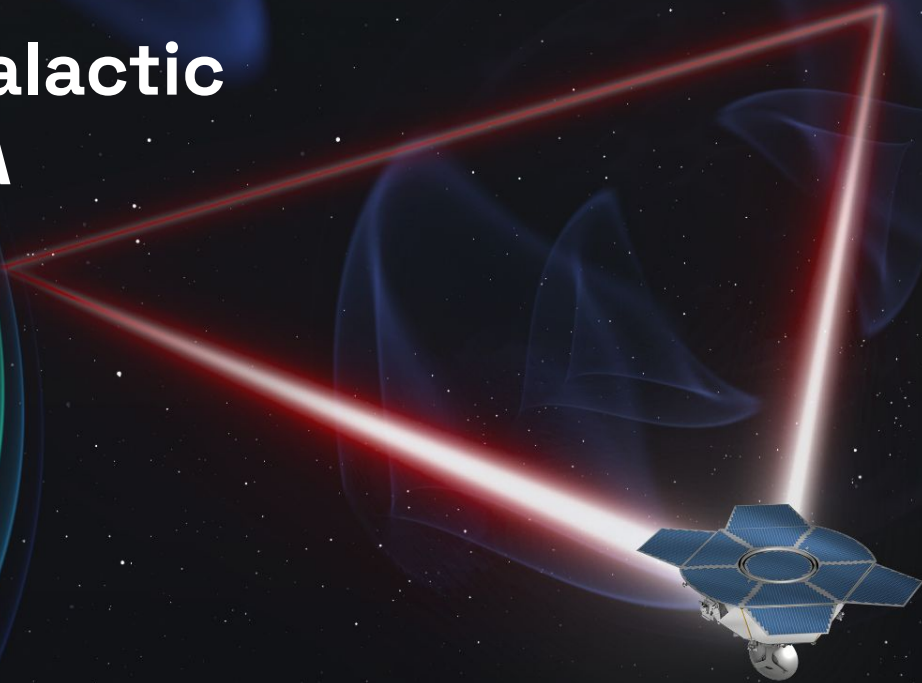


Disentangling the Galactic binary ZOO with LISA

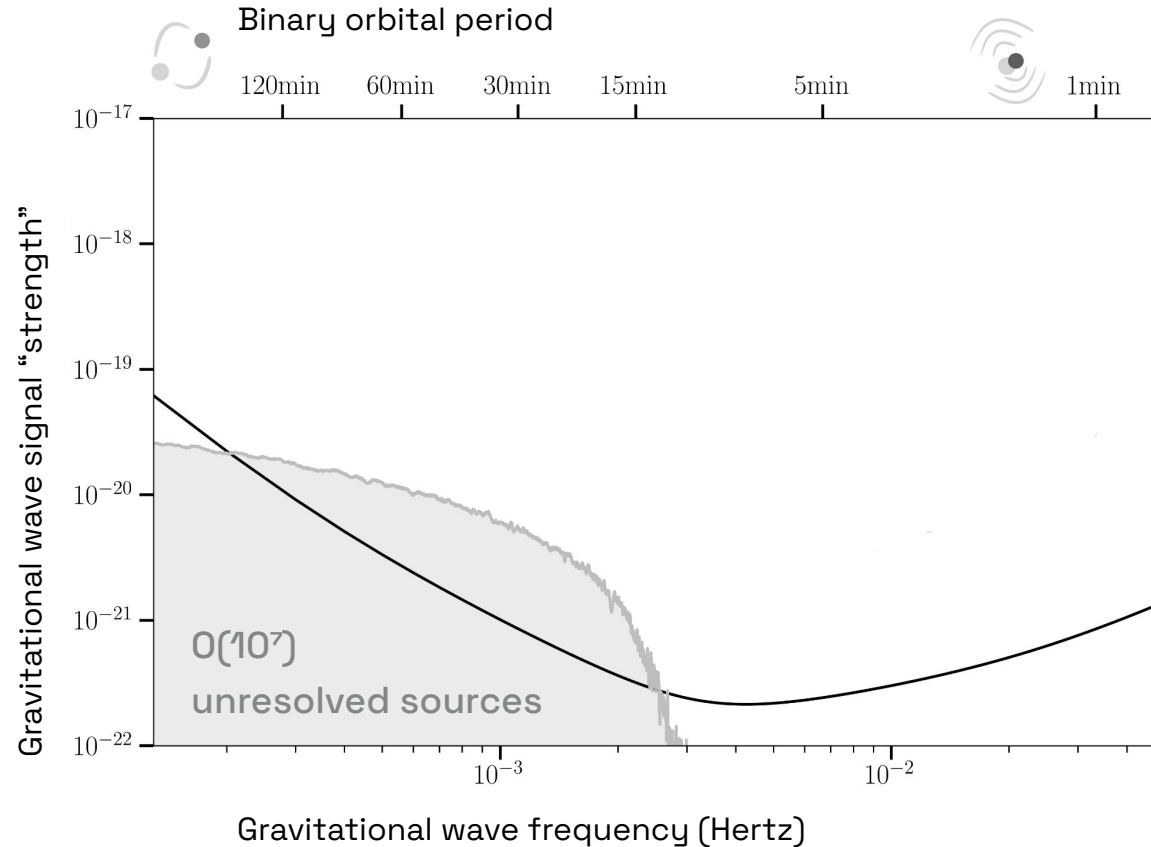
VALERIYA KOROL

