

Hunting for characteristic frequencies of fast variability in cataclysmic variables

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In collaboration with

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Martin Melicherčík

Seminar at Astronomical Institute SAV, 2025

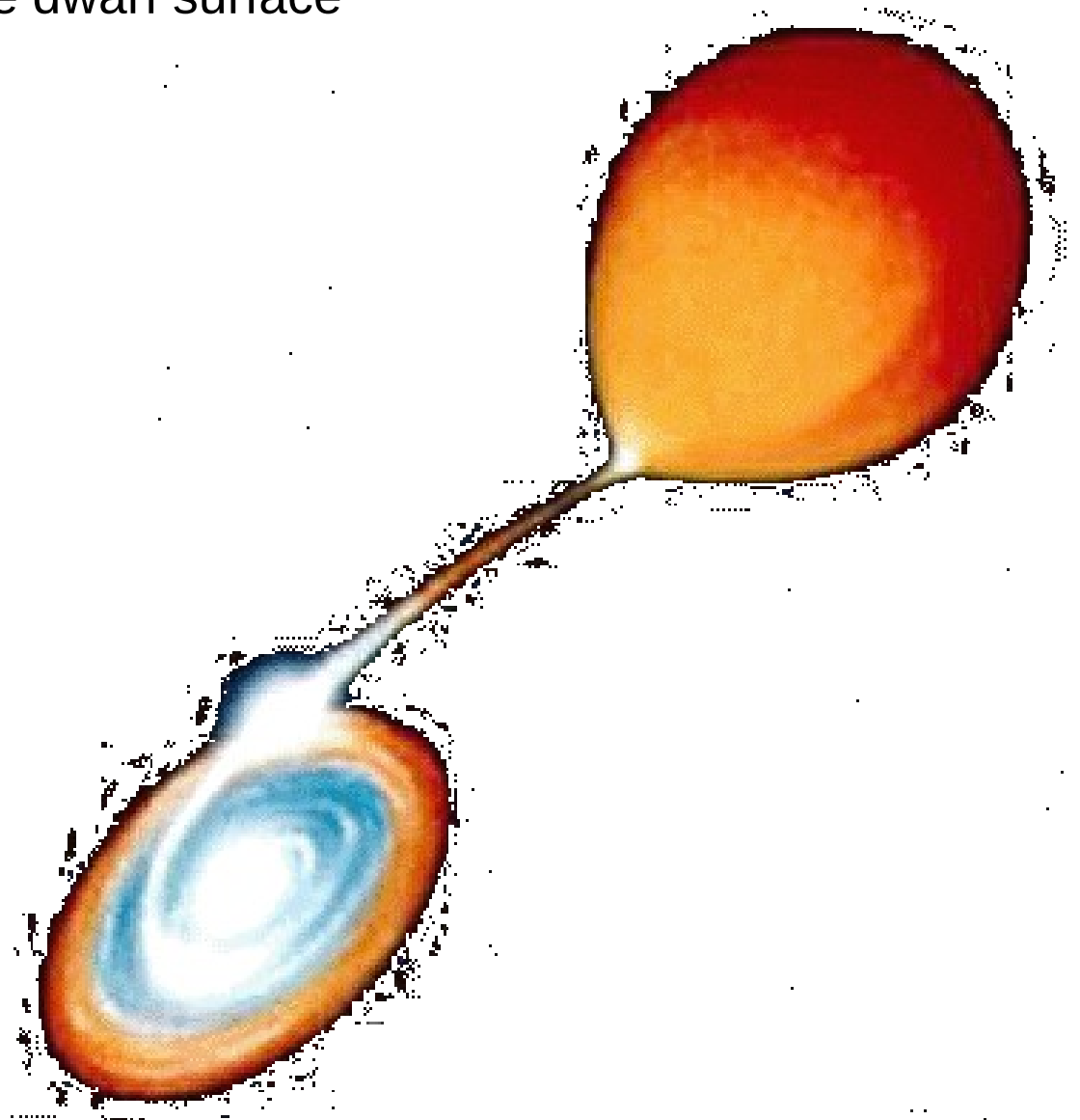
Hunting for characteristic frequencies of fast variability in cataclysmic variables

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Cataclysmic variables

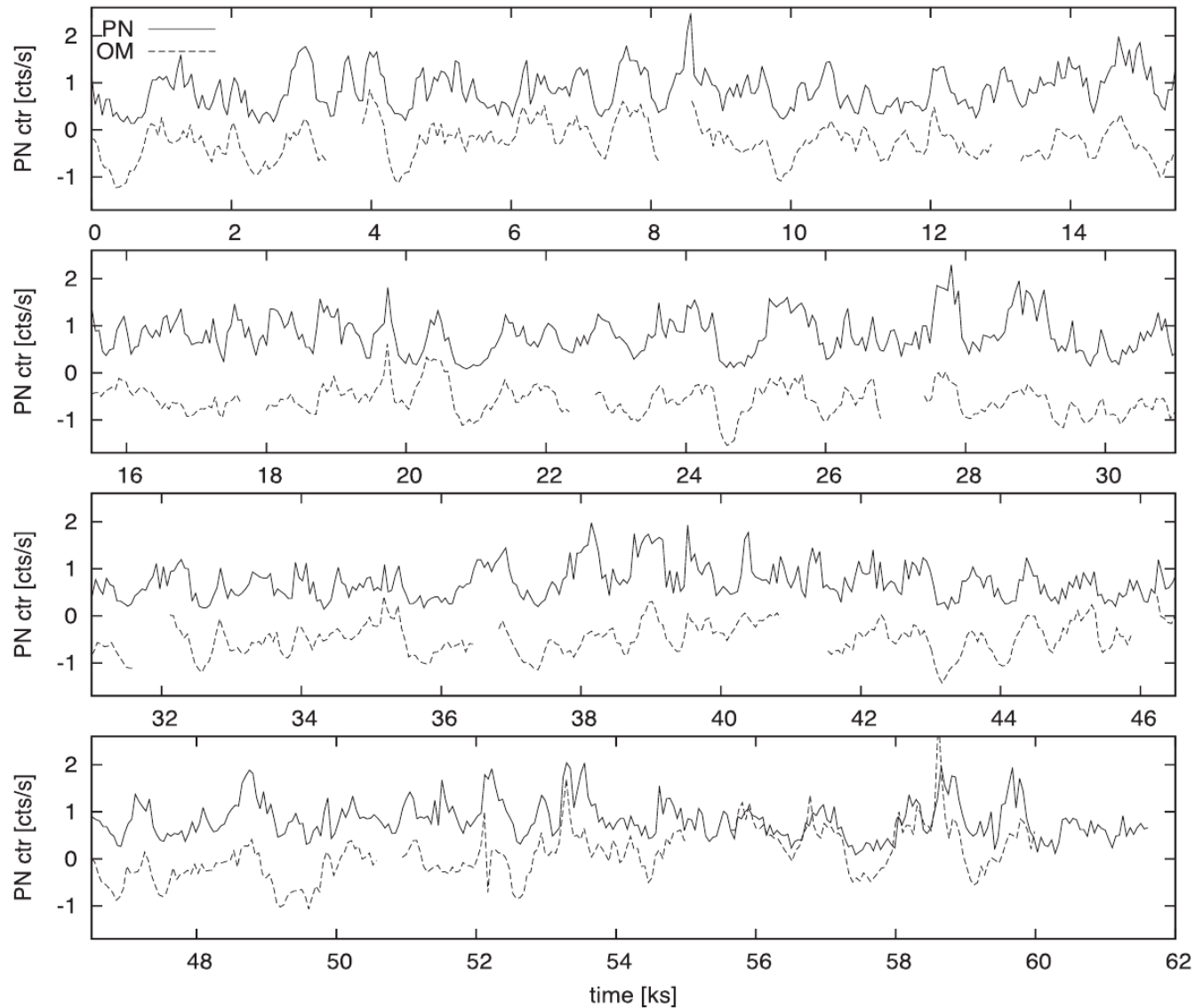
- interacting semi-detached binaries
- secondary star fills the Roche lobe => matter flows toward the white dwarf
- matter is cumulating on the white dwarf surface



Fast variability (flickering)

- flux variations from seconds to (decades of) minutes

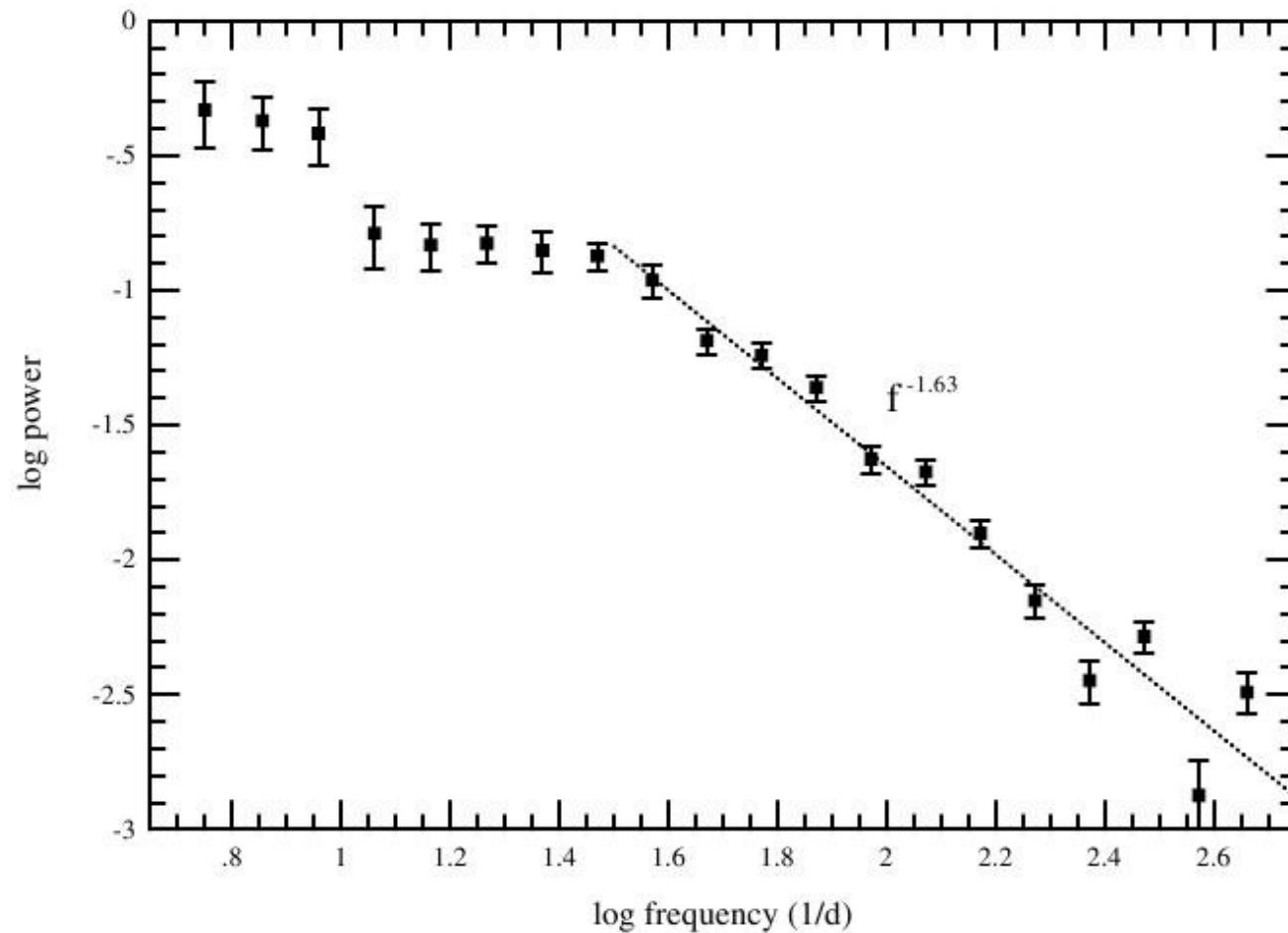
MV Lyr (Dobrotka et al. 2017)...XMM-Newton



Power density spectrum

- break frequencies in PDS

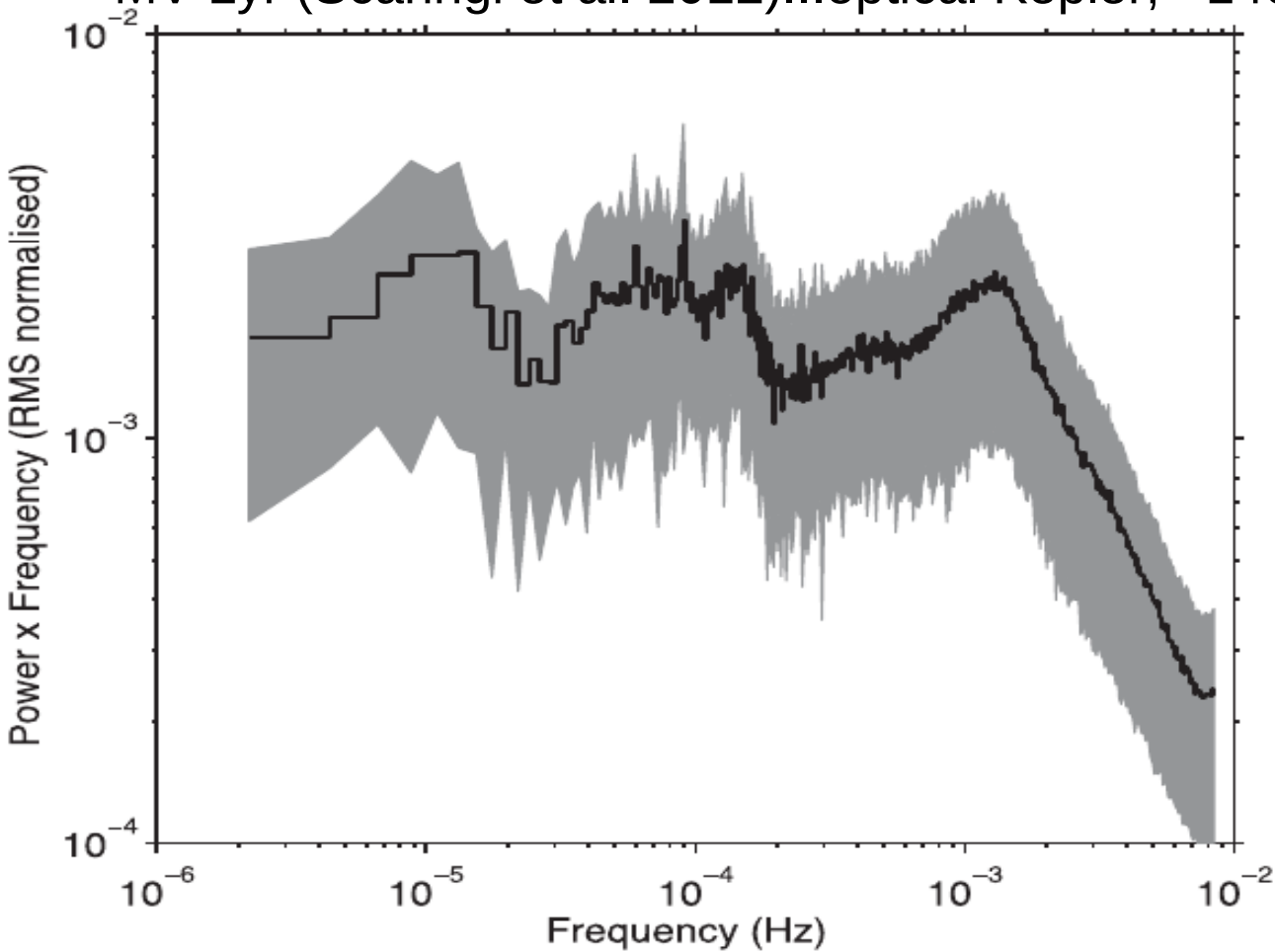
KR Aur (Kato et al. 2002)...17 obs., mean duration 2.5h, 50s cadence



