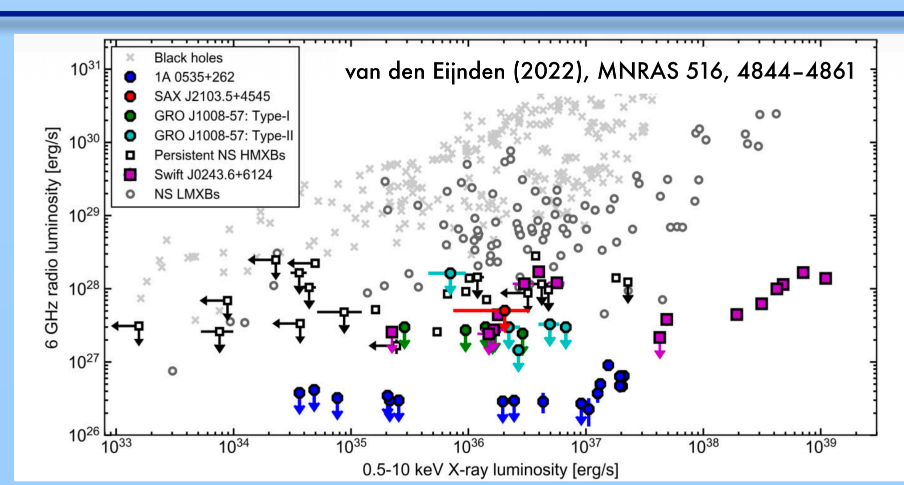
Optical and IR magnitudes also vary on longer time scales.

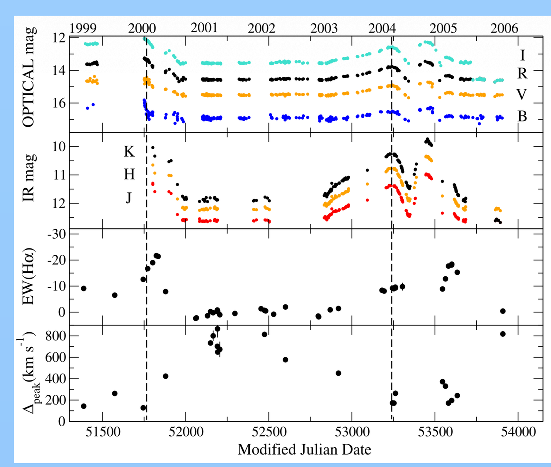
Radio emission detected in a few cases during bright outbursts, likely dominated by jet emission, but rather weak.

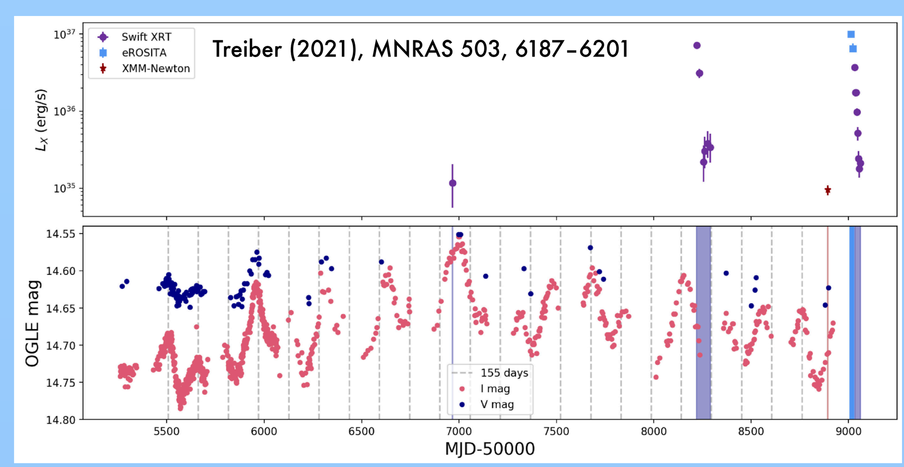
Also gamma-ray binaries with Be companion.



