Quasiperiodic X-ray eruptions in galactiv nuclei

Potential topics for BSc. and MSc. theses

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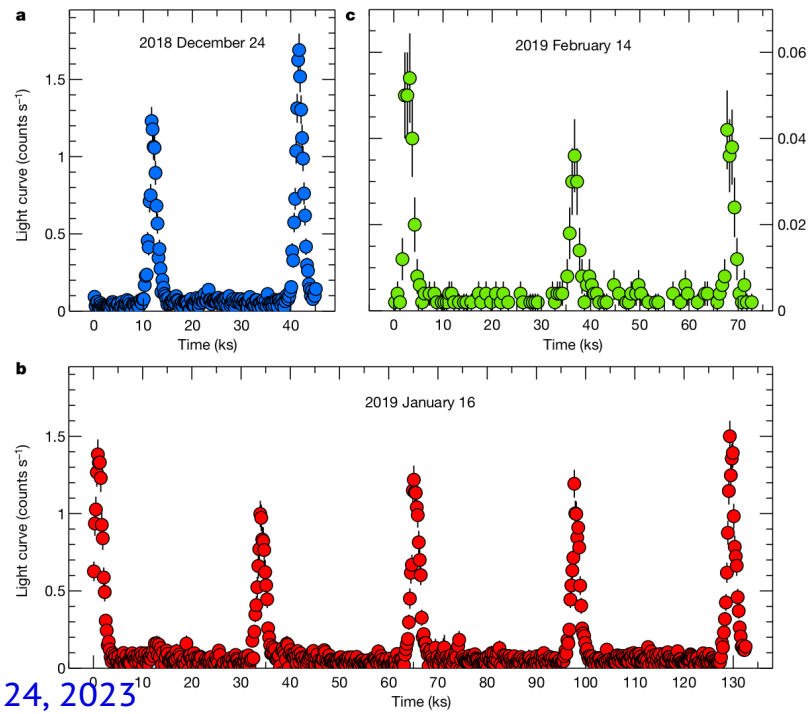
What are Quasiperiodic Eruptions (QPEs)?

- a new class of short-duration, large-amplitude X-ray flares
- duration ranges from an hour to several days
- recurrence timescale (periodicity) ranges from a few hours to tens of days
- **first source:** GSN 069 (Miniutti et al. 2019): **flares last one hour, repeat every 9 hours** $\rightarrow$ **duty cycle of** ~ 0.1

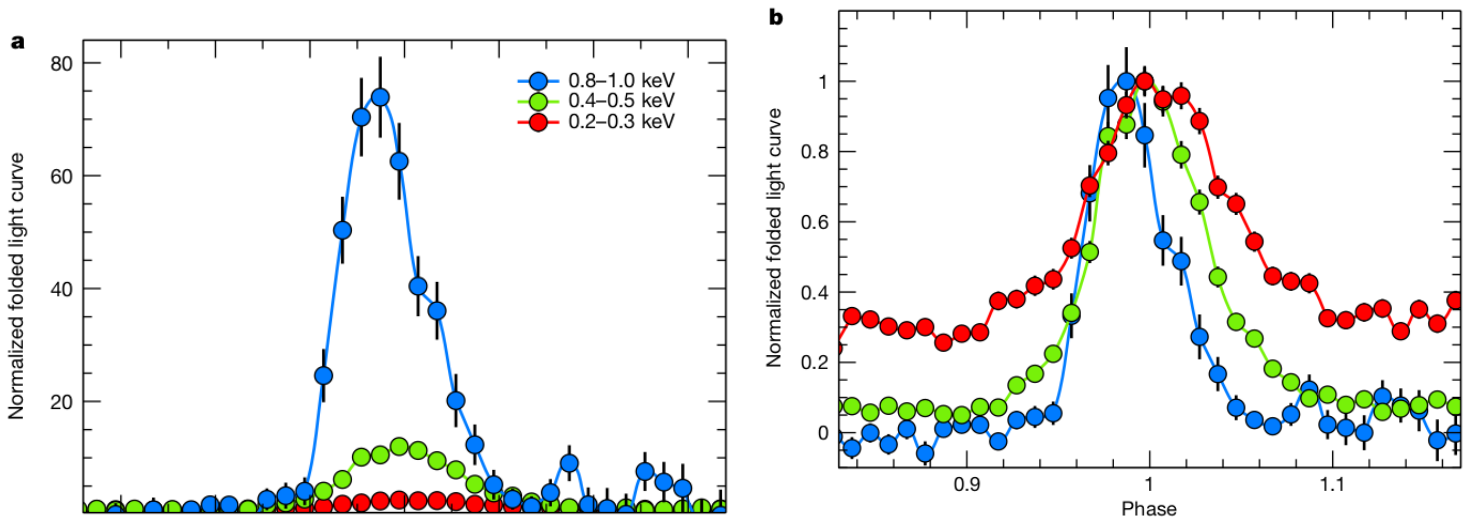
Soft X-ray light curves (0.4-2 keV)