Power density spectrum

- break frequencies in PDS
- multicomponent structure

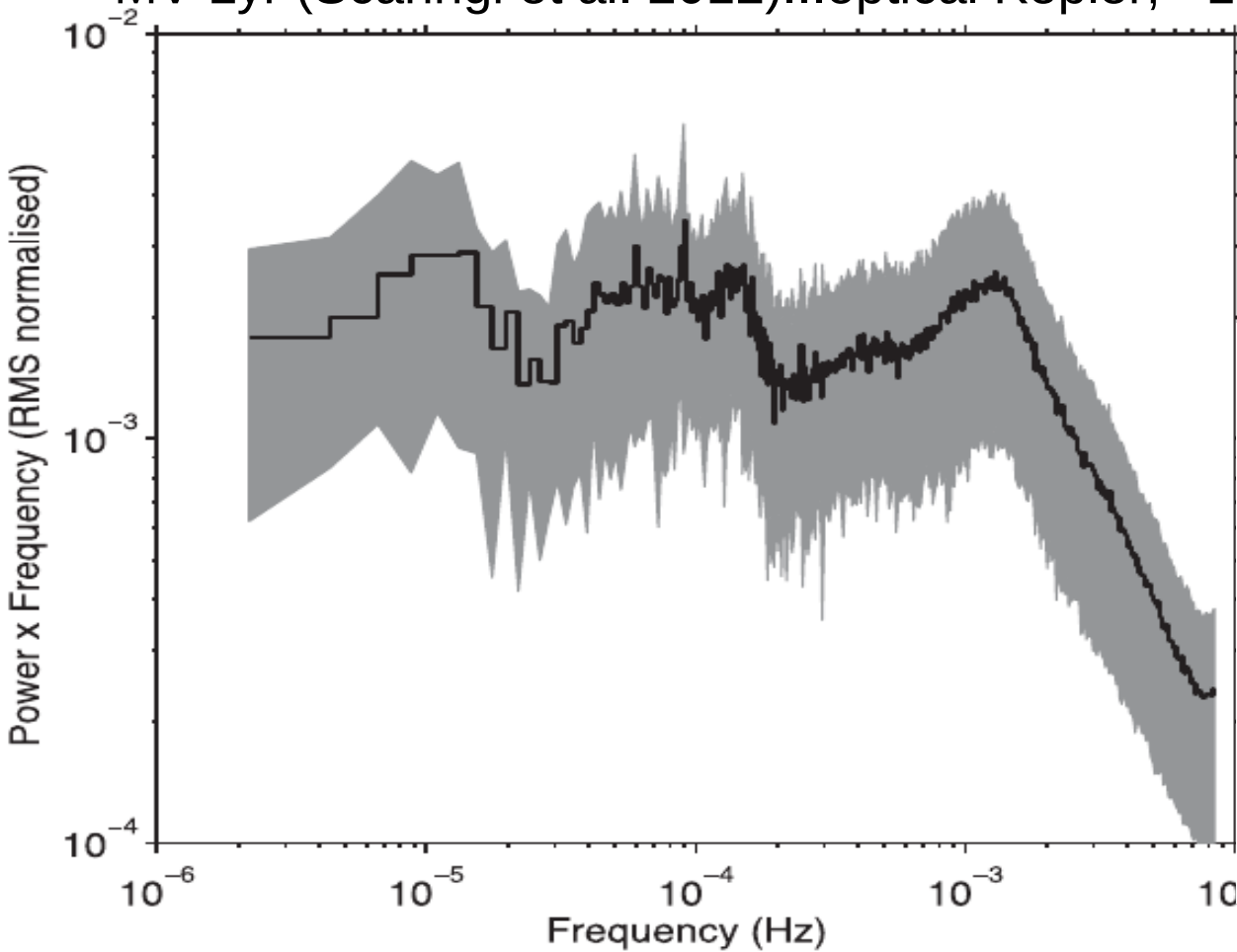
MV Lyr (Scaringi et al. 2012)...optical Kepler, ~1400d, 60s cadence



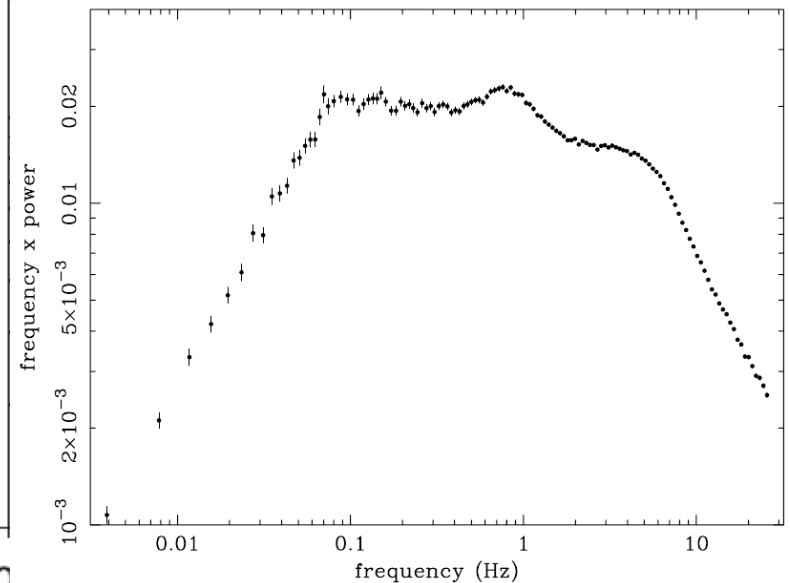
Power density spectrum

- break frequencies in PDS
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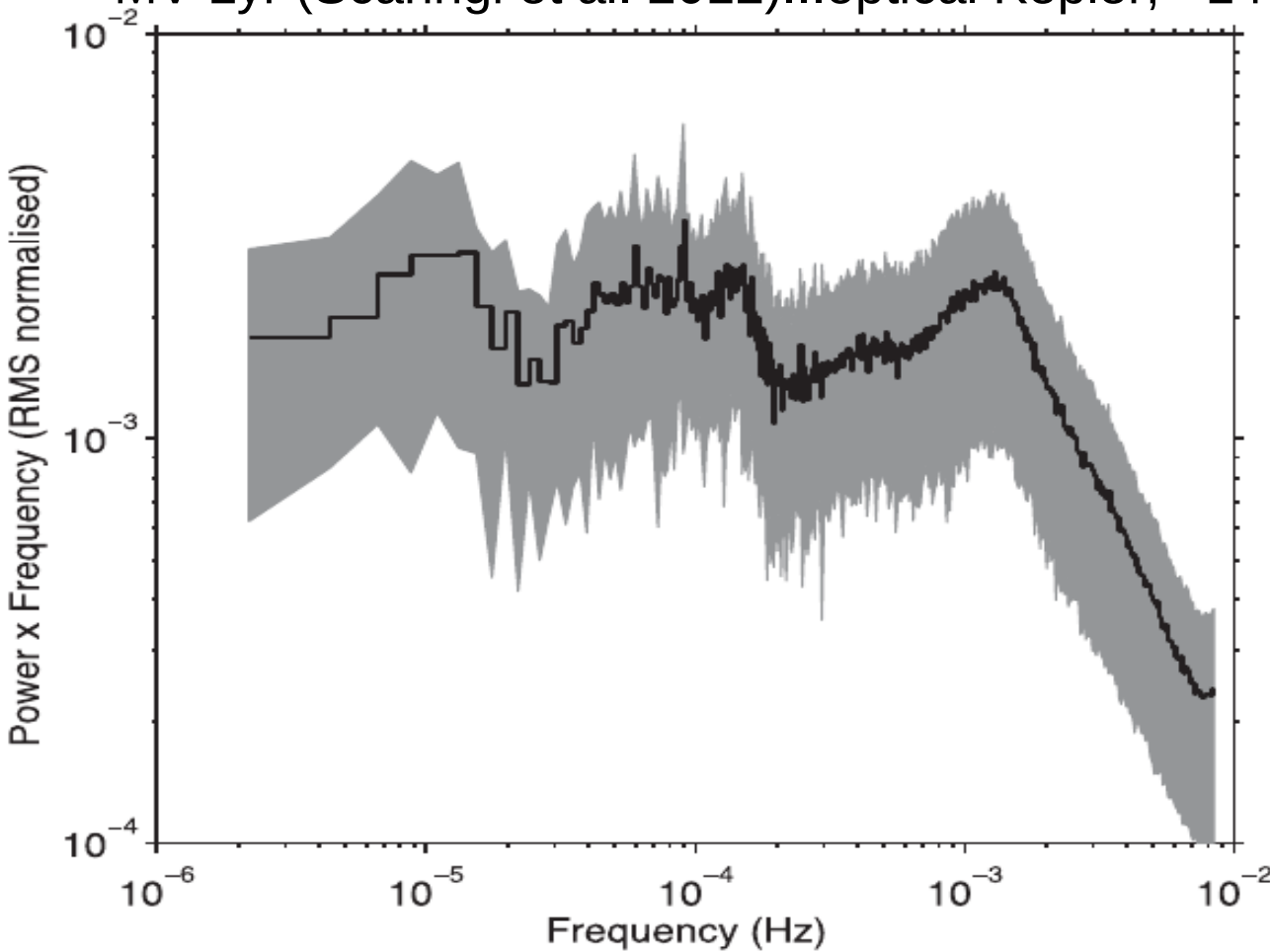
Cyg X-1 (Uttley et al. 2005)
X-ray RXTE



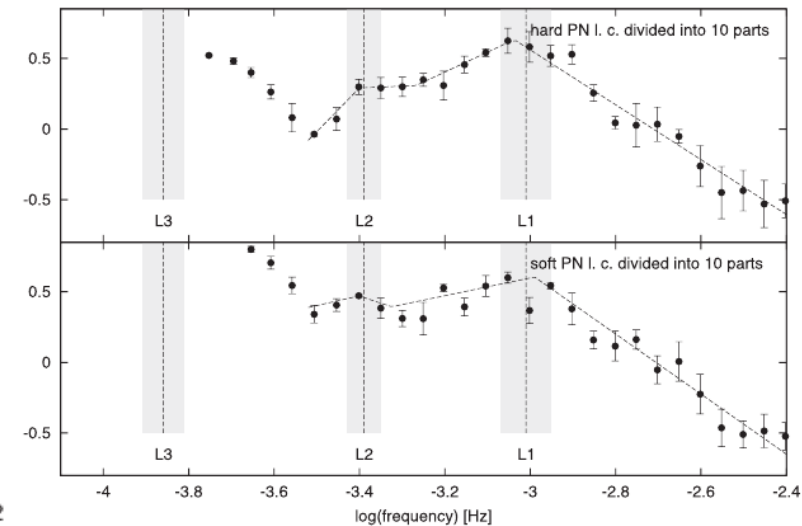
Power density spectrum

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- multicomponent structure

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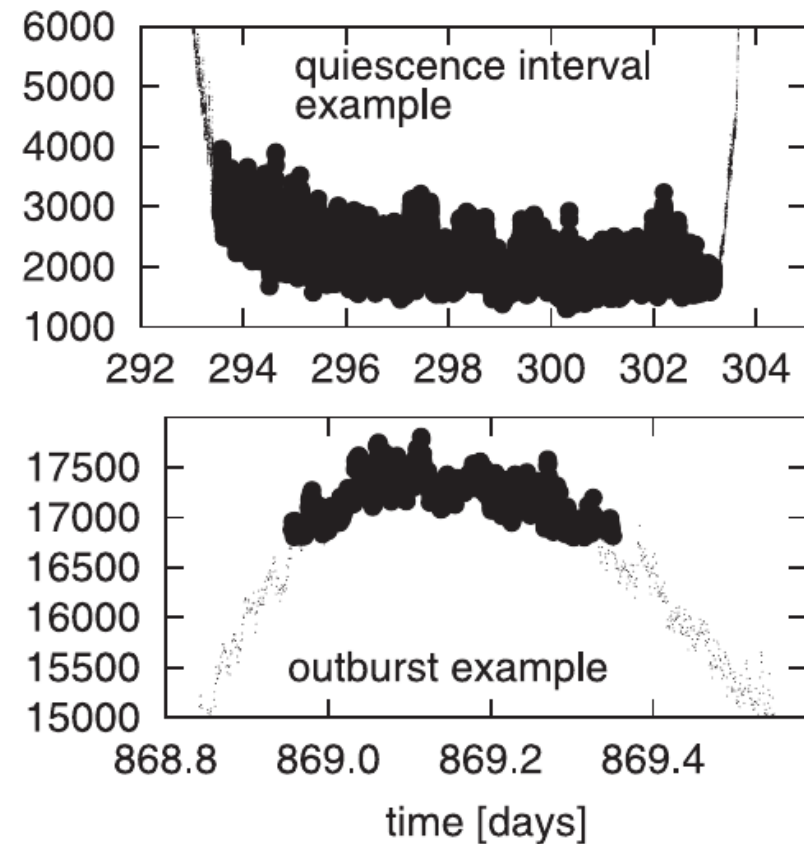
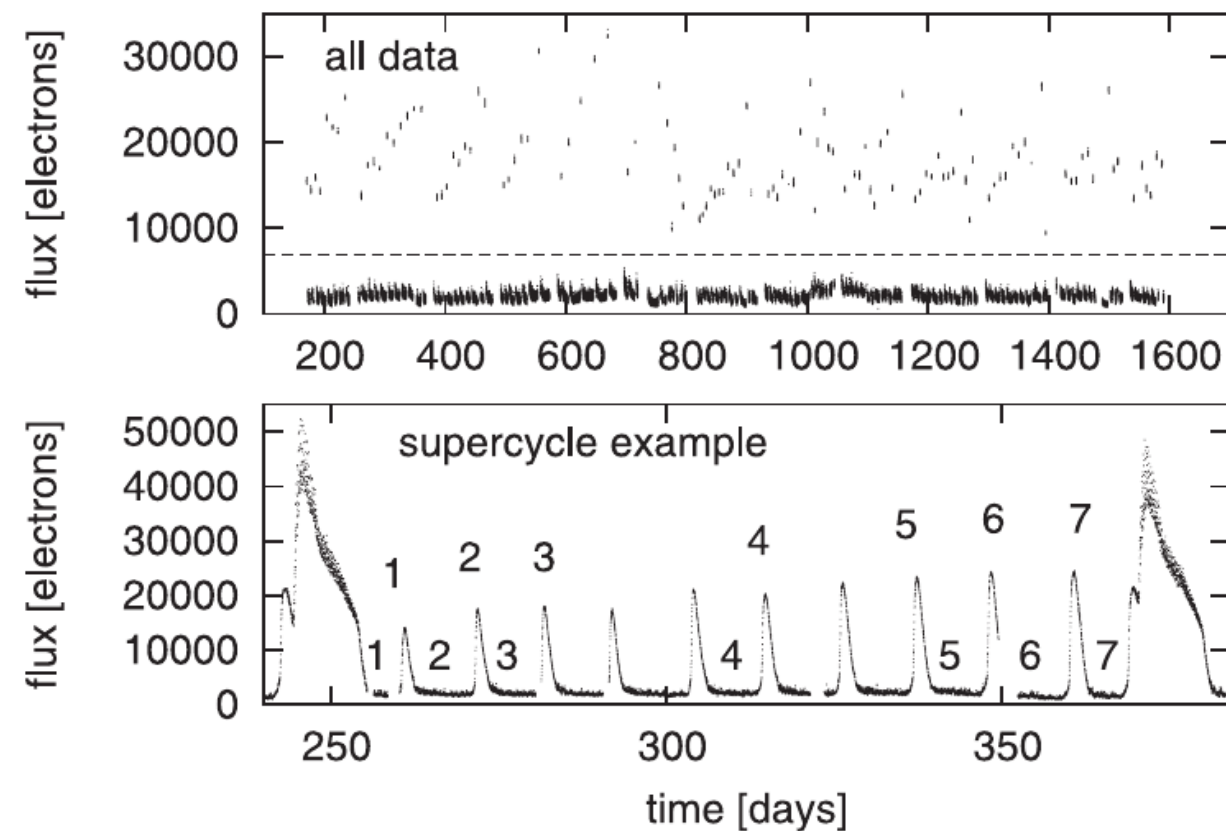
XMM-Newton
(Dobrotka et al. 2017)