Reig (2011), Astrophys Space Sci 332, 1–29







Common statements about Be X-ray binary outbursts

Two basic types:

Type I ("normal"): quasi-periodic at periastron; shorter than one orbital period; L_X varies by ~10.

Type II ("giant"): rare; at any orbital phase; may be longer than orbital period; L_X can vary by 10^{3-4} and reach super-Eddington brightness.

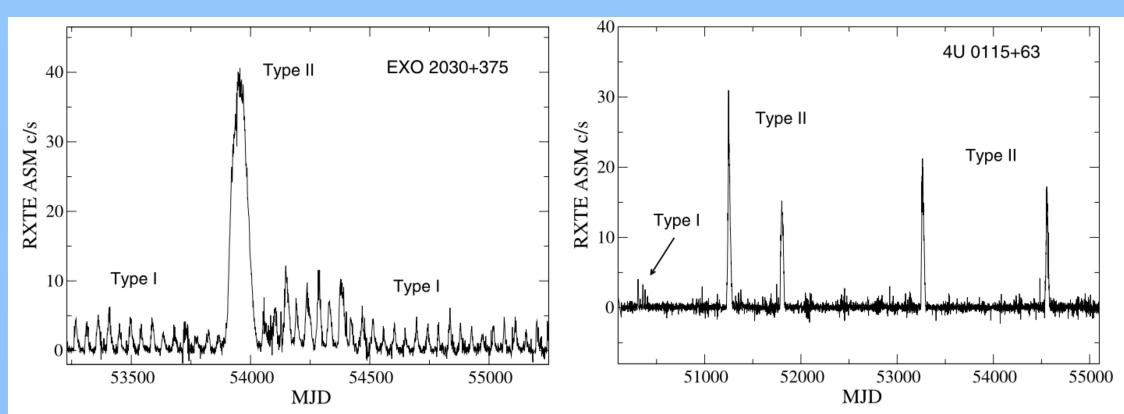
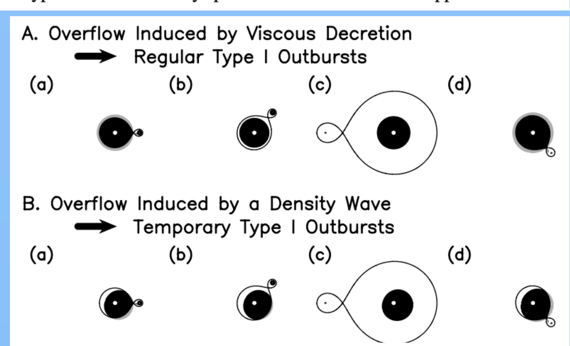


Fig. 9 Long-term *light curves* of EXO 2030+375 (*left*) and 4U 0115+63 (*right*). Although the two systems have been seen to display both type I and type II outbursts, type II outbursts in EXO 2030+375 are rare whereas type I are almost always present. In 4U 0115+63 the opposite occurs

Reig (2011), Astrophys Space Sci 332, 1–29

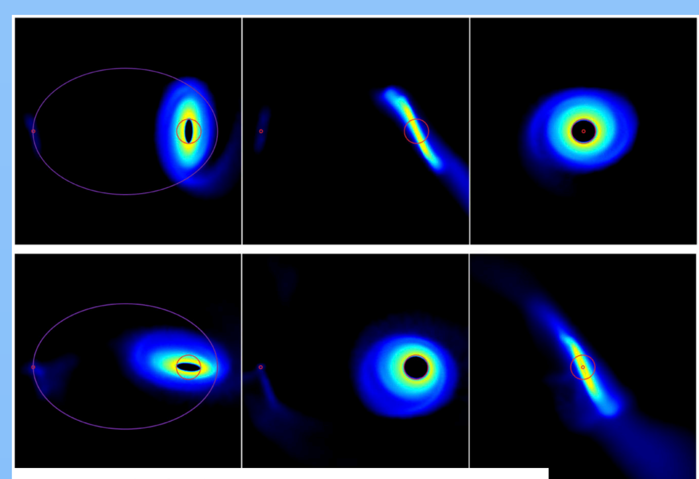
Type I outbursts
triggered by periastron passage fuelling reservoir of matter, presumably an accretion disk.