What are Quasiperiodic Eruptions (QPEs)?

- the X-ray spectrum is soft
- temperature at the flare peak (100-200 keV: 1.2-2.3$\times 10^6$ K)
- during the flare, spectrum hardens and becomes soft again at the end
- soft X-ray luminosity reaches $L_{\rm X} \approx 10^{42} - 10^{44}\,{\rm erg\,s^{-1}}$
- **representative source:** GSN 069 (Miniutti et al. 2019)

Folded X-ray flares in different X-ray energy bands



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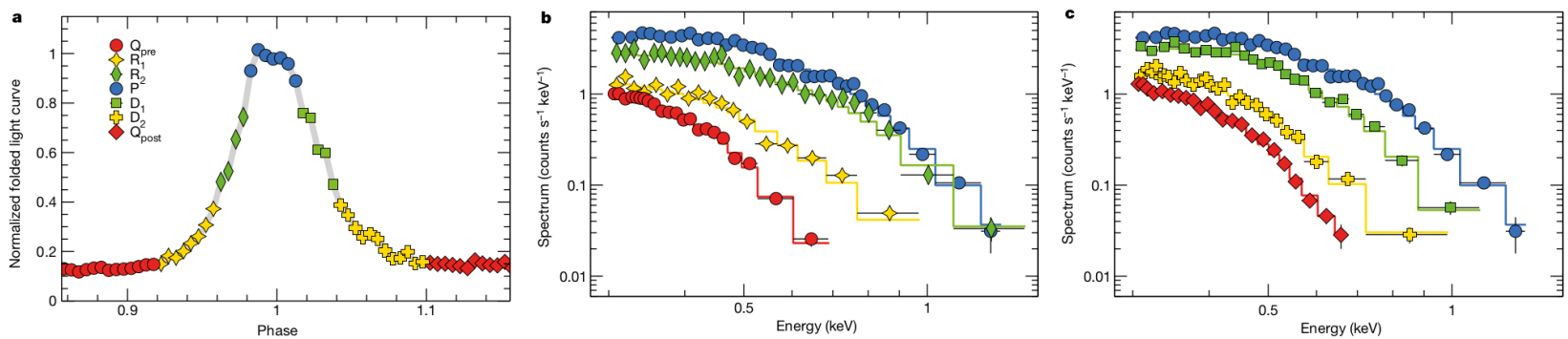
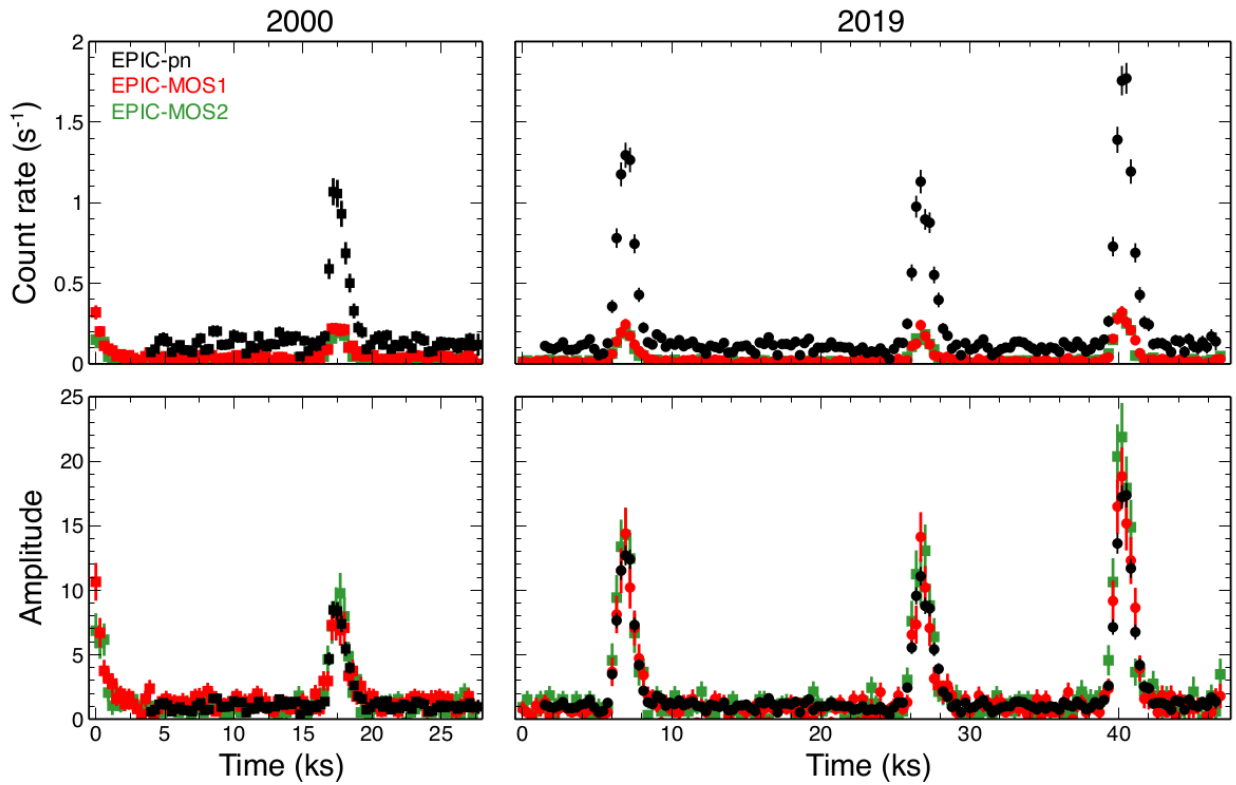
Folded X-ray light curve (0.2-2 keV), and phase-resolved spectra during flare rise and decay