Multicomponent PDS

Dwarf nova V 1504 Cyg, Kepler

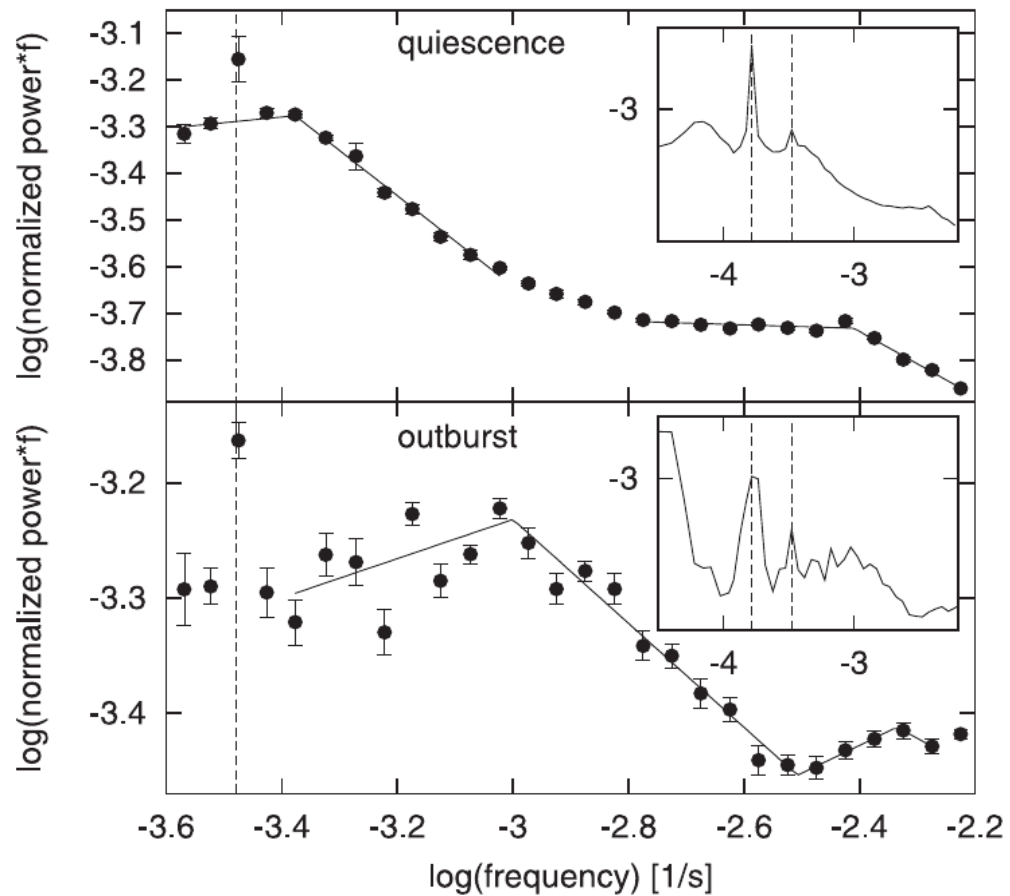
Dobrotka et al. (2015)



Multicomponent PDS

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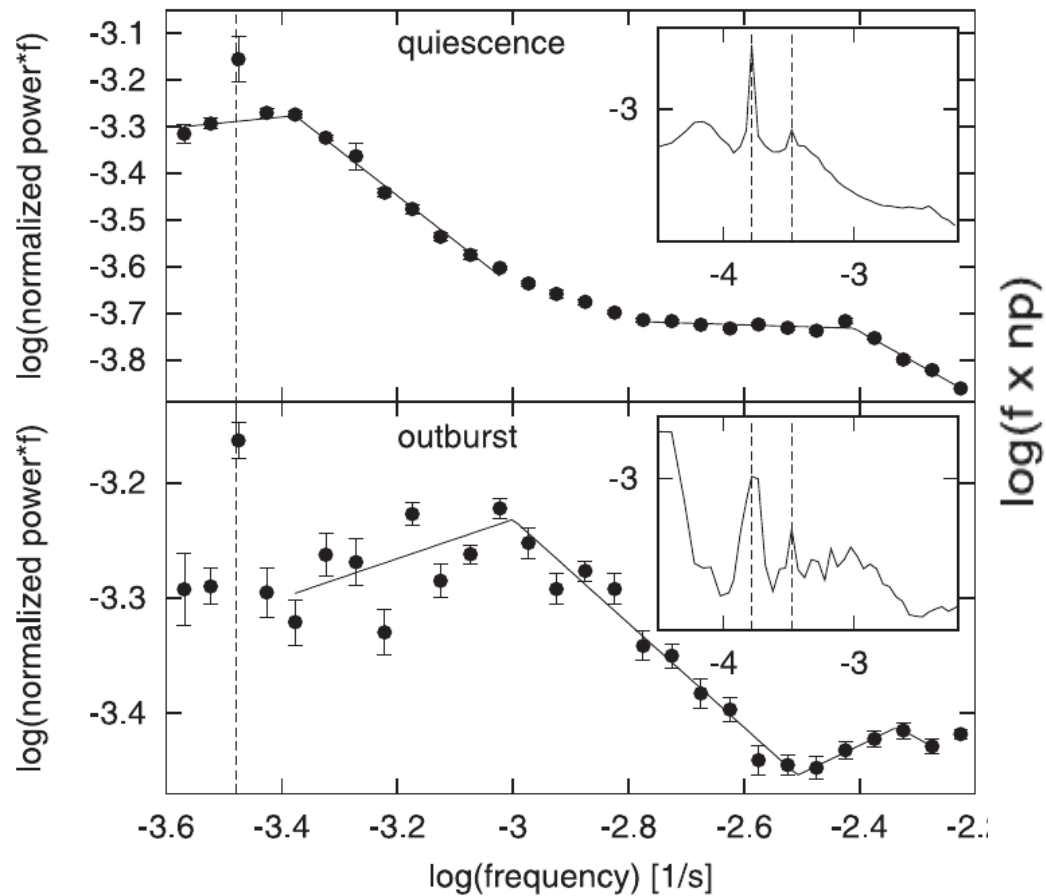
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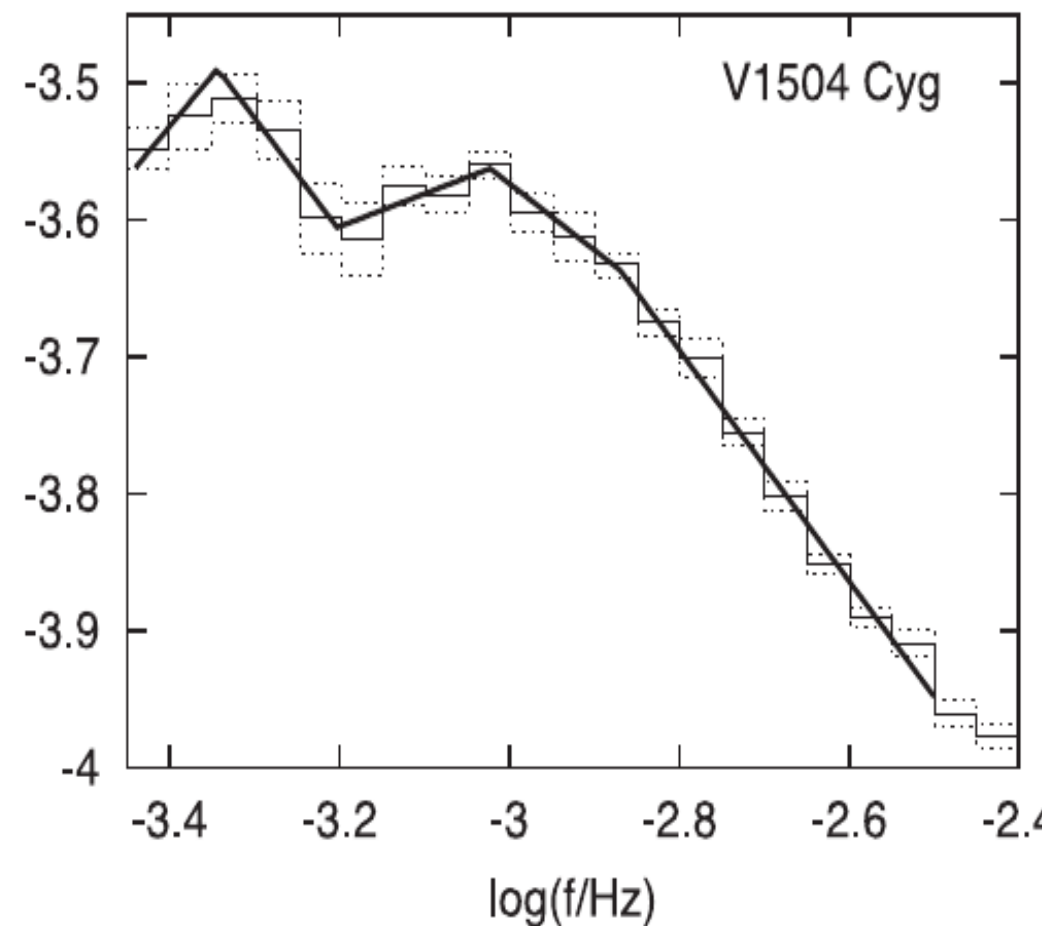
Multicomponent PDS

Dwarf nova V 1504 Cyg, Kepler

Dobrotka et al. (2015)



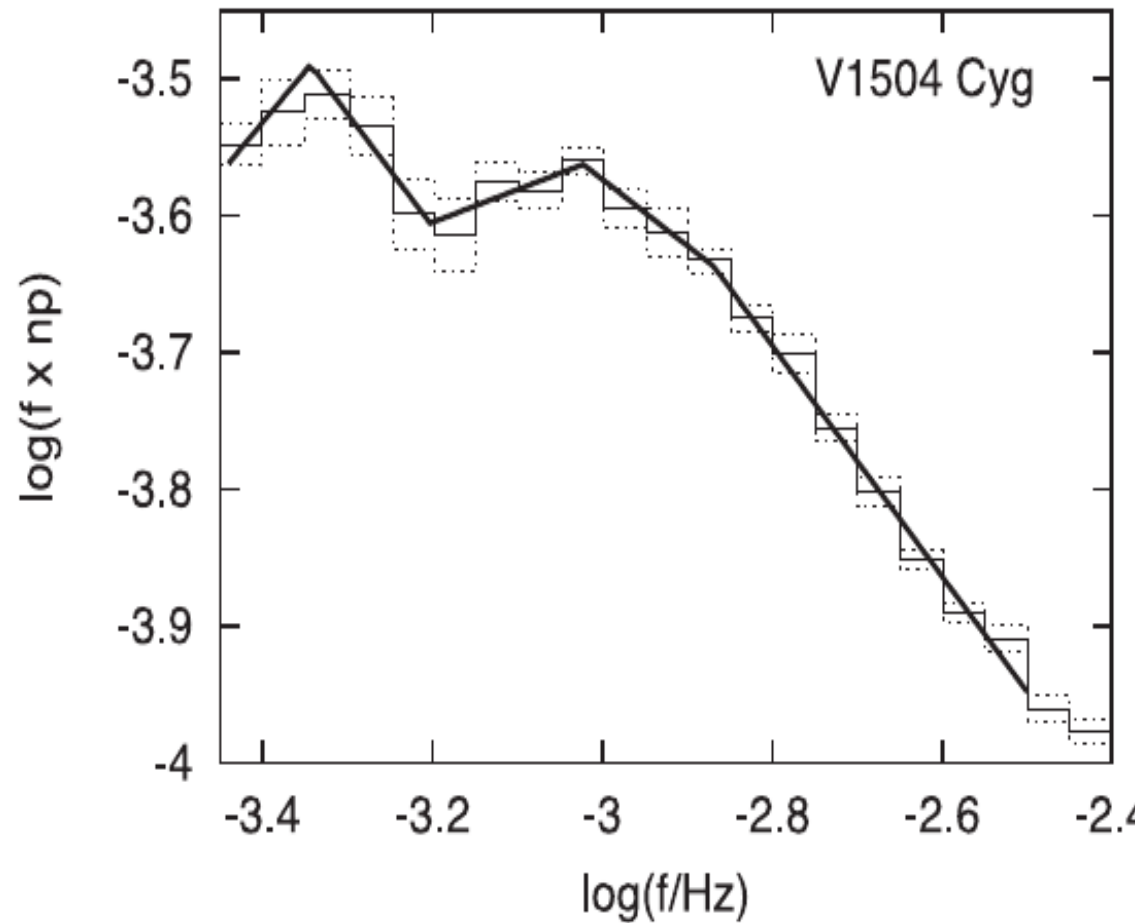
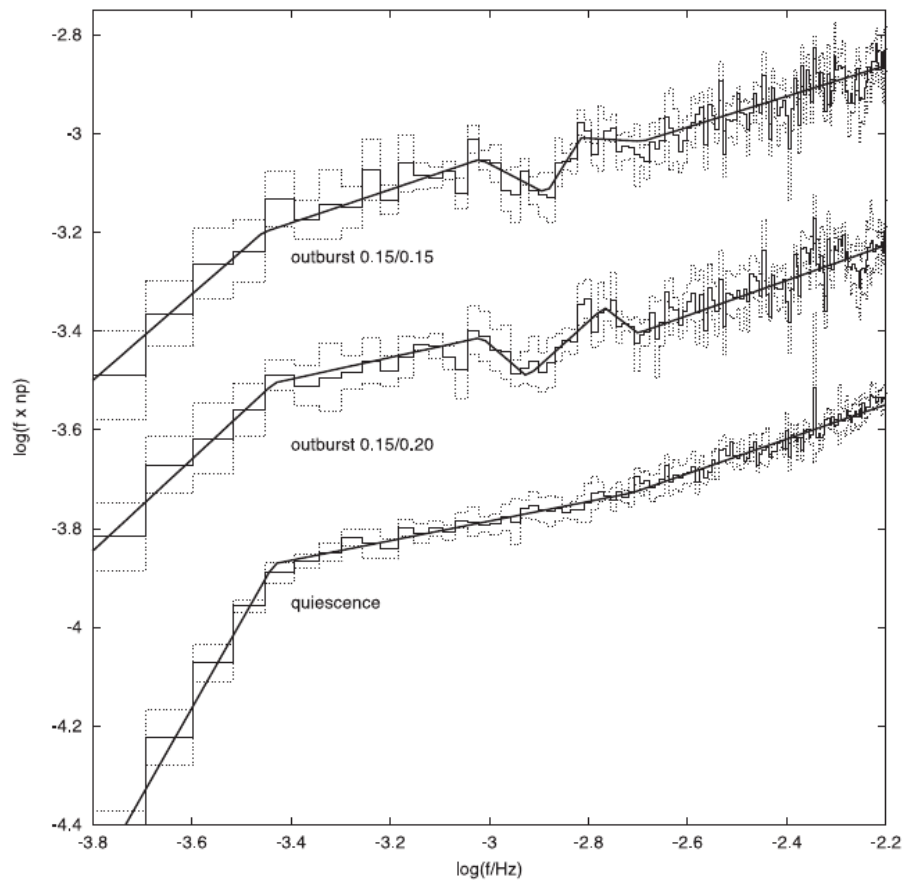
Dobrotka et al. (2016)



Multicomponent PDS

Dwarf novae V344 Lyr & V 1504 Cyg, Kepler

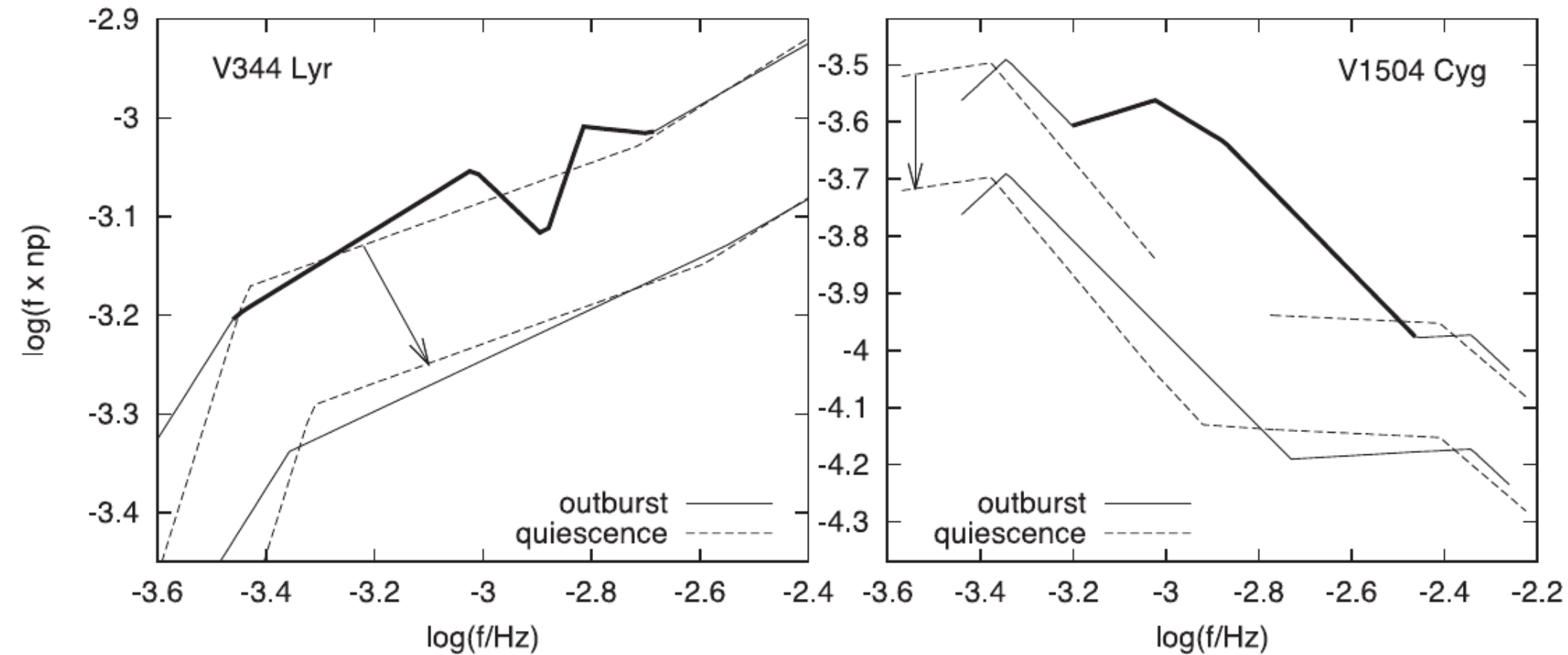
Dobrotka et al. (2016)