SRON

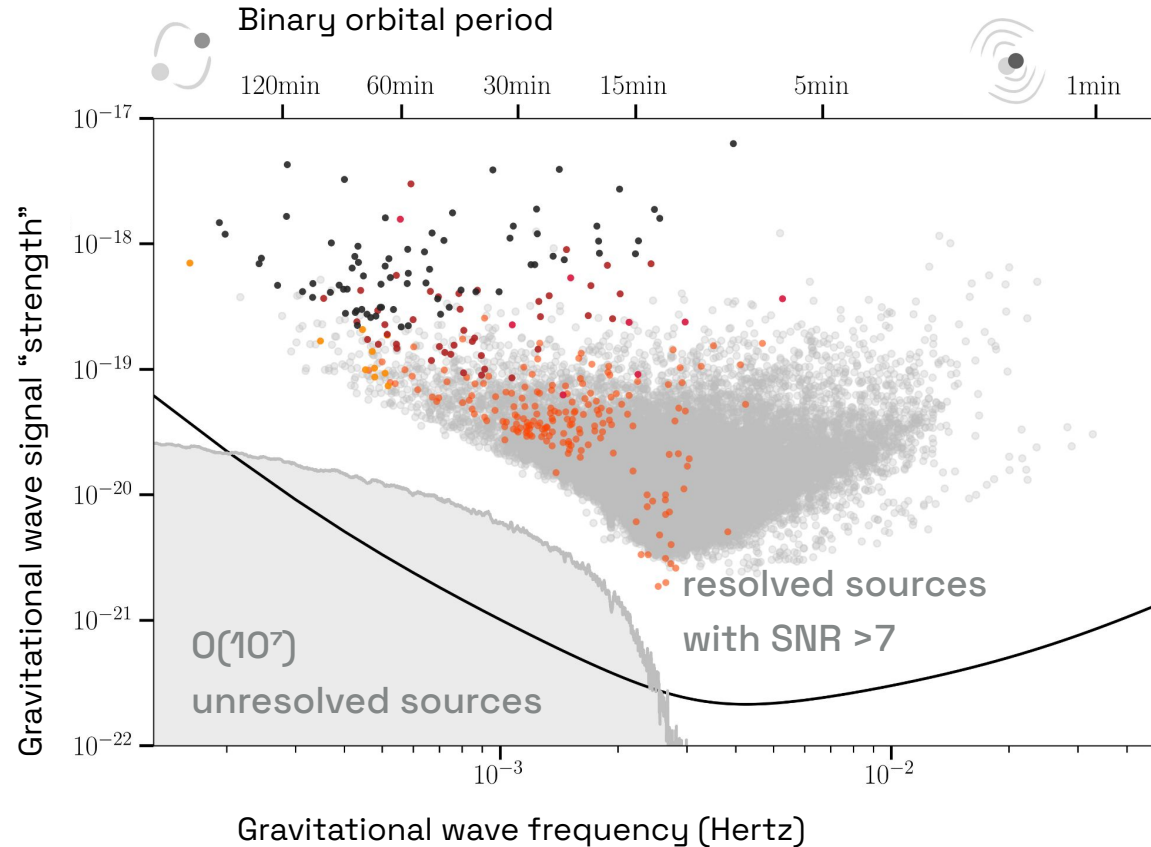
SPACE
RESEARCH
ORGANISATION
NETHERLANDS



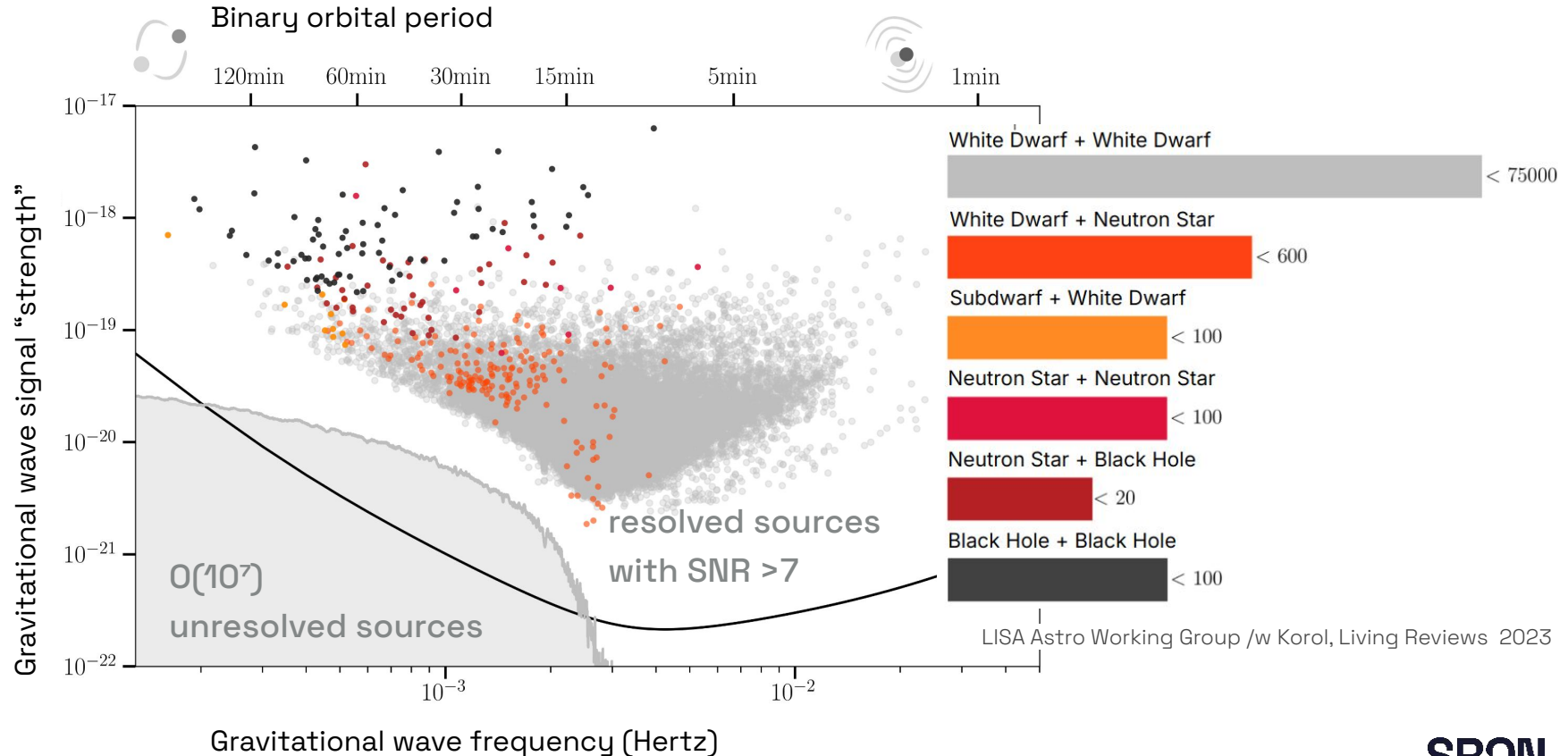
The Galactic binary gold mine