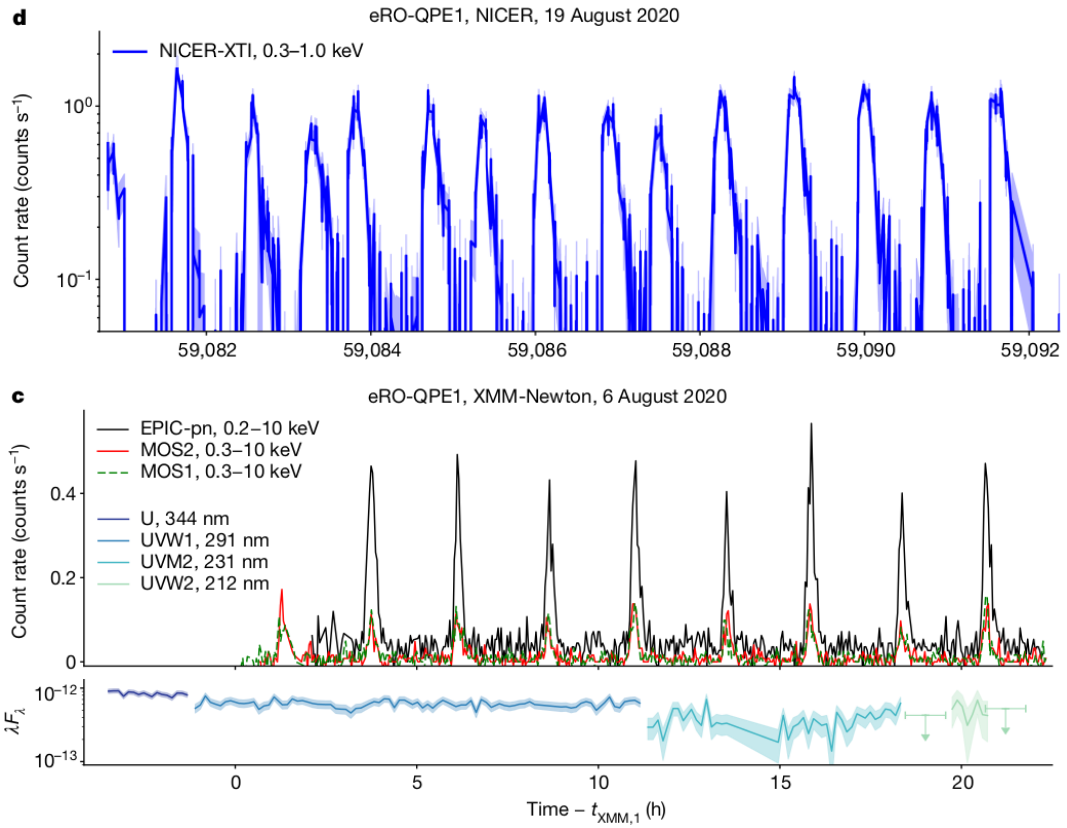
More sources: RX J1301.9+2747

- analysis by Giustini et al. 2020
- **active galaxy**
- recurrence times: 5.6 and 3.6 hours (long-short alternation)
- flare duration: 0.5 hour, duty cycle: ~ 0.1