Multicomponent PDS

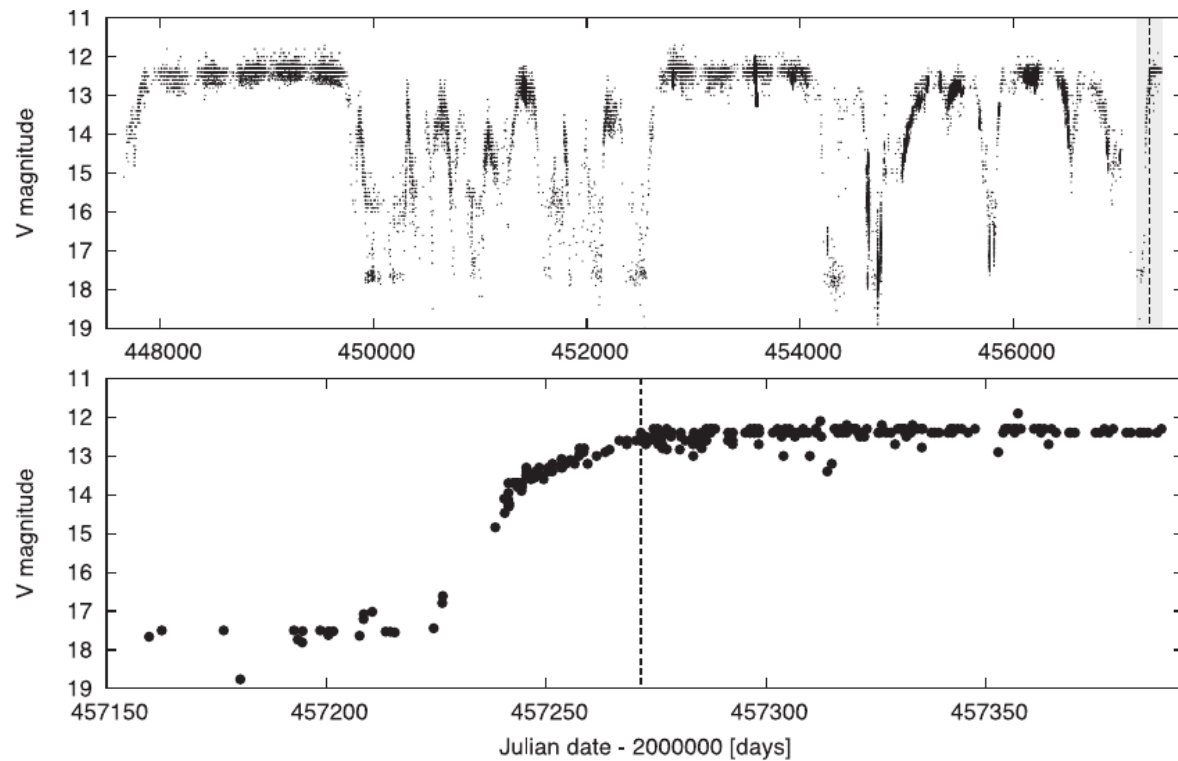
Dwarf novae V344 Lyr & V 1504 Cyg, Kepler

Dobrotka et al. (2016)

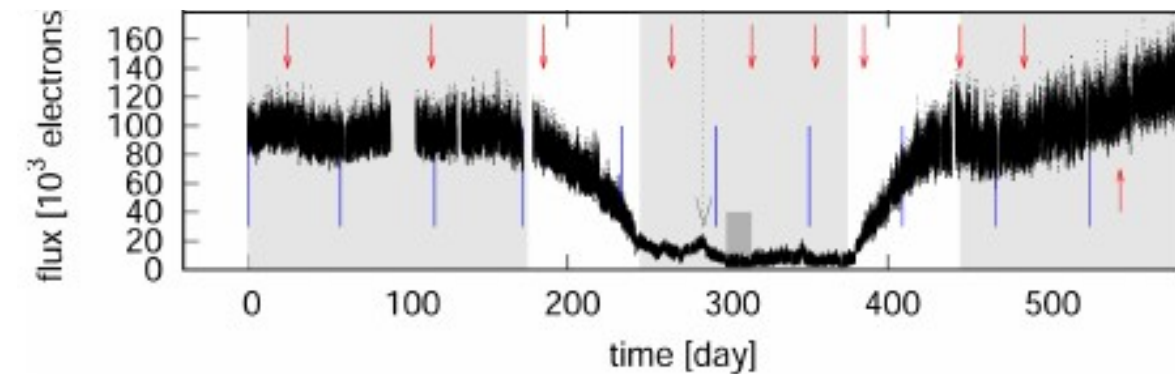


Multicomponent PDS

MV Lyr state transition, Kepler



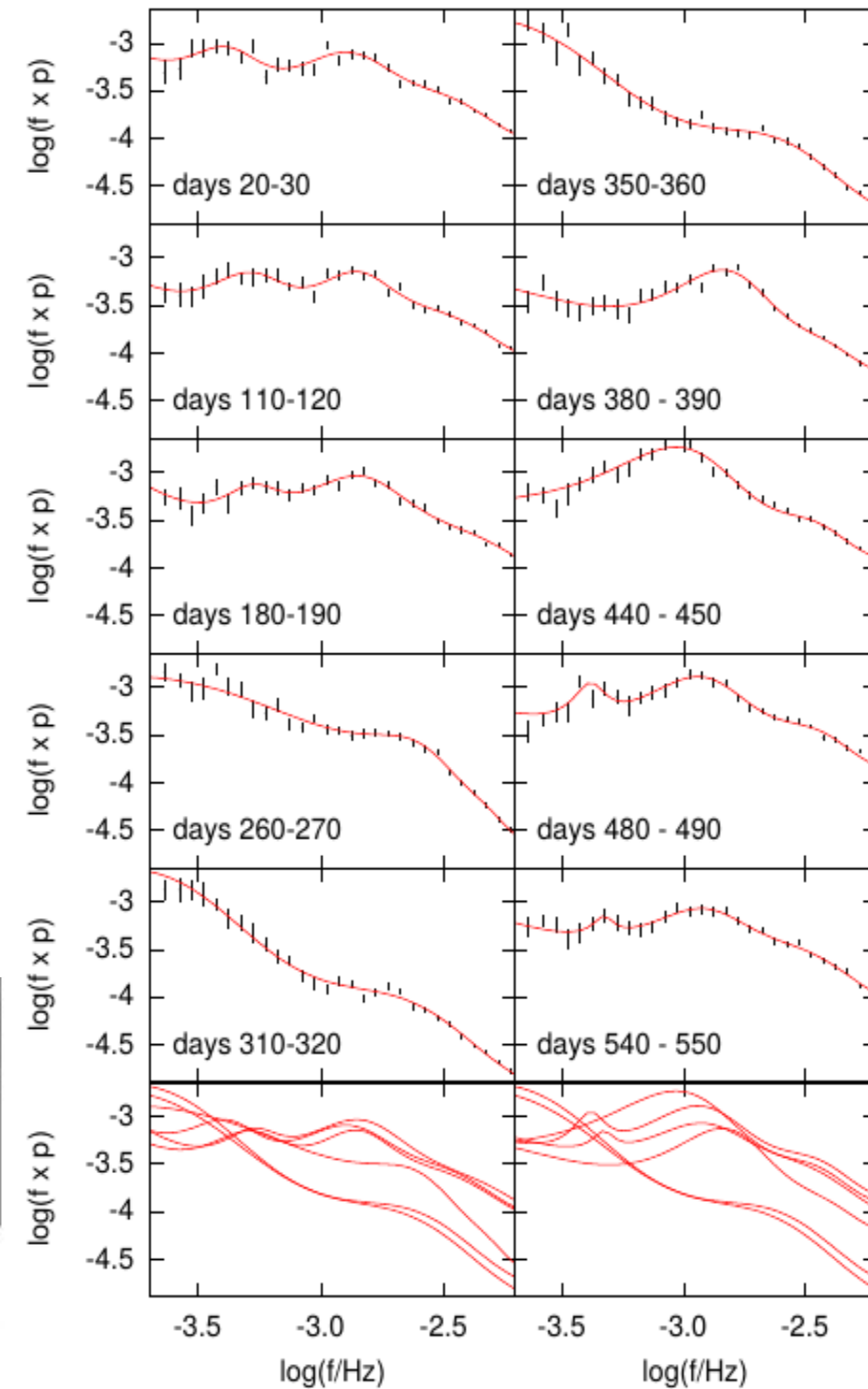
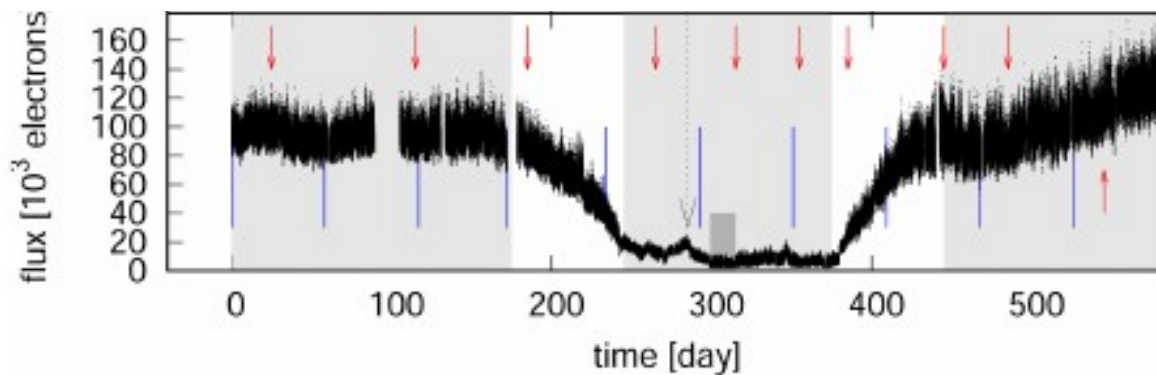
Dobrotka et al. (2020)



Multicomponent PDS

MV Lyr state transition, Kepler

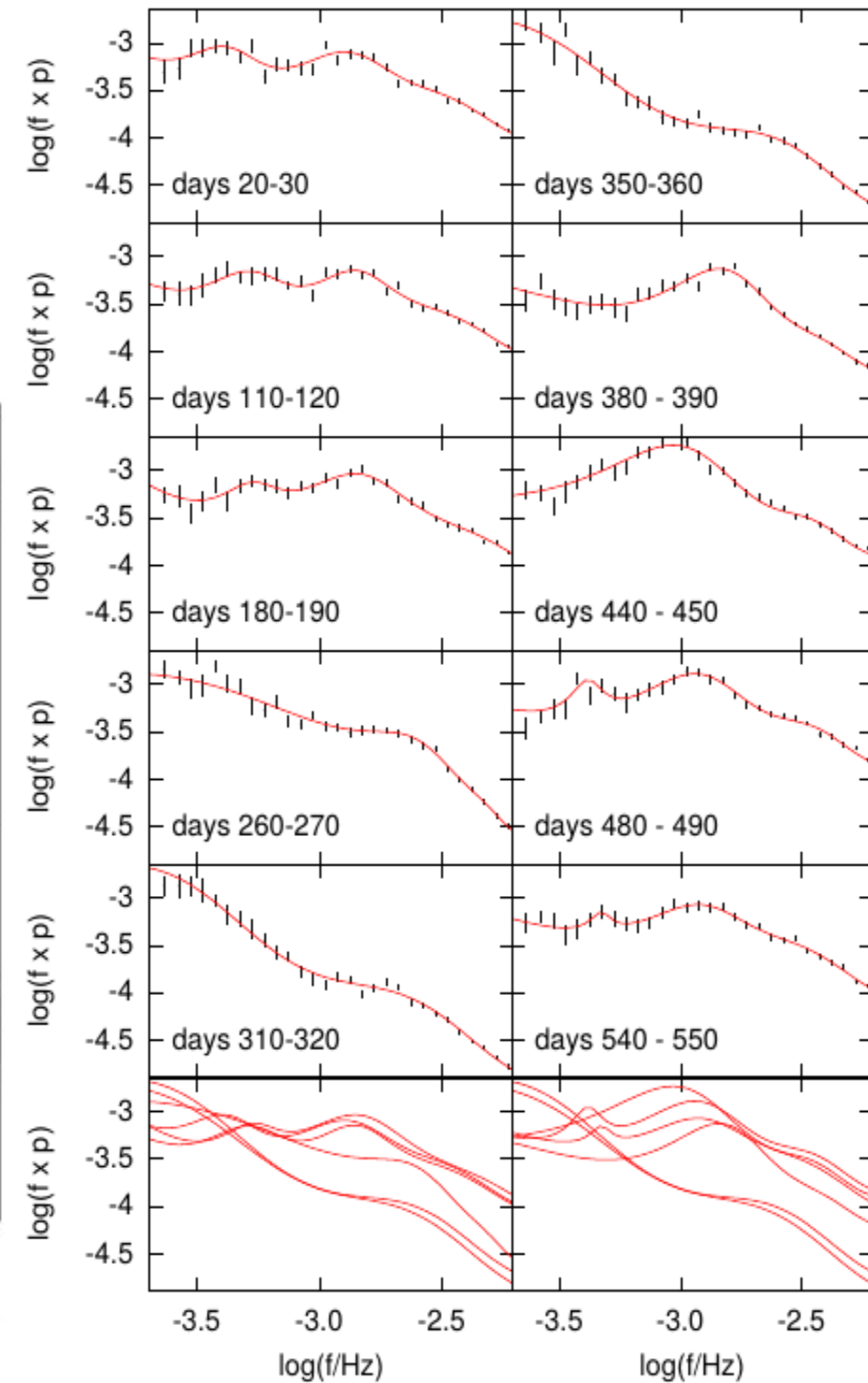
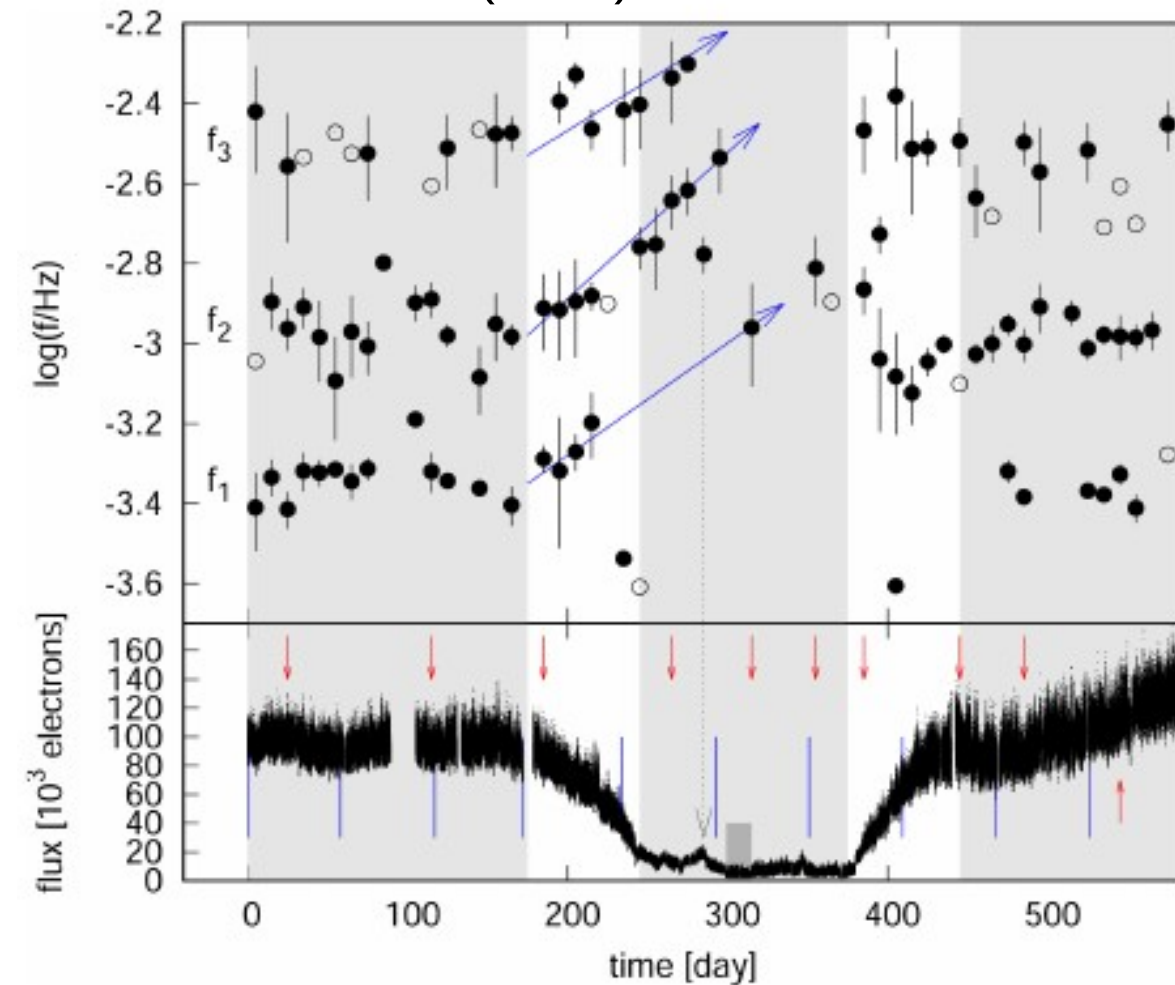
Dobrotka et al. (2020)