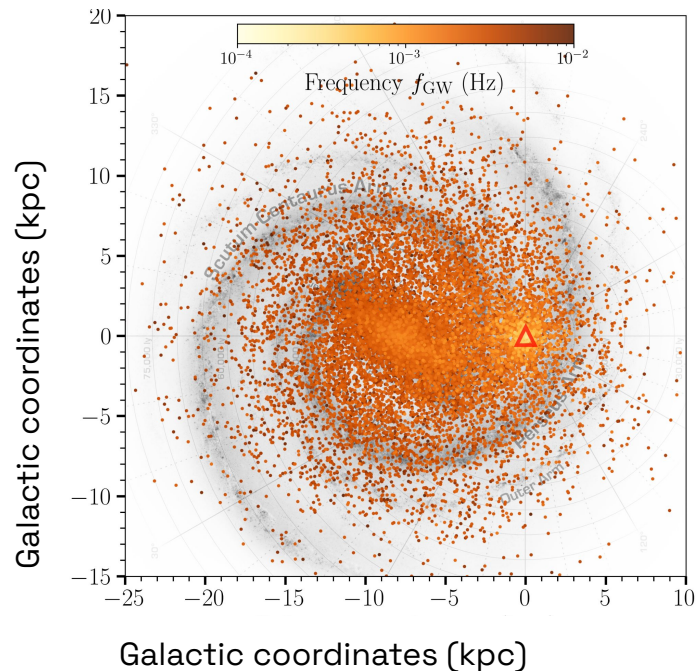
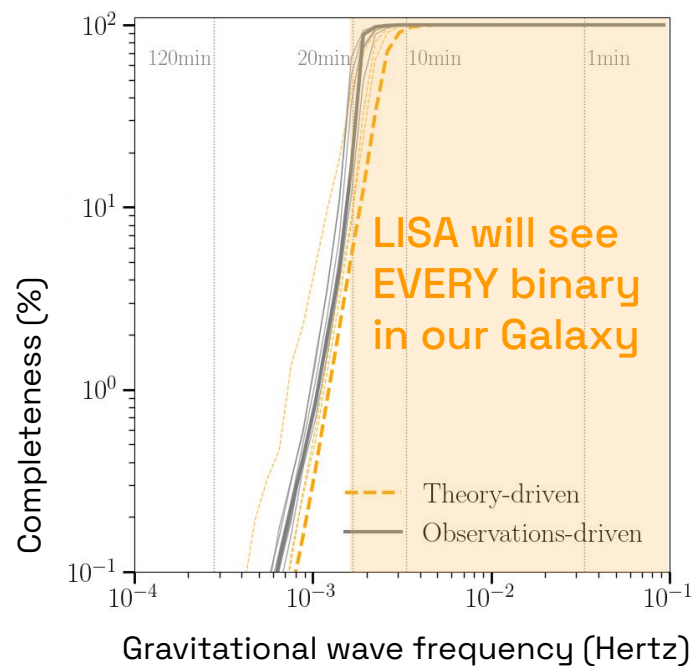
The Galactic binary gold mine



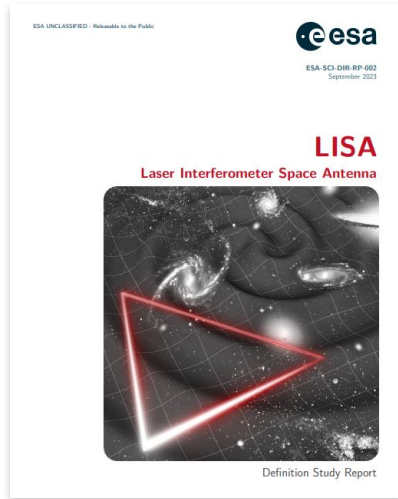
The Galactic binary gold mine



The Galactic binary gold mine



What astrophysics do we promise from the LISA catalogue?