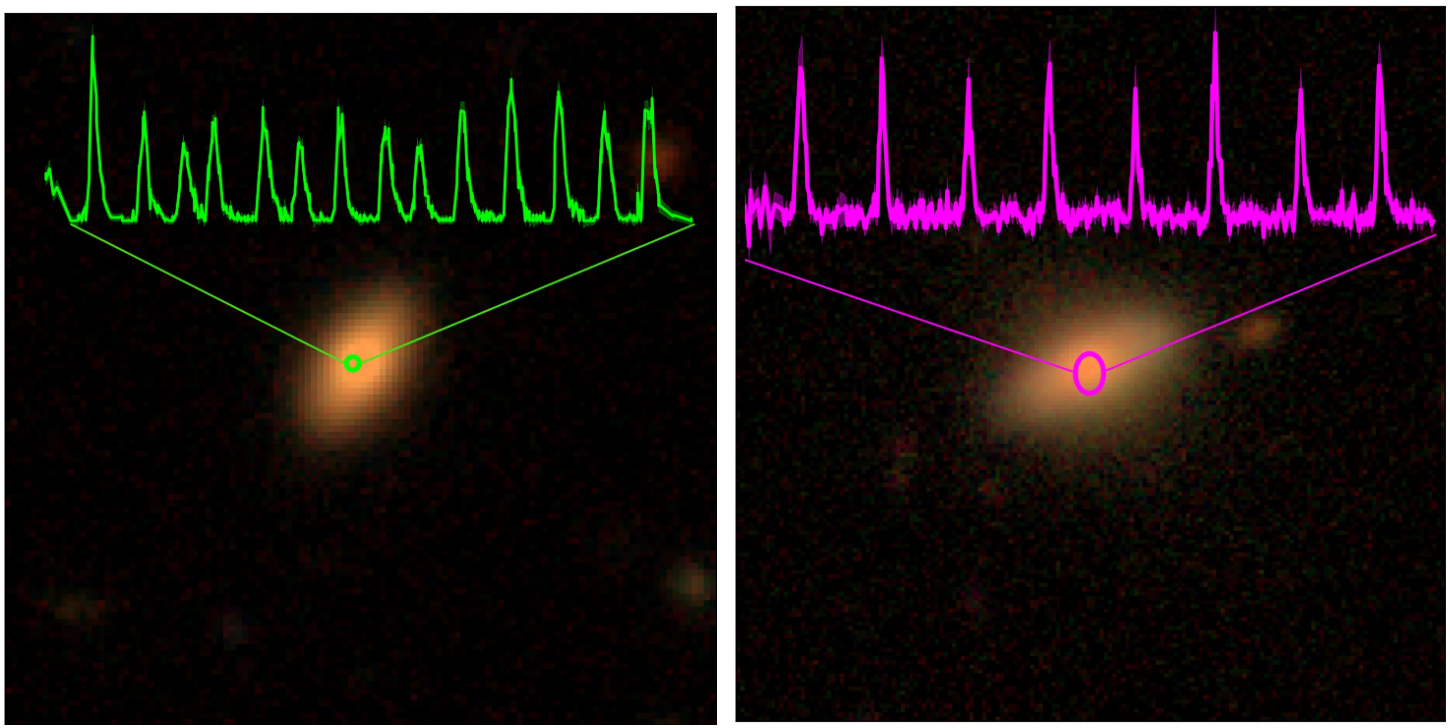
More sources: eRO-QPE1 and eRO-QPE2

- analysis by Arcodia et al. (2021)
- **quiescent galaxies**
- recurrence times and flare duration: 18.5 hours and 7.6 hours (eRO-QPE1); and 2.4 hours and 27 minutes (eRO-QPE2)
- duty cycles: 0.4 (eRO-QPE1) and 0.2 (eRO-QPE2)



1st Thesis topic: QPE properties

- what are the relations between the flare duration and period?