Multicomponent PDS

MV Lyr state transition, Kepler

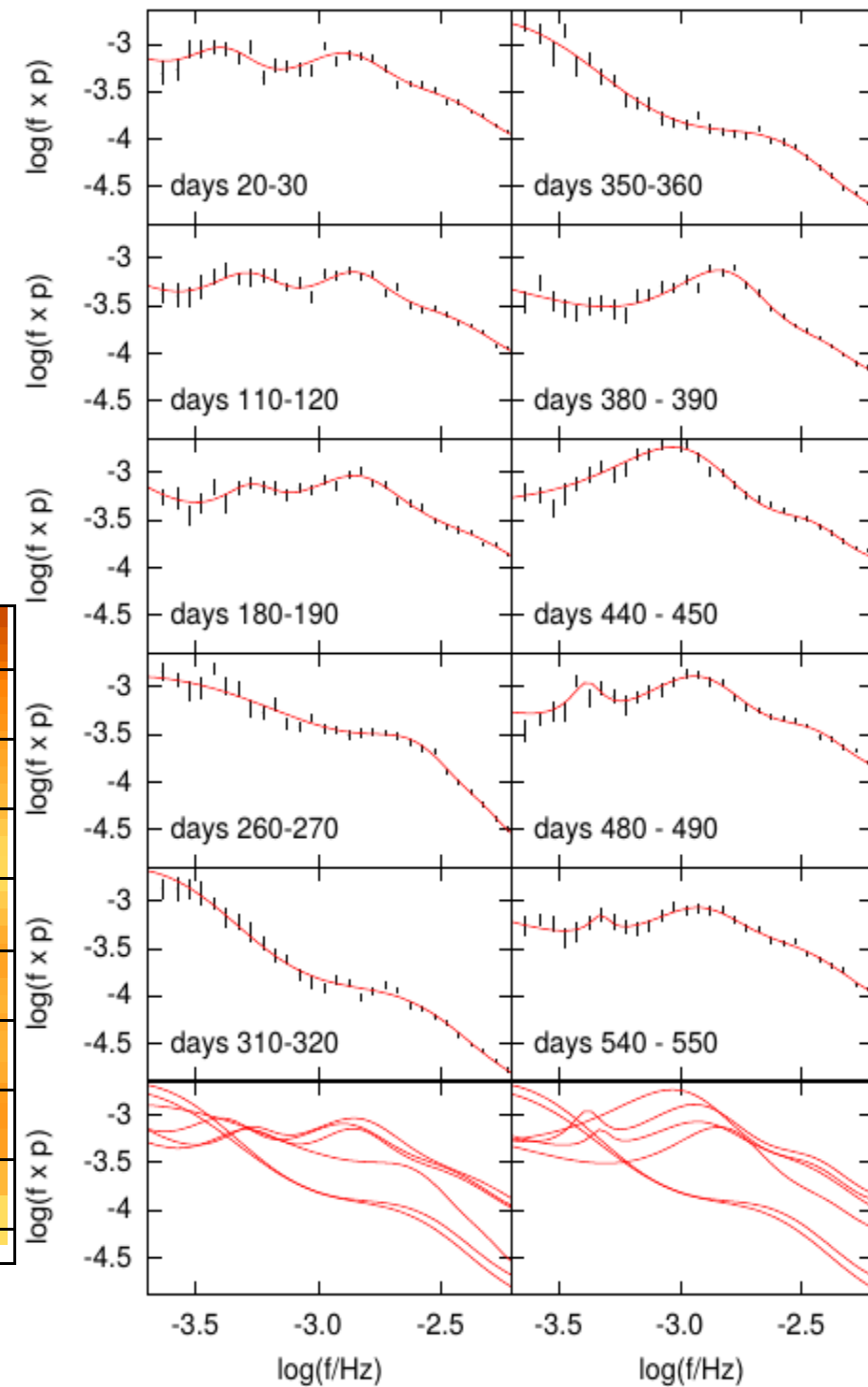
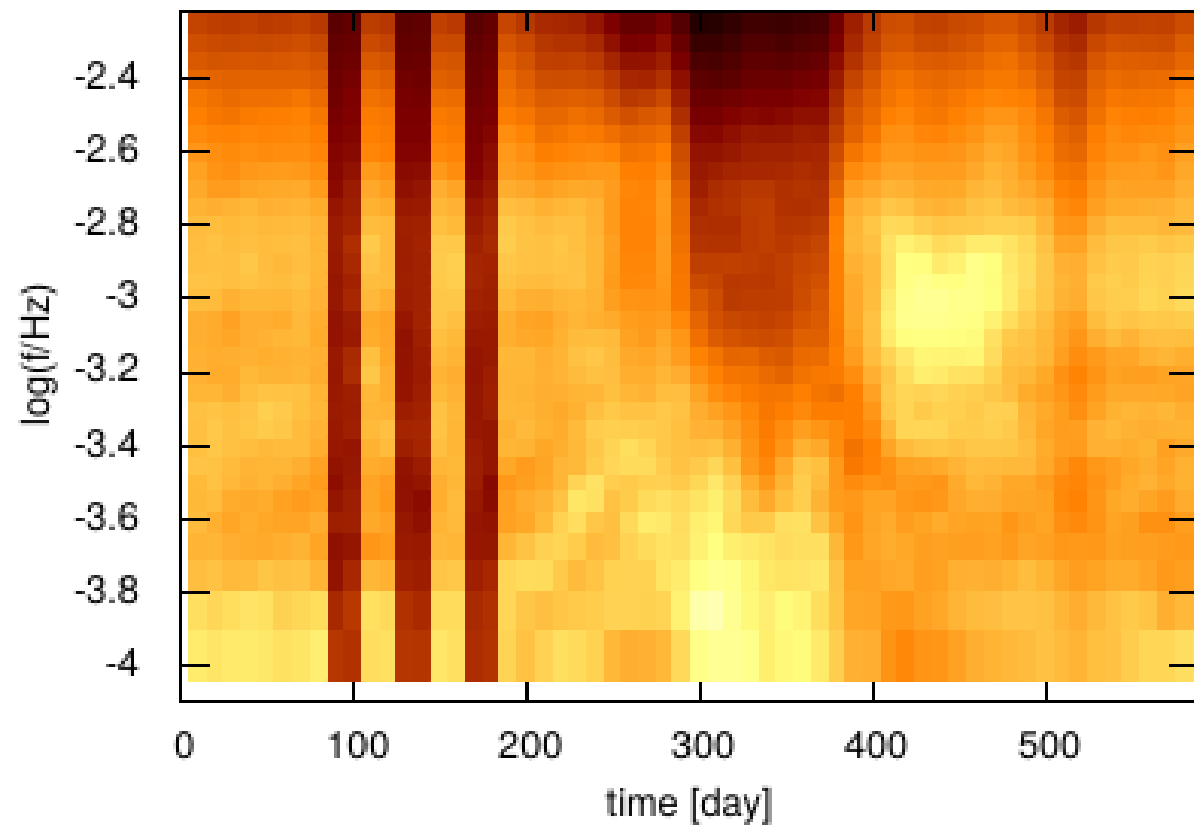
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Multicomponent PDS

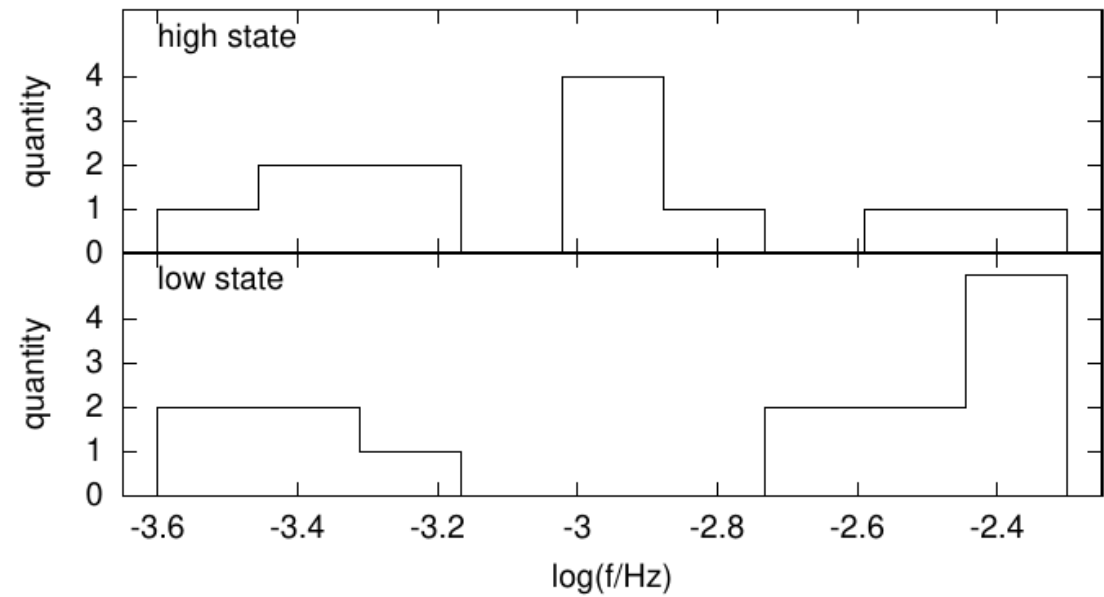
MV Lyr state transition, Kepler

Dobrotka et al. (2020)



Multicomponent PDS

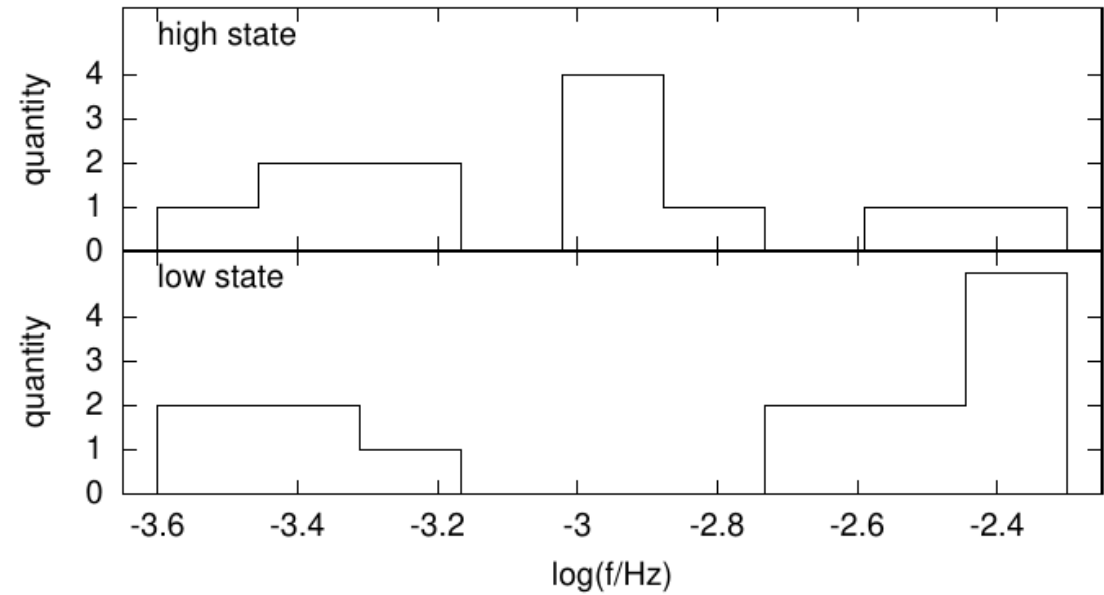
CVs in general



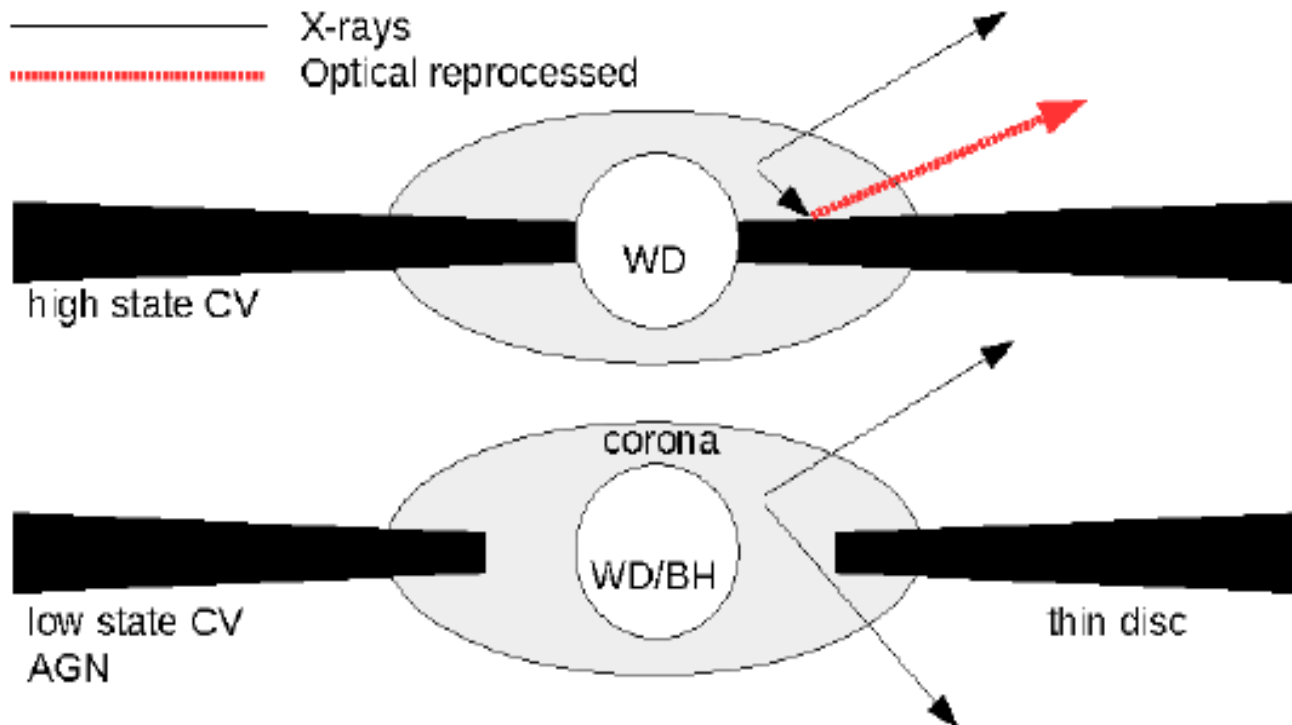
Dobrotka et al. (2020)

Variability sources

CVs in general



Dobrotka et al. (2020)