Okazaki & Negueruela (2001), A&A 377, 161–174

What triggers giant outbursts?

Type II outbursts
have been explained invoking a variety of factors including a decretion disk significantly tilted relative to the orbital plane, a misaligned and/or warped disk. This is an open field of research.



Martin & Charles (2024), MNRAS 528, L59–L65

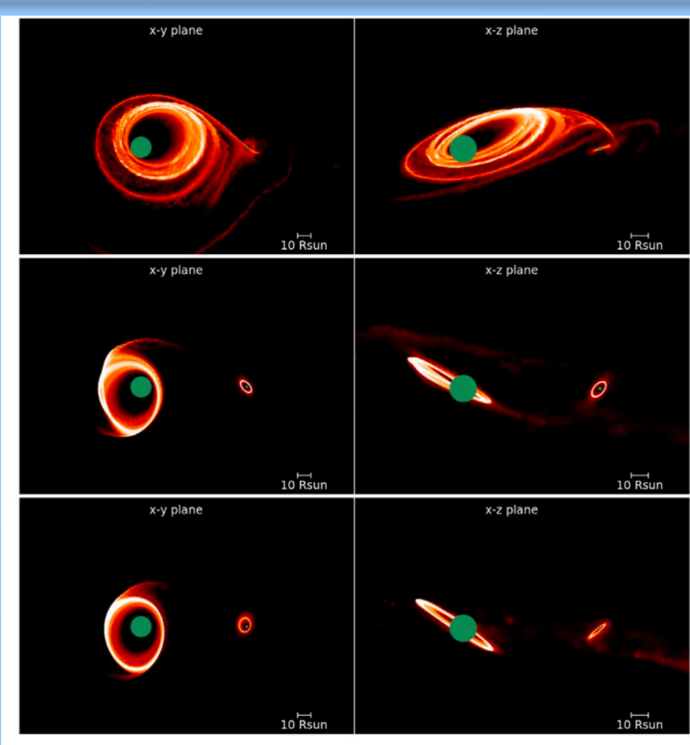
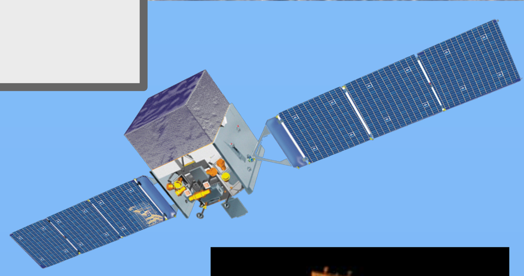


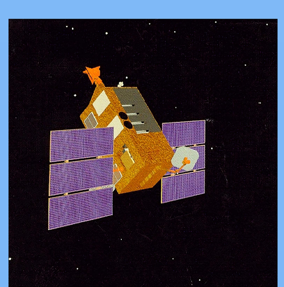
Figure 3. Column density plots of the Be star and neutron star disks. The binary components are shown in green and their size is determined by their accretion radii. The view is of the *x*–*y* plane (i.e., the binary orbital plane) (left panels) and of the *x*–*z* plane (right panels). The color scale spans about three orders of magnitude in density and is the same for all the plots. The first, second, and third rows correspond to 29, 33, 38 P_b.