- evaluation of periodicity significance/irregularity level
- flare amplitude: dependence of peak luminosity vs. temperature
- estimation of the emission area/length-scale
- spectral properties



2nd Thesis topic: Model interpretations

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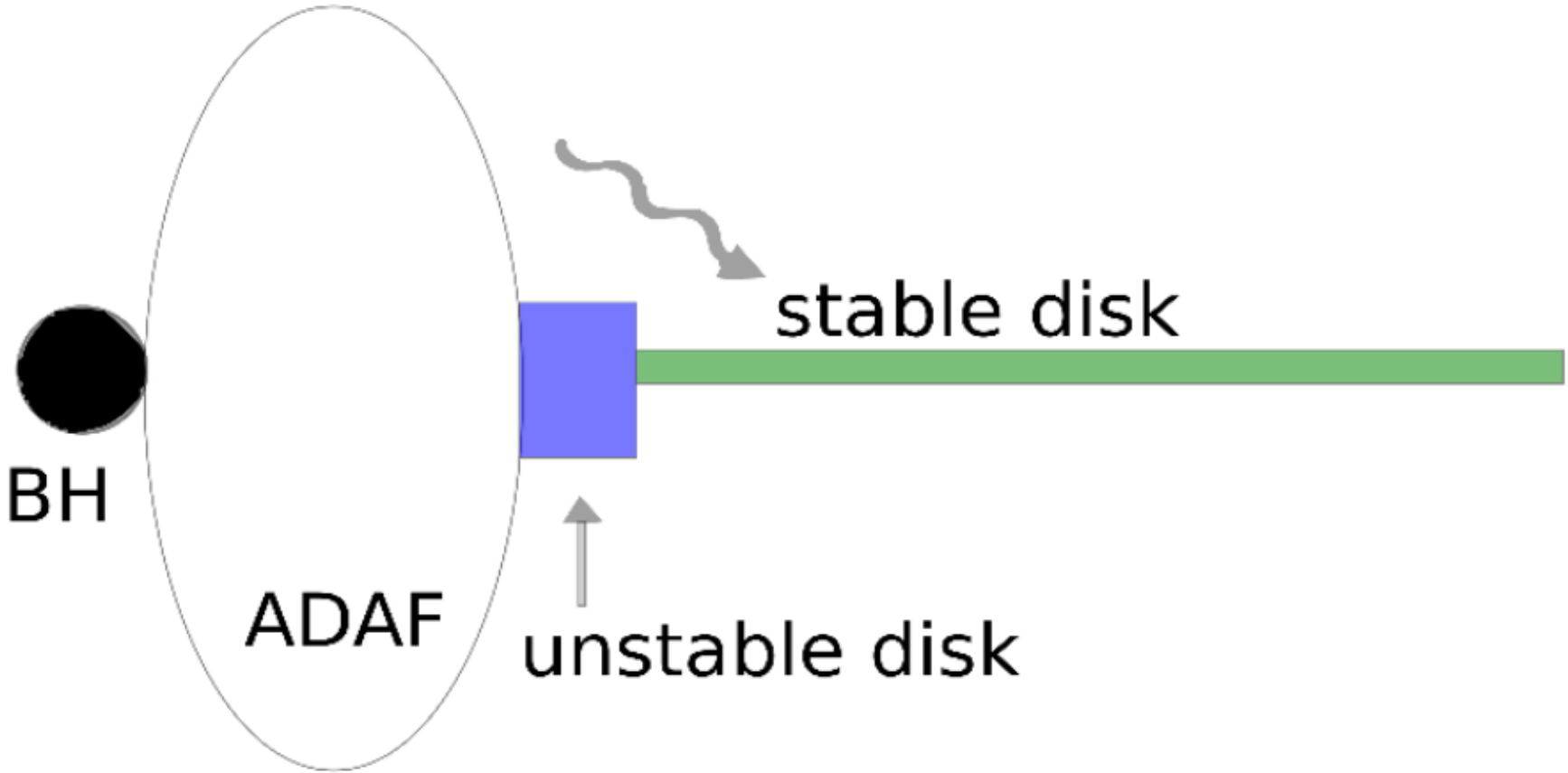
6. **own, unique model (best option)**
7. **(Bayesian) fitting routine $\rightarrow$ application to real data and new QPE sources**