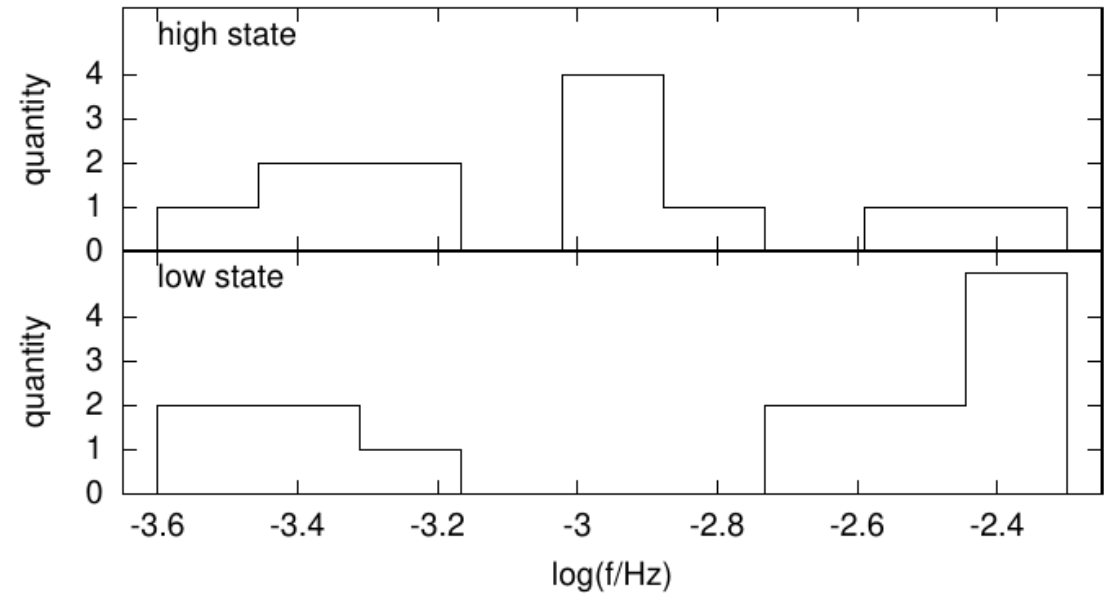
Dobrotka et al. (2024)

Variability sources

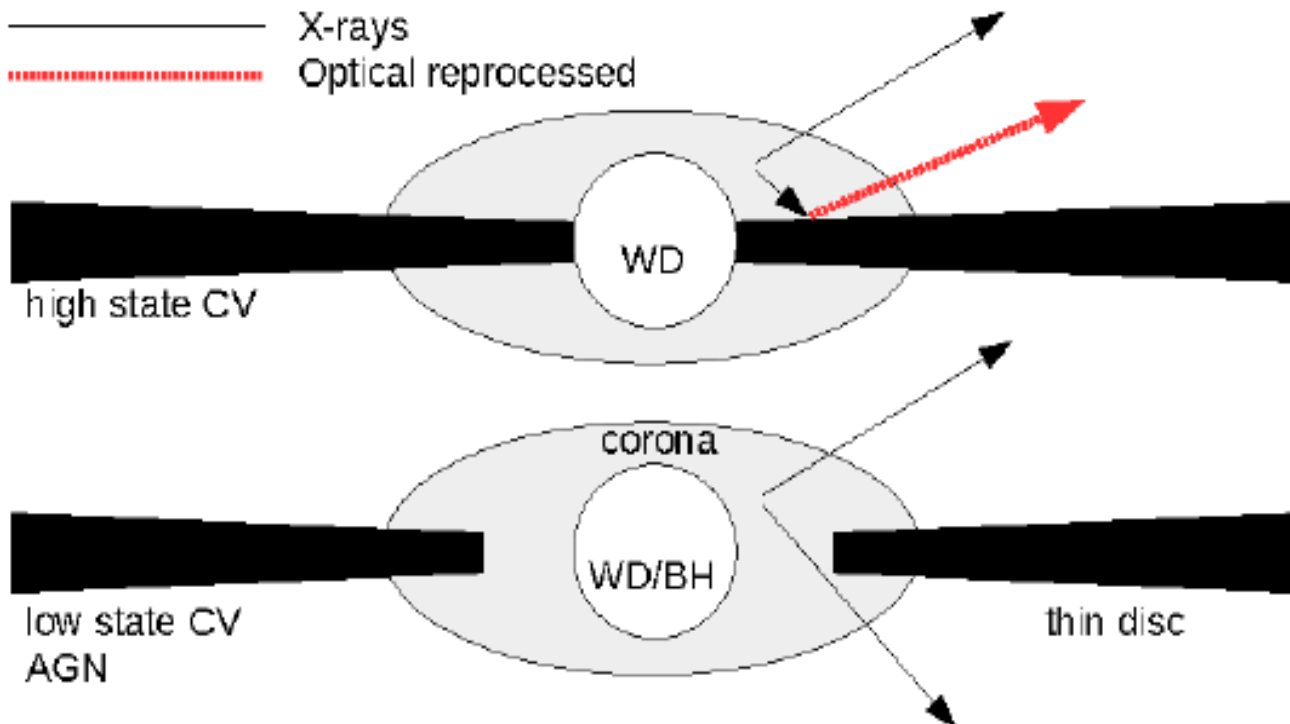
CVs in general

BUT, energy problem!!!!

$$L_X/L_{\text{opt}} < 1$$



Dobrotka et al. (2020)



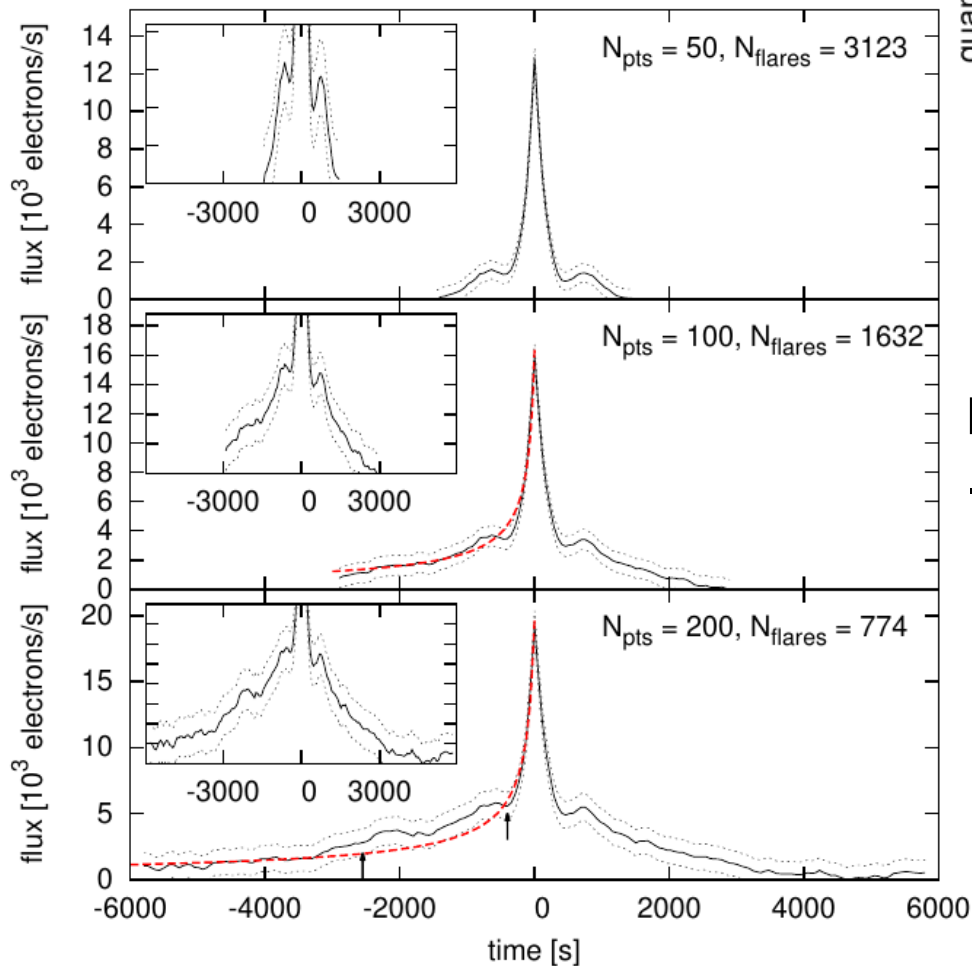
Dobrotka et al. (2024)

Variability sources

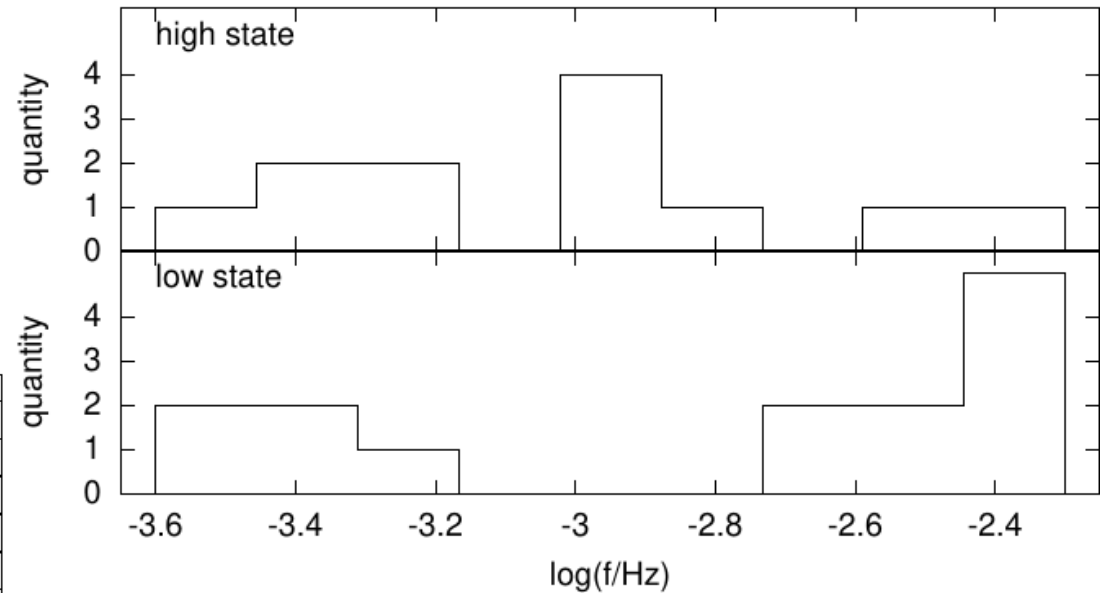
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Dobrotka et al. (2019)



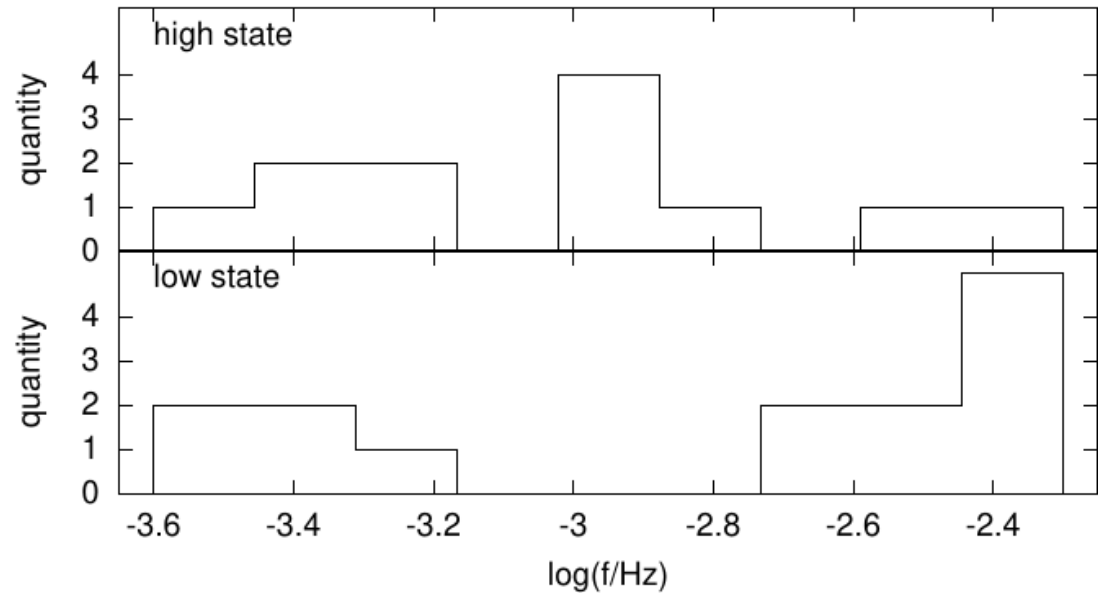
Dobrotka et al. (2020)

Flickering flare has substructures
...but this is another seminar

Search for mHz break frequency in TESS

CVs in general

- only 12 measurements in HS
- only 14 measurements in LS



Dobrotka et al. (2020)

~1 mHz freq

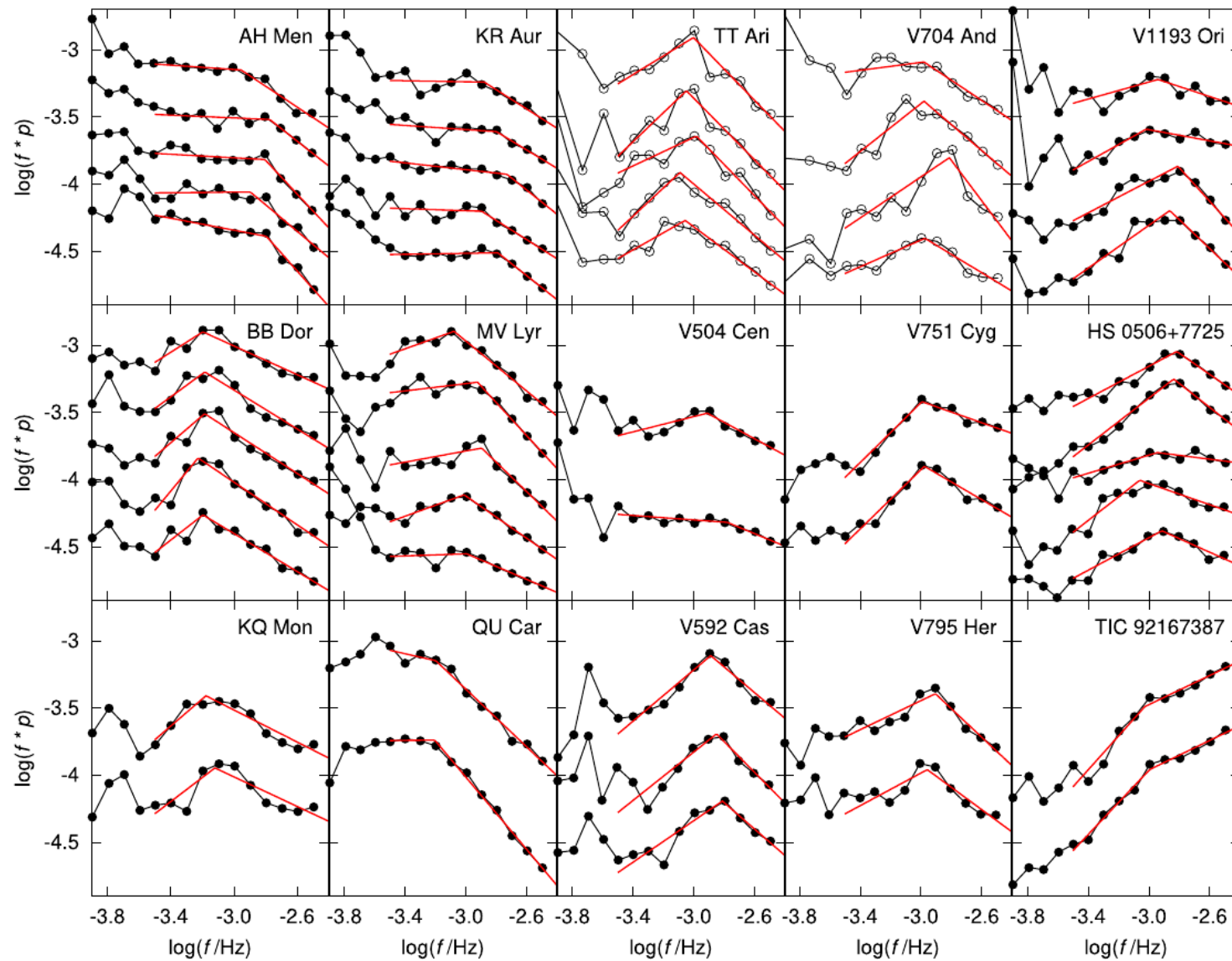
- really preferred?
- really present only in the high state?