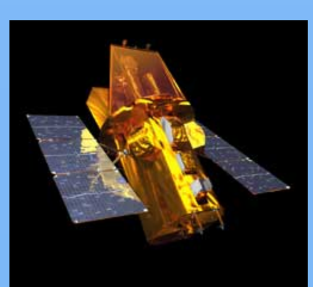
Franchini & Martin (2021), ApJL 923, L18

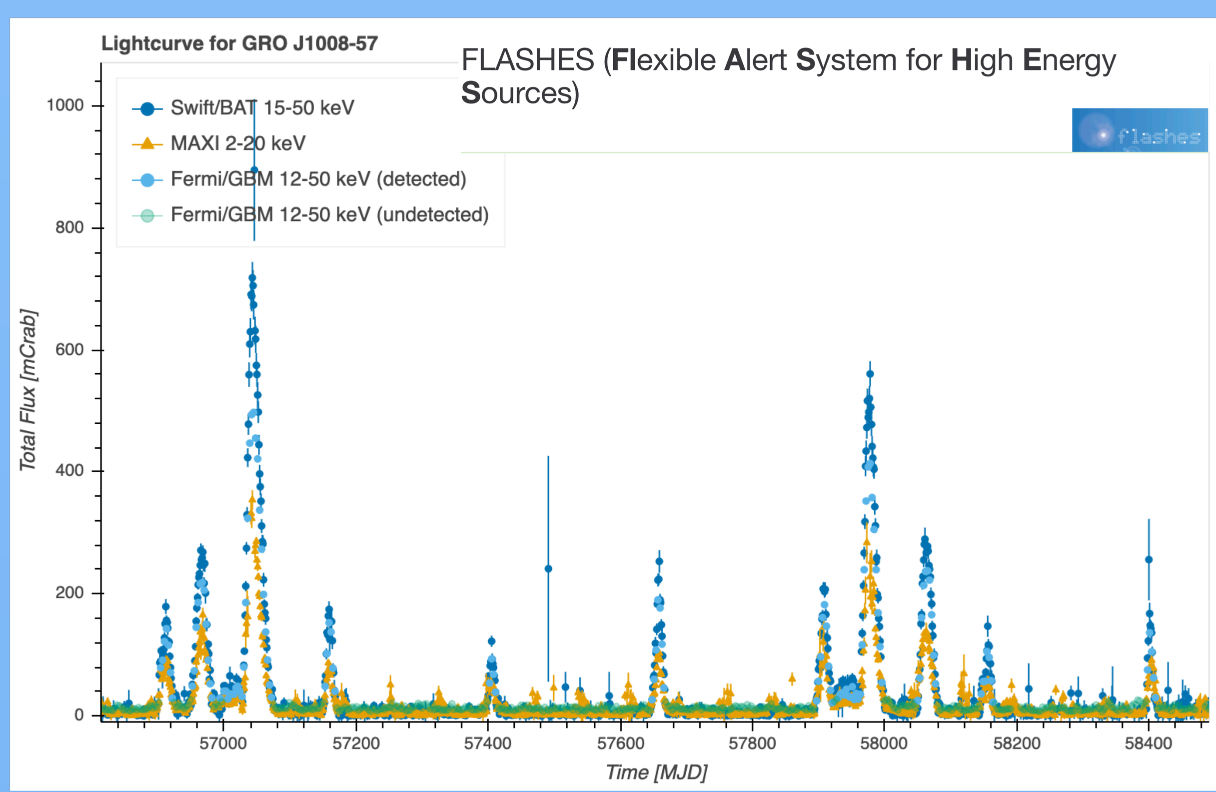
35 years of publicly available X-ray monitoring data

CGRO/BATSE:	1991–2000
RXTE/ASM:	1996–2012
Swift/BAT:	2004–...
Fermi/GBM:	2008–...
MAXI:	2009–...