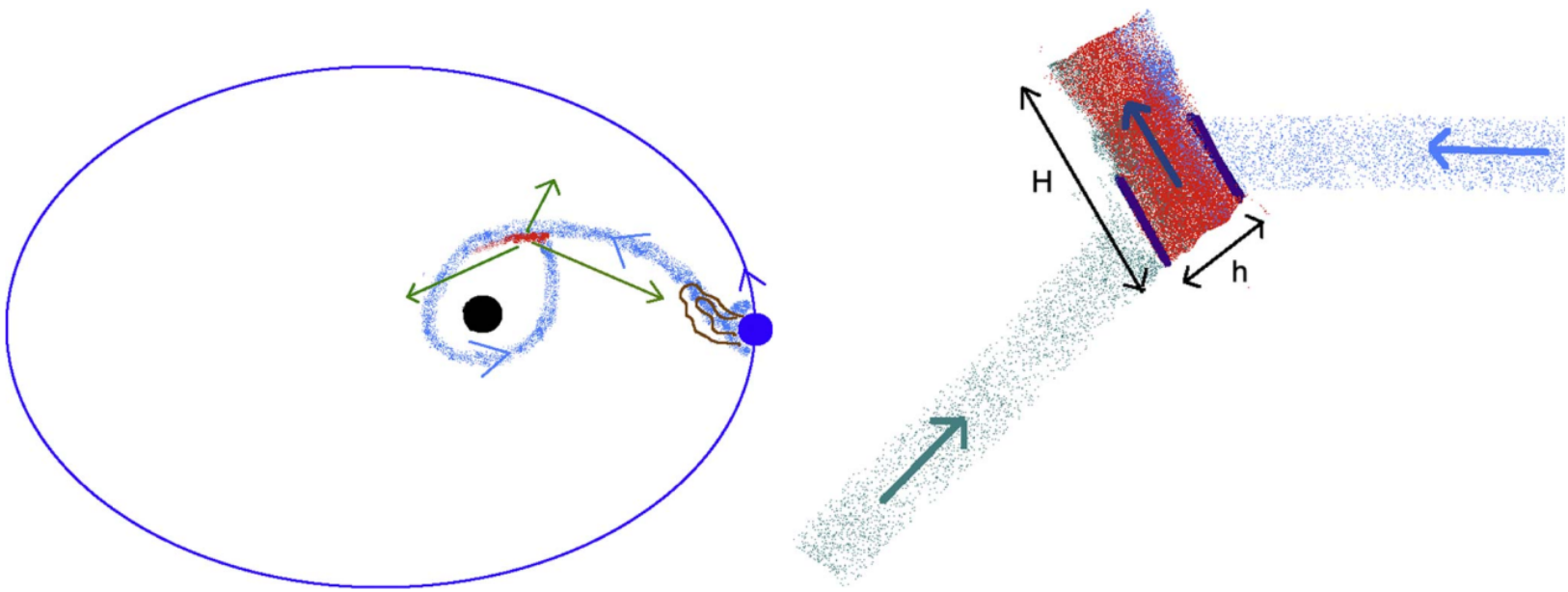
QPE model 1: Accretion disc instability

Regular increase of the accretion rate due to radiation-pressure instability operating in a narrow zone (Sniegowska et al., 2020)