Search for mHz break frequency in TESS

TESS data

- 61 nova like CVs (focus to high state only so far)
- 15 detections

Dobrotka et al. (2024)

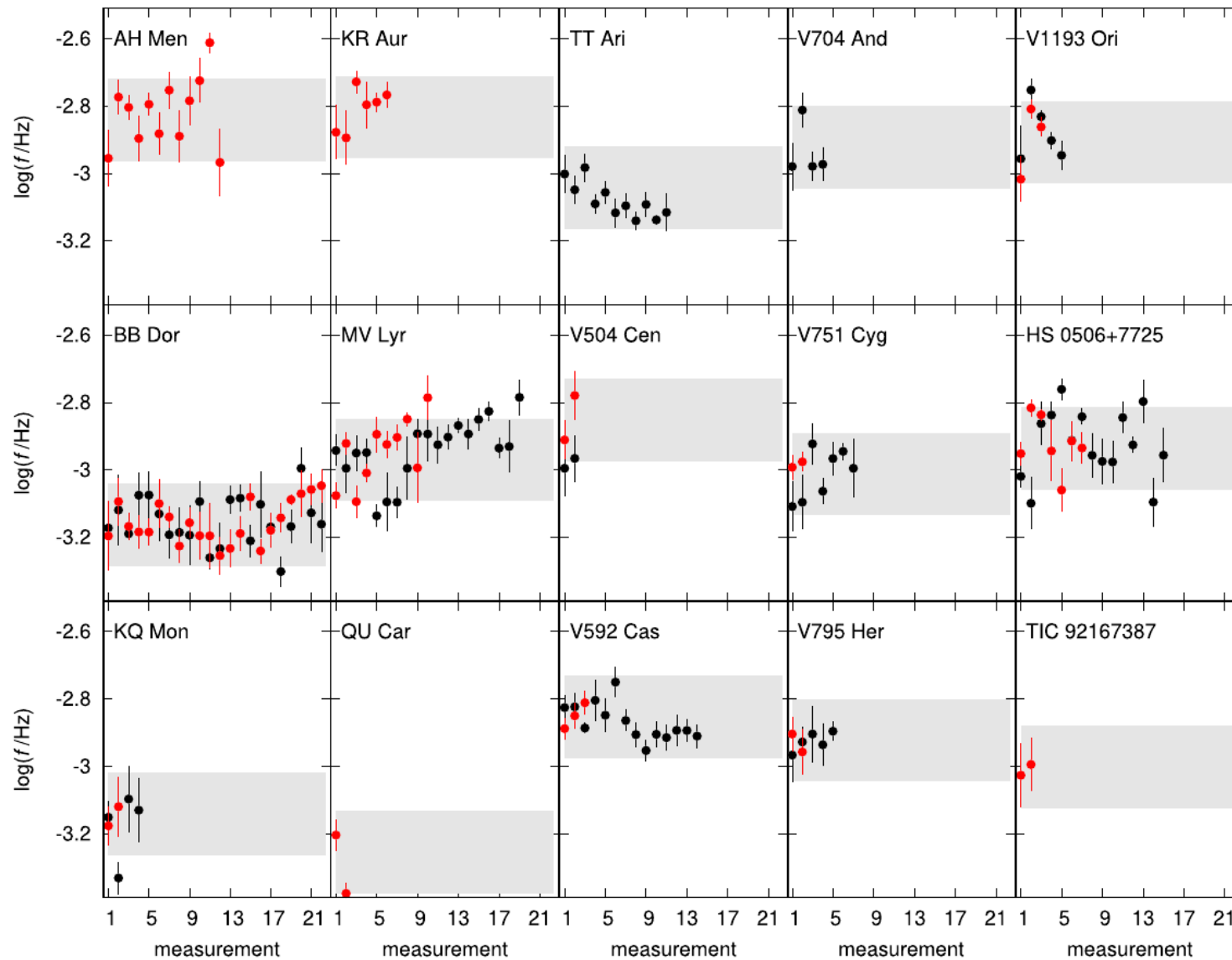


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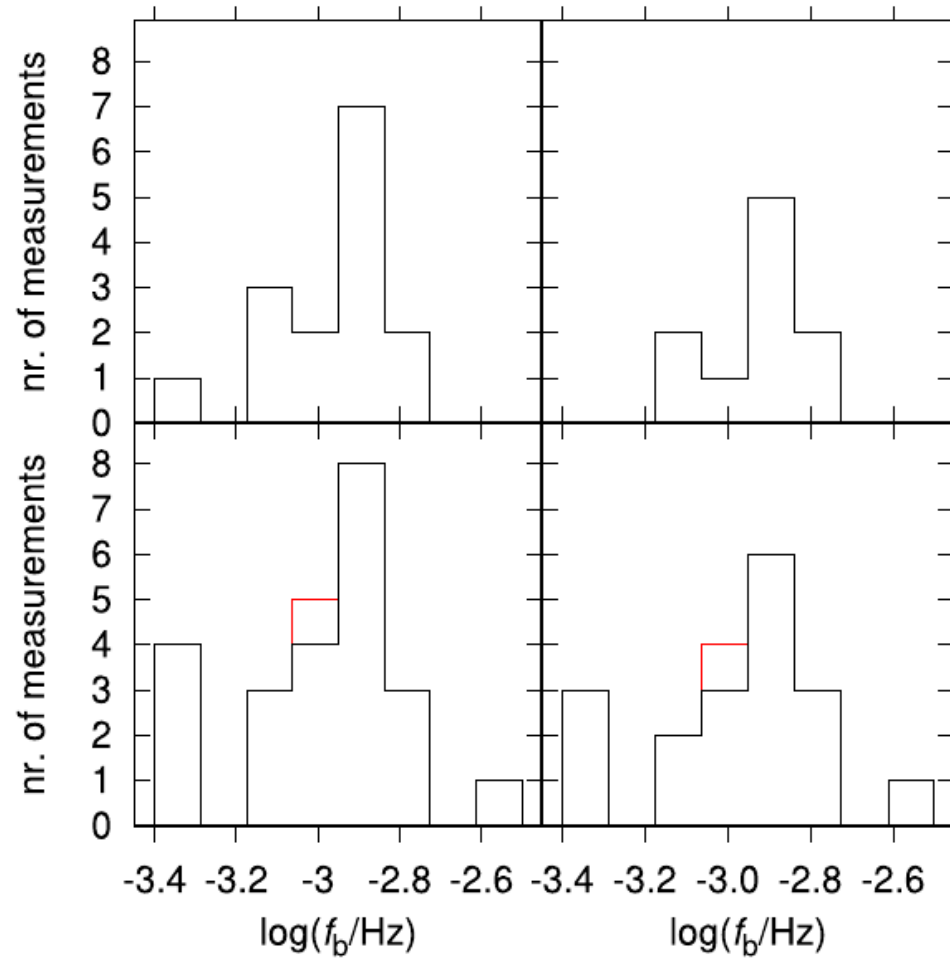


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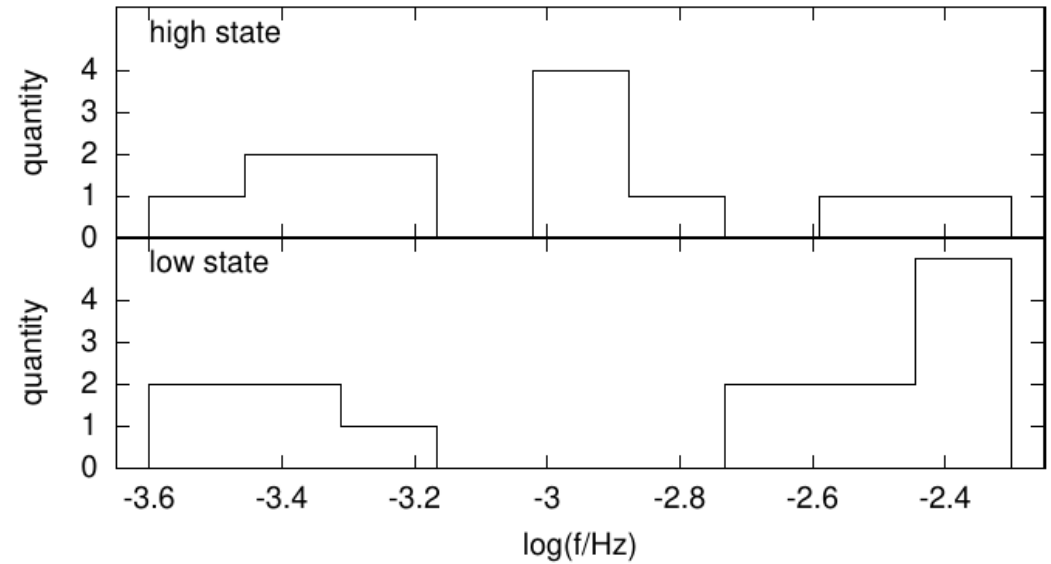
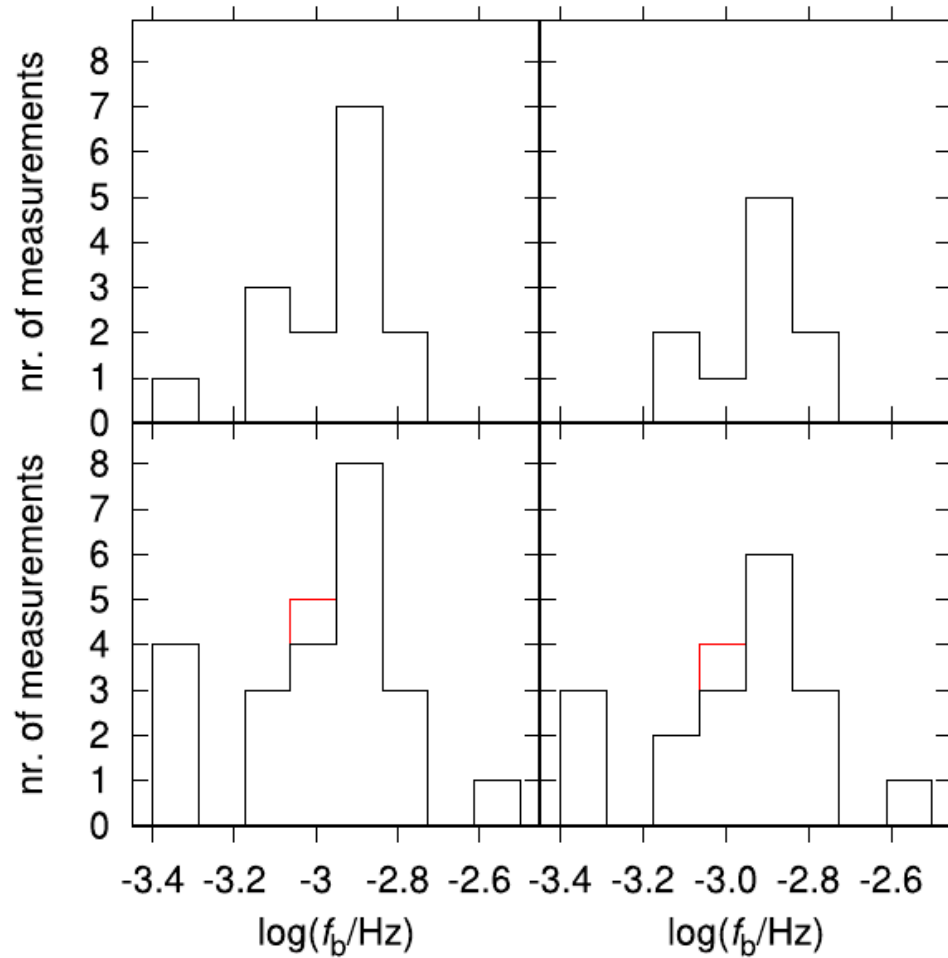


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99%, 96% confidence vs 69%



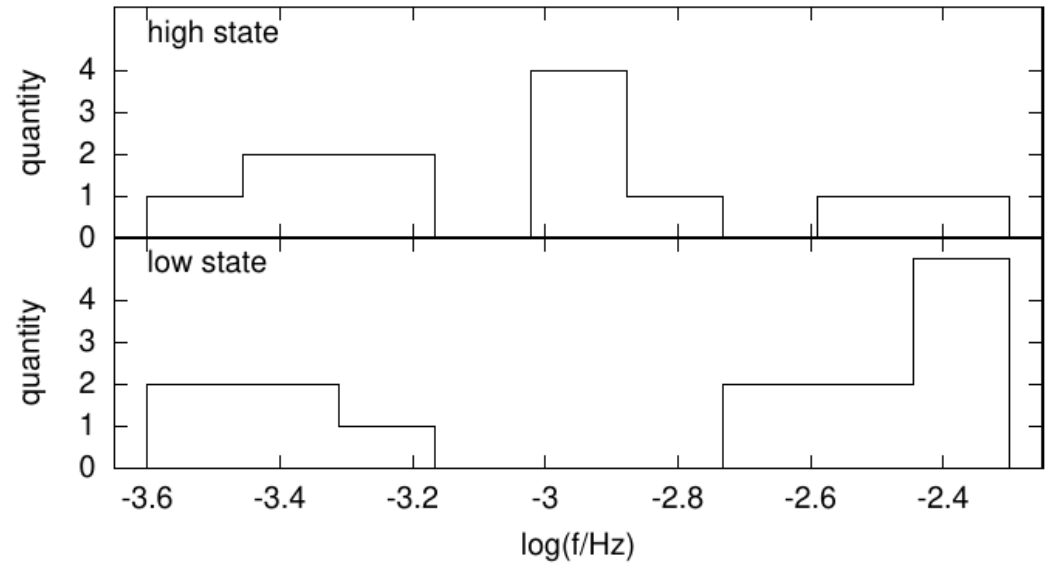
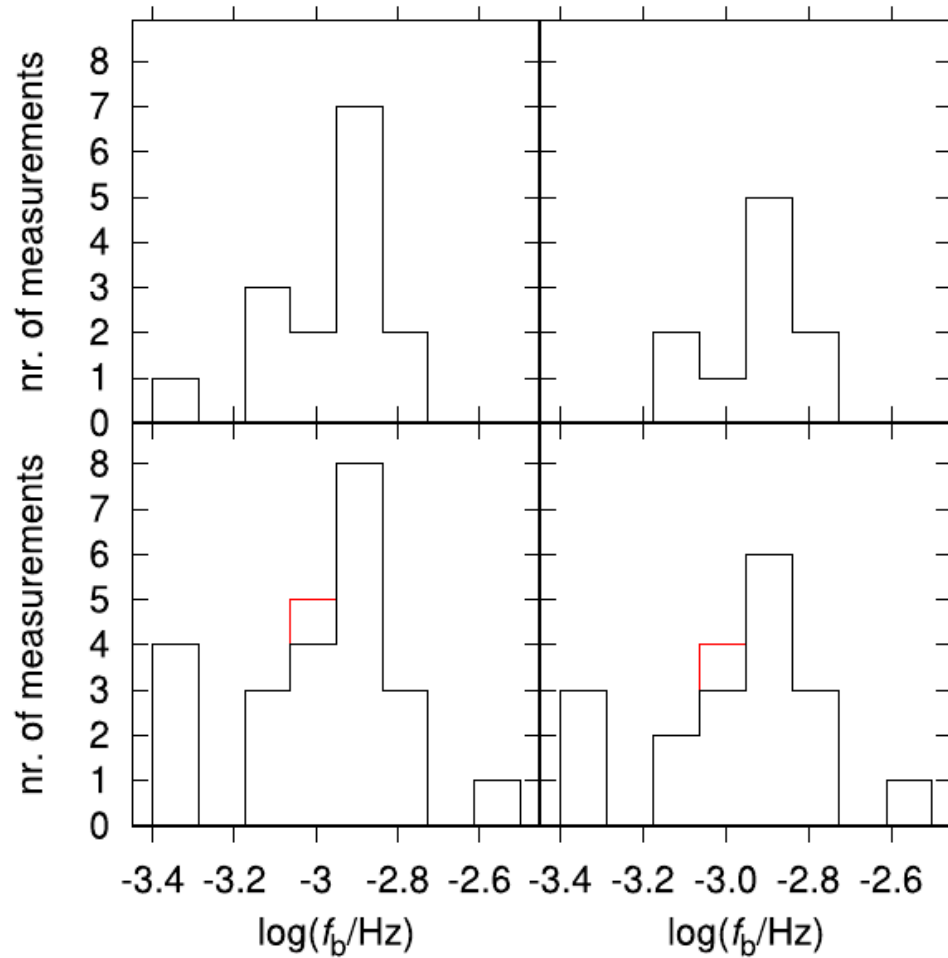
Dobrotka et al. (2024)