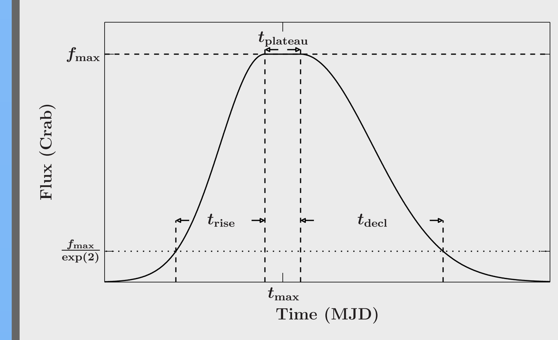


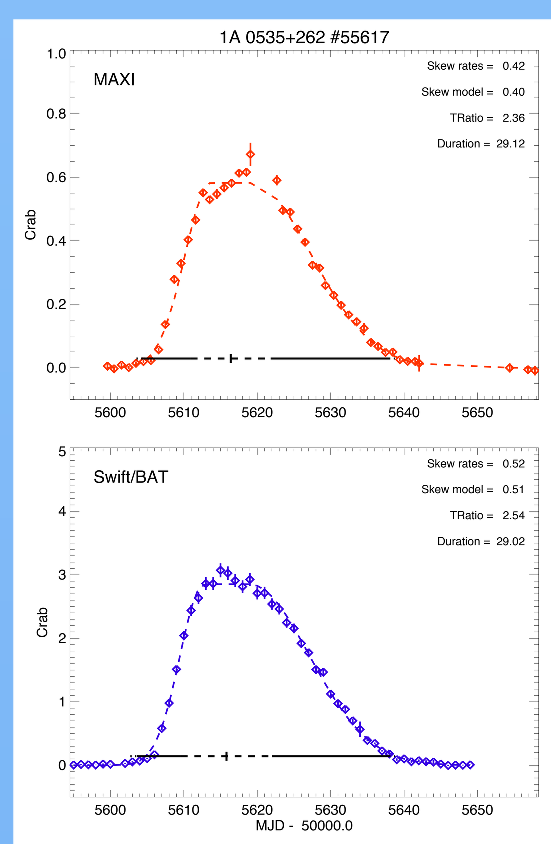




Standardized outburst description

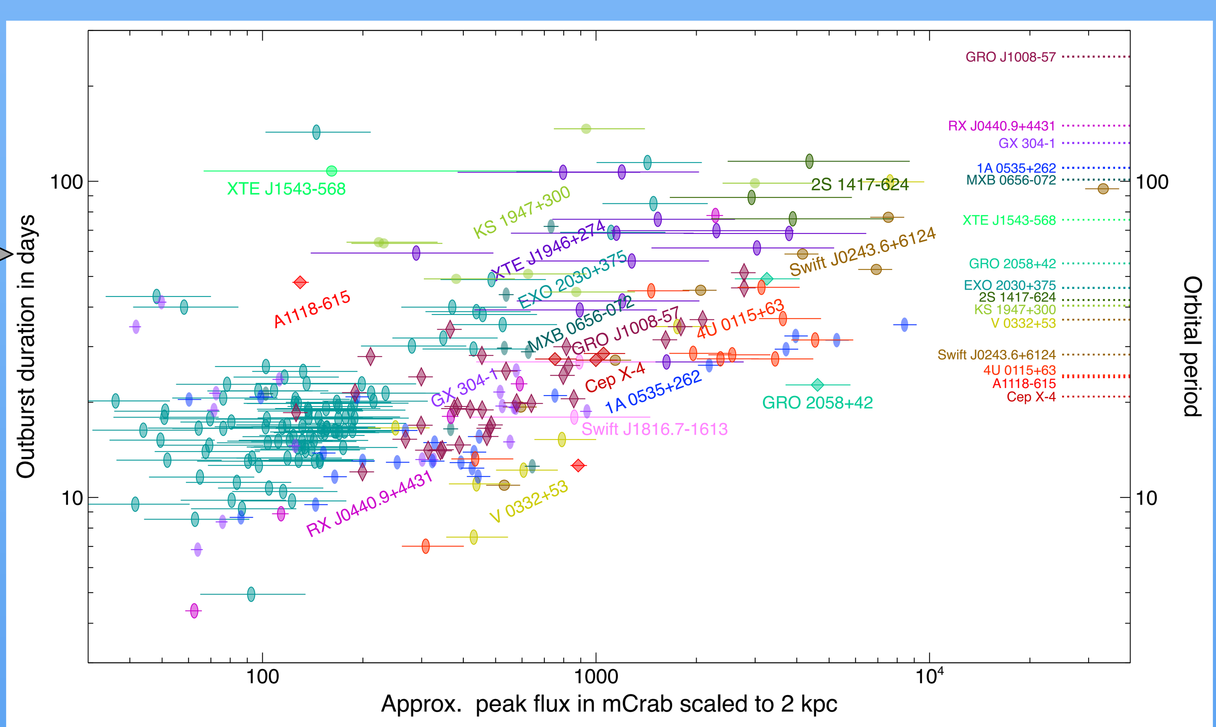
Most outbursts are well described by a simple phenomenological model: 2 Gaussian halves with different slopes, occasionally separated by a flat 'plateau'. Rise and decline times defined as '2σ' from peak.