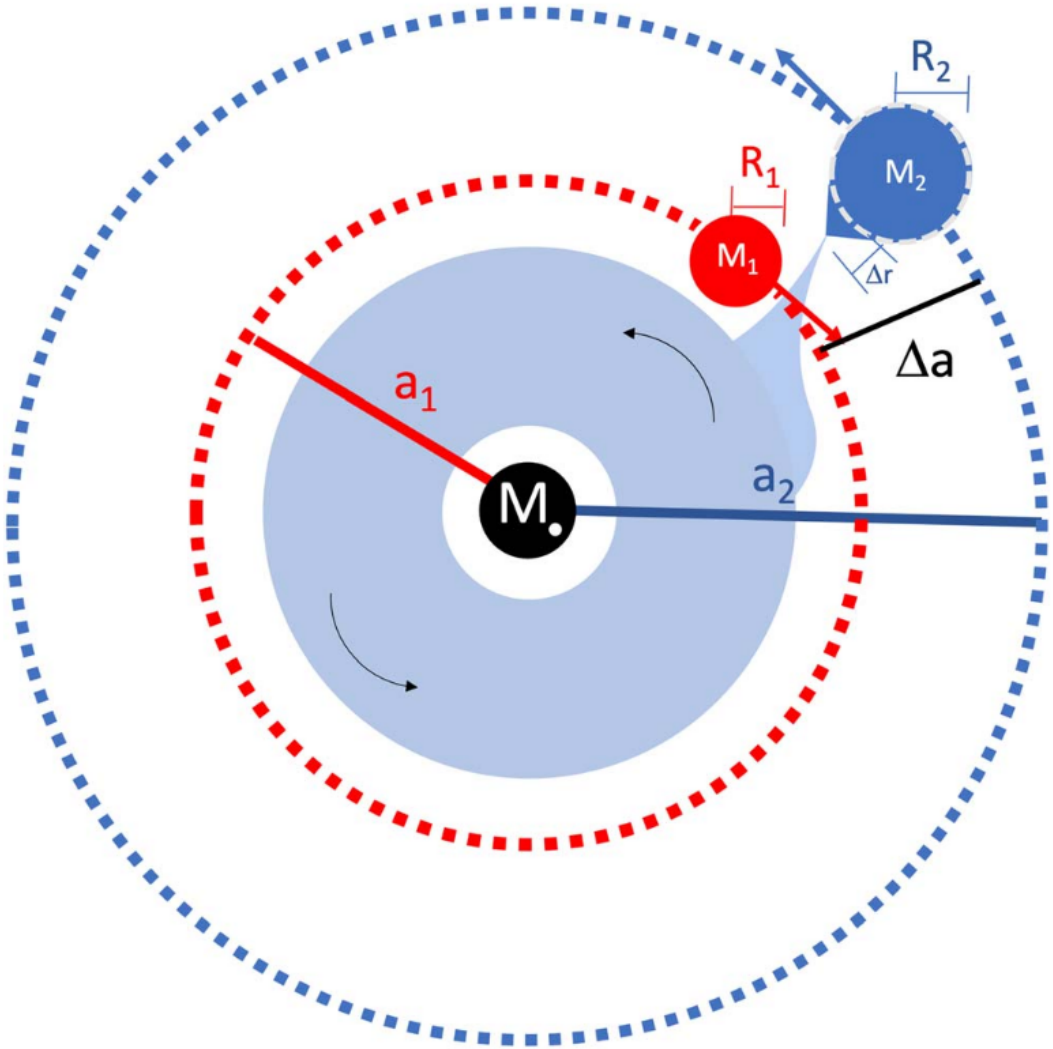
QPE model 2: Roche-lobe overflow from an orbiting star

See e.g. Krolik & Linial (2022)