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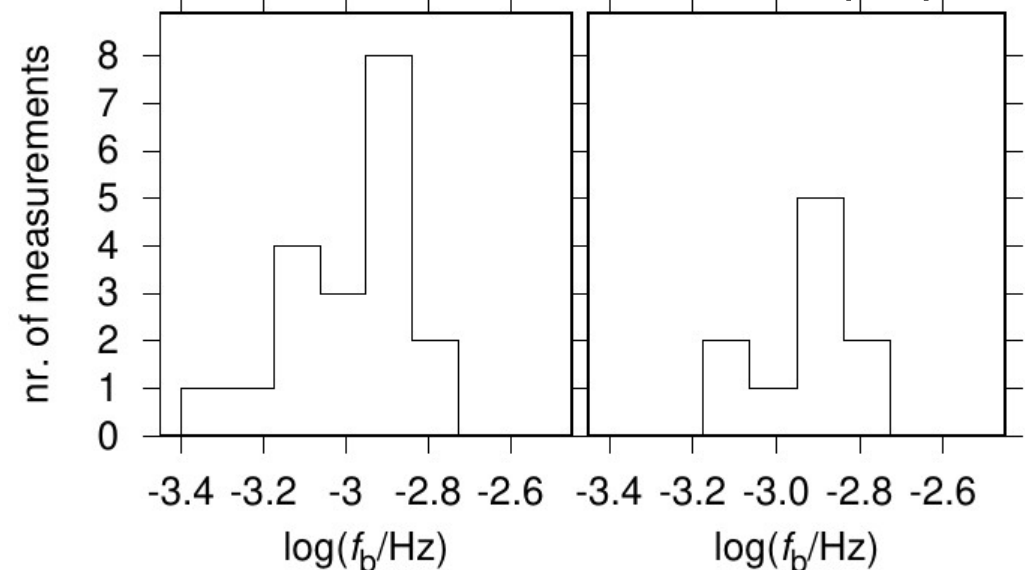
TESS data

- 61+39 nova like CVs (focus to high state only so far)
- 15+4 detections

99%, 96% confidence vs 69%



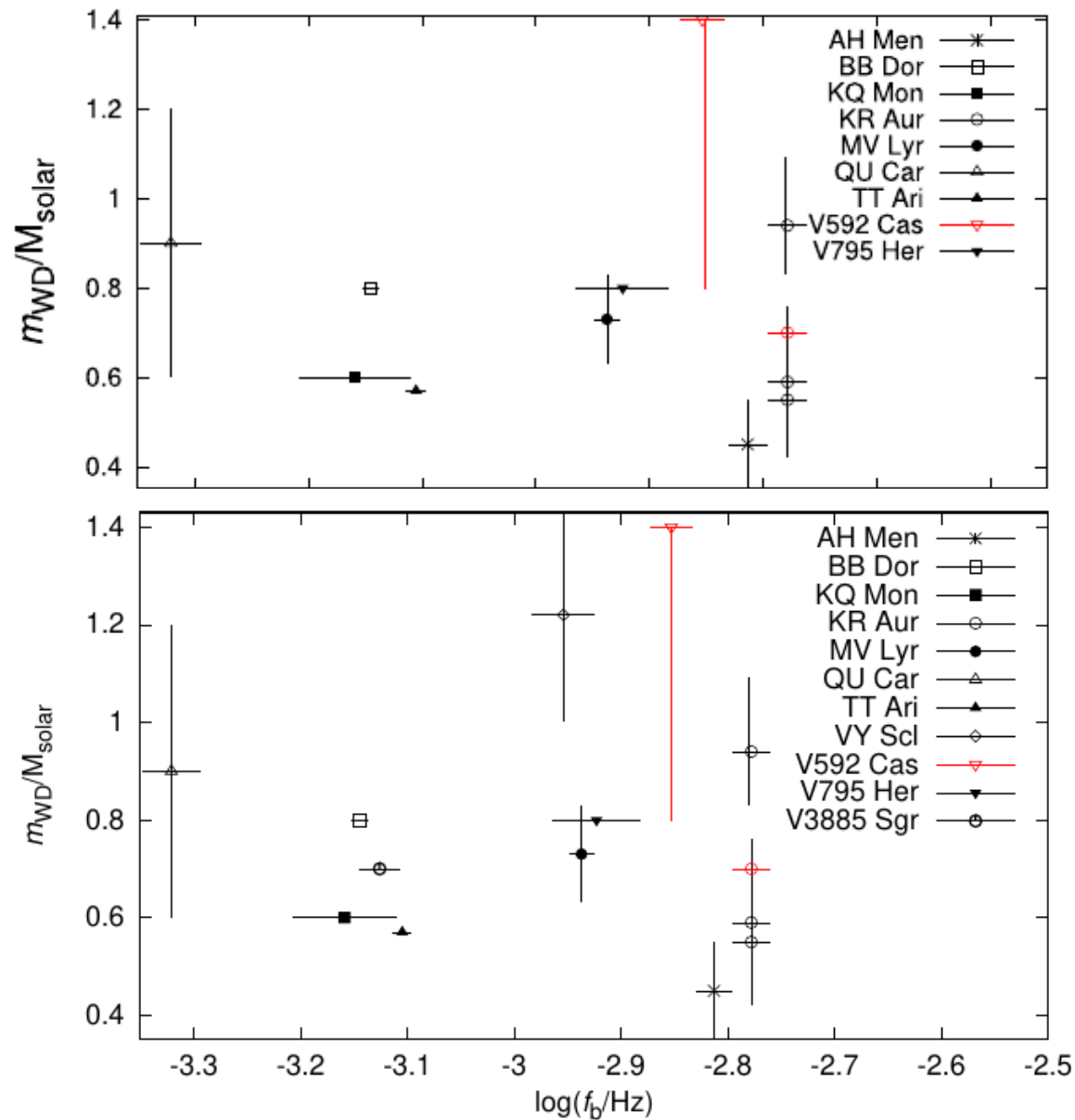
Dobrotka et al. (2024)
Dobrotka et al., in prep



Variability sources

Inner disc or corona?

m_{WD} vs freq

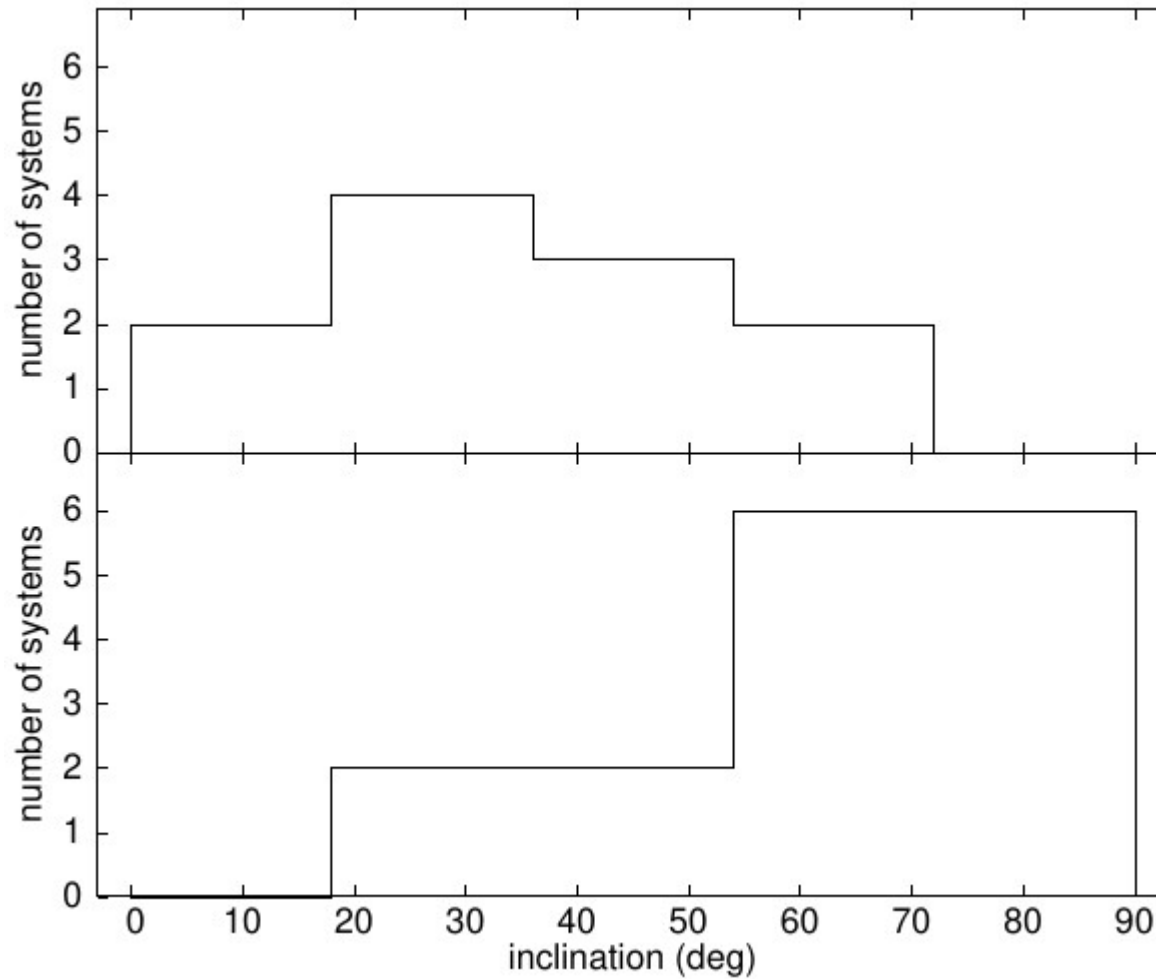


Dobrotka et a. (2024)

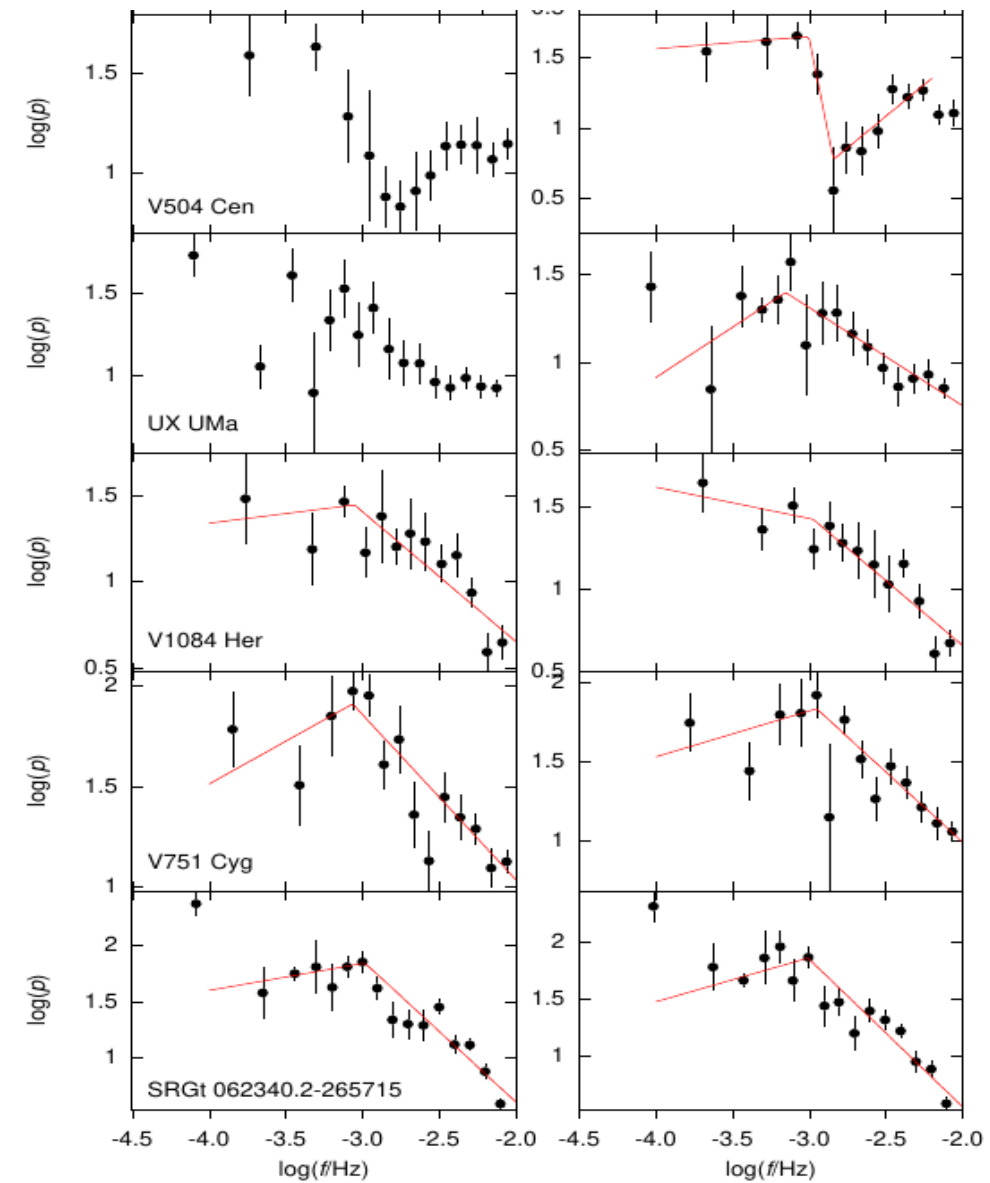
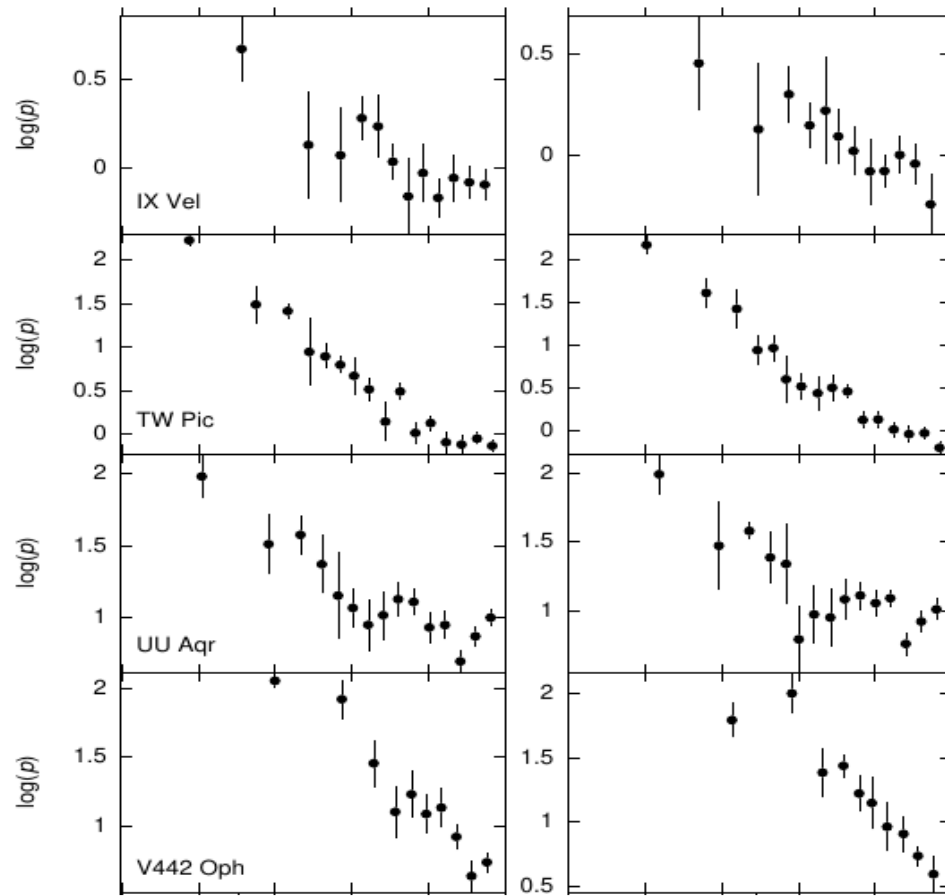
Dobrotka et al., in prep

Variability sources

detection vs non-detection of break frequency



Search for mHz break frequency in XMM-Newton



Hunting for characteristic frequencies of fast variability in cataclysmic variables

Conclusions:

- CVs have multicomponent PDSs like X-ray binaries
- there is a preferred frequency close to 1 mHz with more than 96% confidence
- it is not correlated with the m_{WD}
- it is seen for inclinations < 70 degrees
- it increases during transition from high to low state (seen only in MV Lyr)

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Conclusions:

- CVs have multicomponent PDSs like X-ray binaries
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Questions:

- is the ~ 1 mHz frequency present or absent during low state?
- does it increase during transition from high to low state in general?
- what is the source, inner disc or corona?

Hunting for characteristic frequencies of fast variability in cataclysmic variables

END

Thank you for your attention

Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00378.

Seminar at Astronomical Institute SAV, 2025