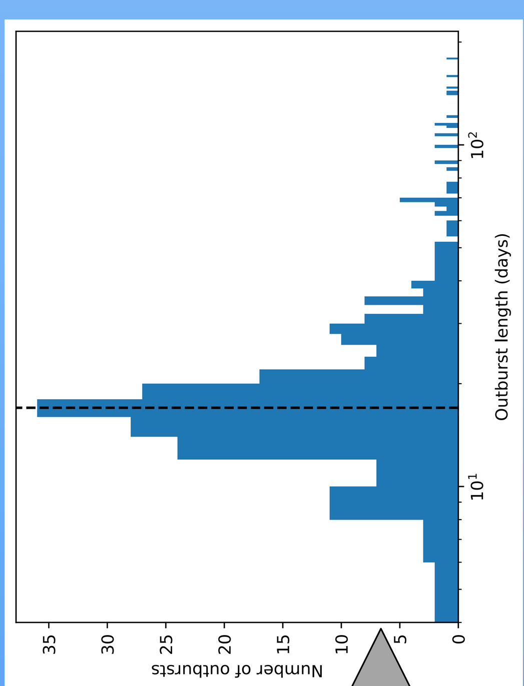


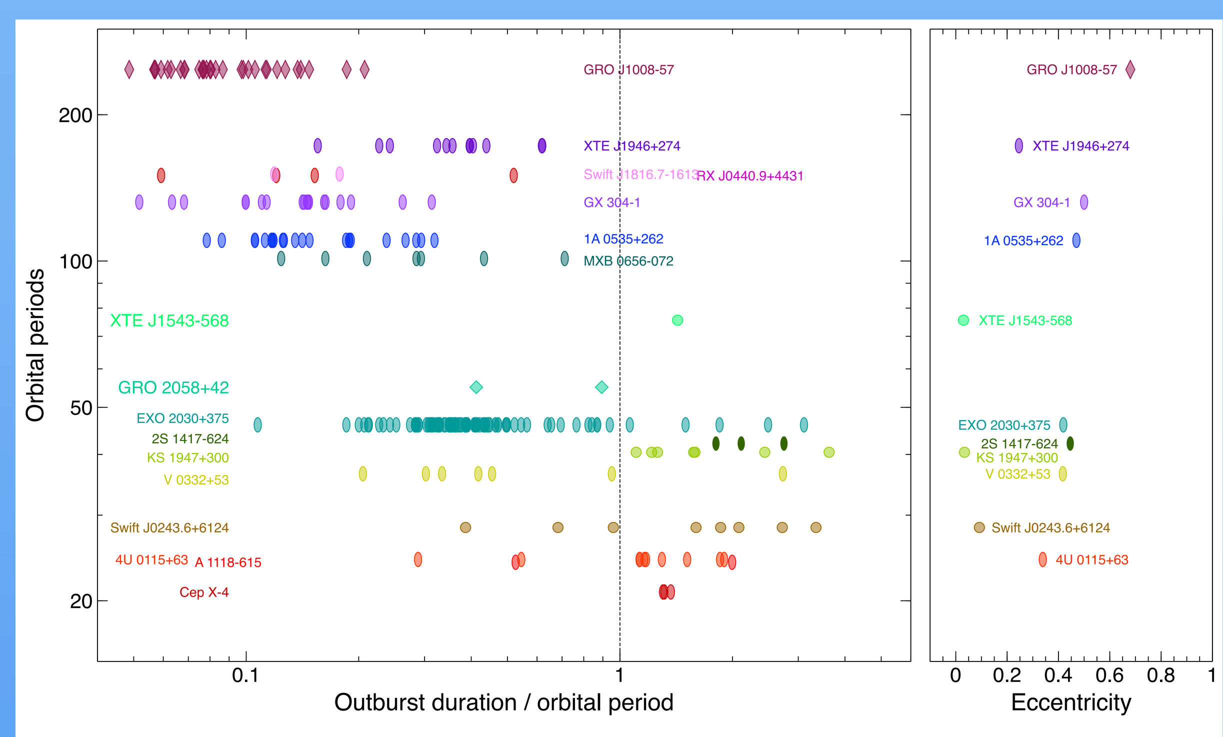


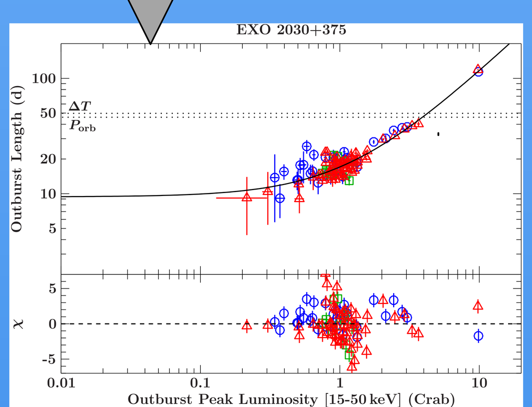
Preliminary Results

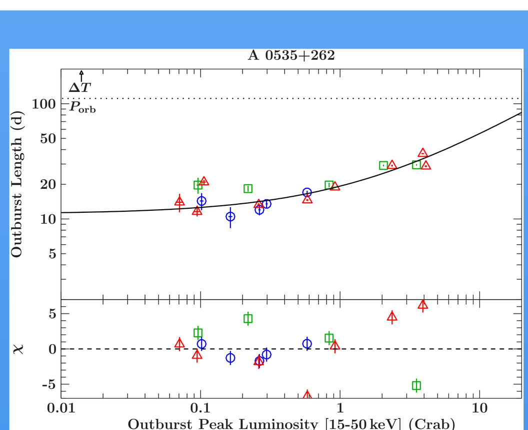
Outburst durations correlate with peak luminosity, but show large scatter and the luminosity-duration relations are specific for each source.

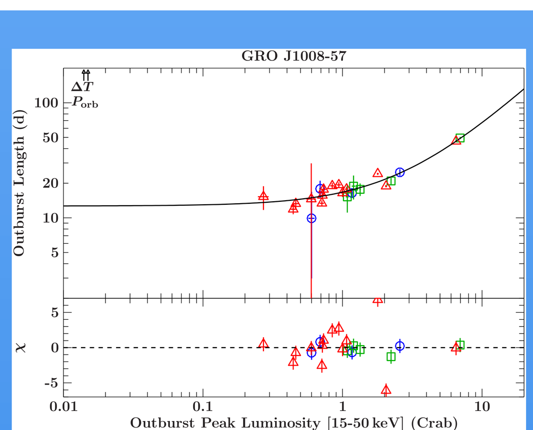












Peak in distribution of outburst durations around two weeks – indicative of a typical mass reservoir?

Sources with long orbital periods only have outbursts where the duration is shorter than this.

Sources with low eccentricity orbits tend to have larger outburst durations divided by the orbital period.

Peter Kretschmar (ESA), Mathias Bissinger (FAU, ECAP) – Future Landscape of Astrophysical Transients, IAU Symposium 406, 18–22 May 2026, Turku, Finland