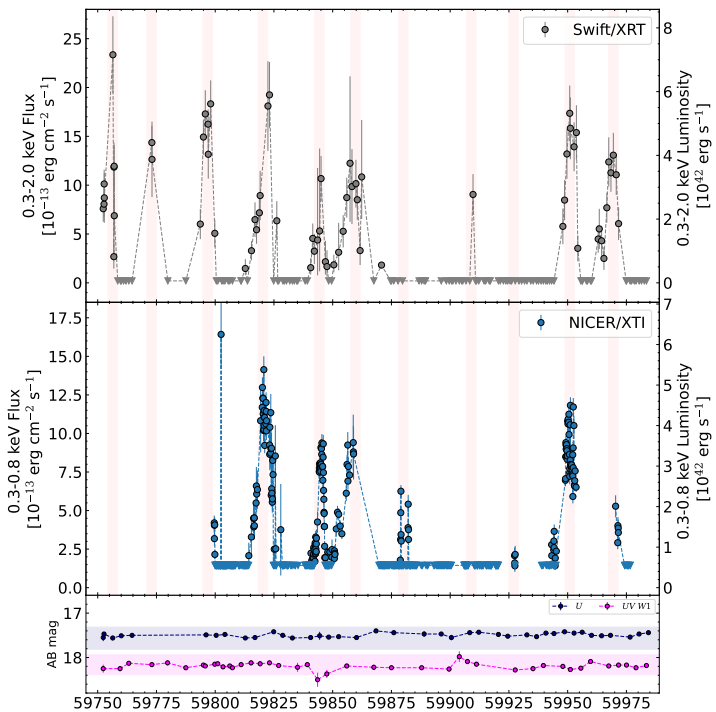
QPE model 3: Two orbiting stars

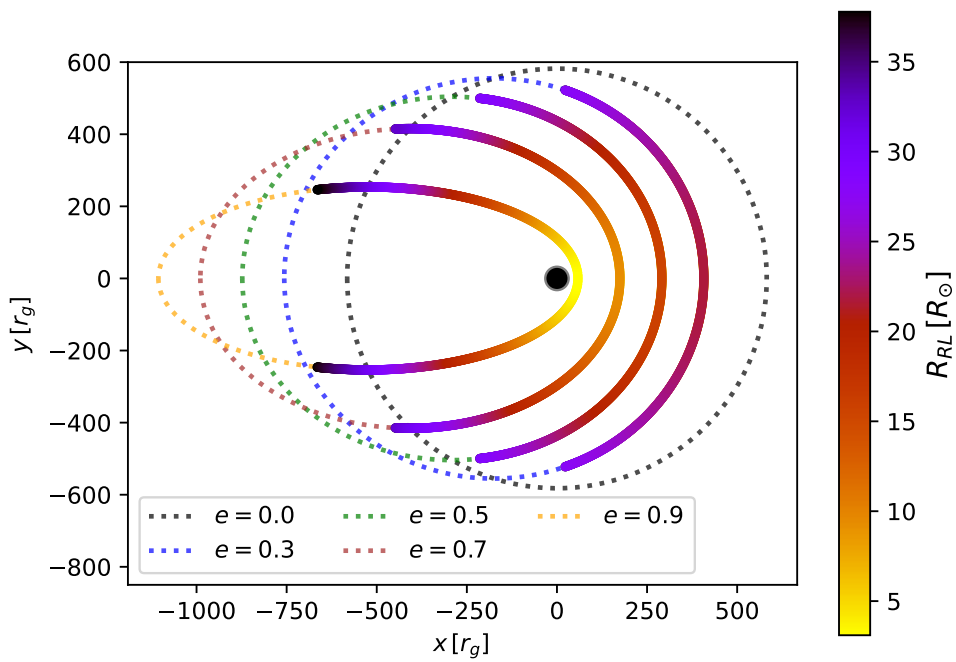
See Metzger, Stone, & Gilbaum (2022)



New QPE source: “Crazy Swift source”

- To be submitted to Nature Astronomy, **Guolo, . . . , Zajaček et al. (2023)**
- mean flare periodicity: 20 days (longest)
- flare duration: 3-8 hours; duty cycle: 0.3





Thank You for Your Attention!

Figure: Image credit: Jack Ciurlo

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