Colpi /w Korol et al. 2024

Reconstruct binary evolution*

→ formation channels, merger rates, binary interactions

Compact-object physics*

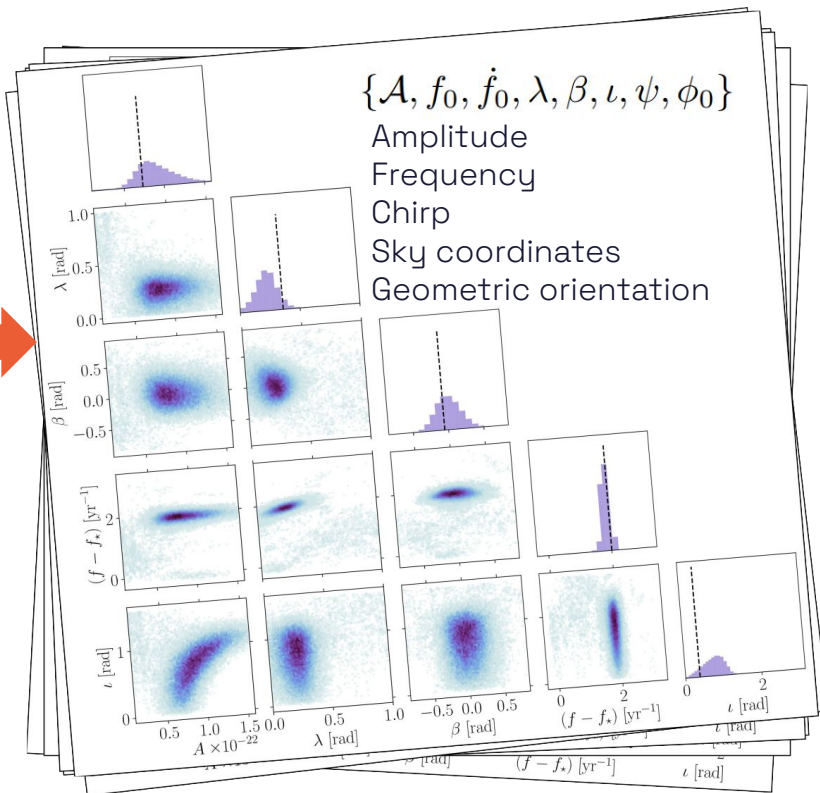
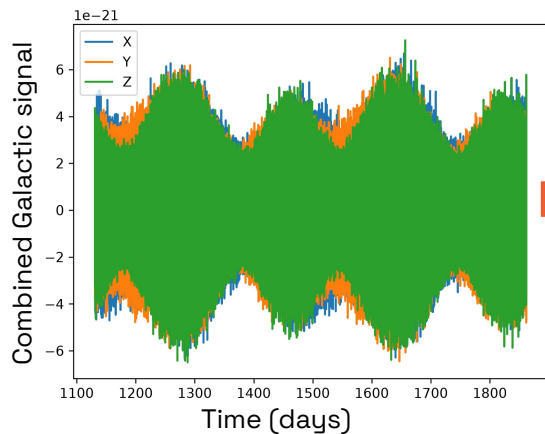
→ WD / NS / BH populations, accretion, tides, NS kicks

Map the Milky Way

→ spatial structure, stellar mass distribution, star formation

* provided we can distinguish between different binary populations.

GW detection $\neq$ astrophysical identification



WDWD?

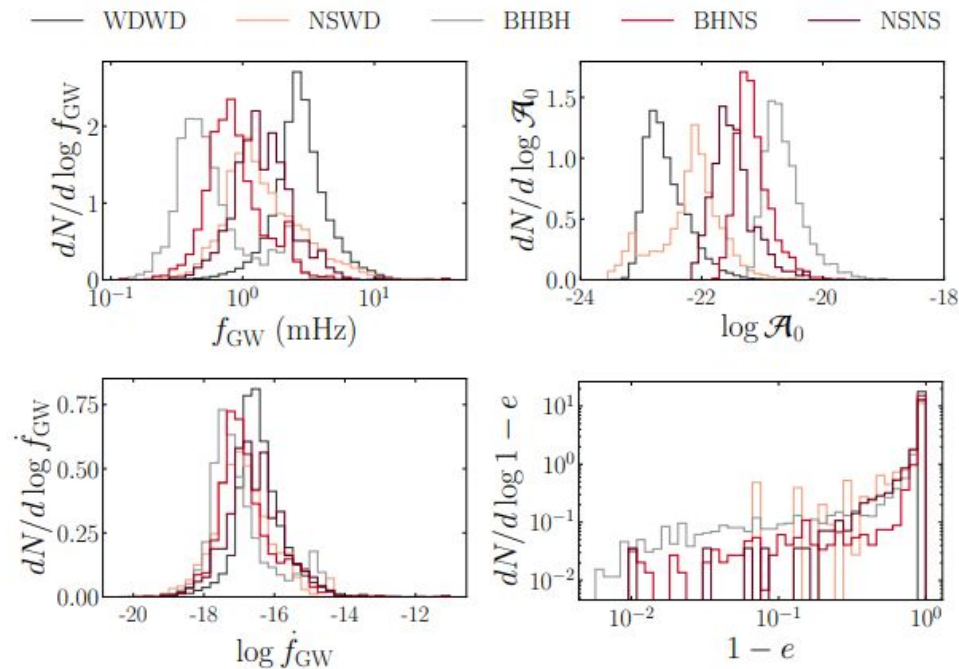
NSWD?

NSNS?

BHNS?

BHBH?

The Galactic zoo overlaps in LISA observables

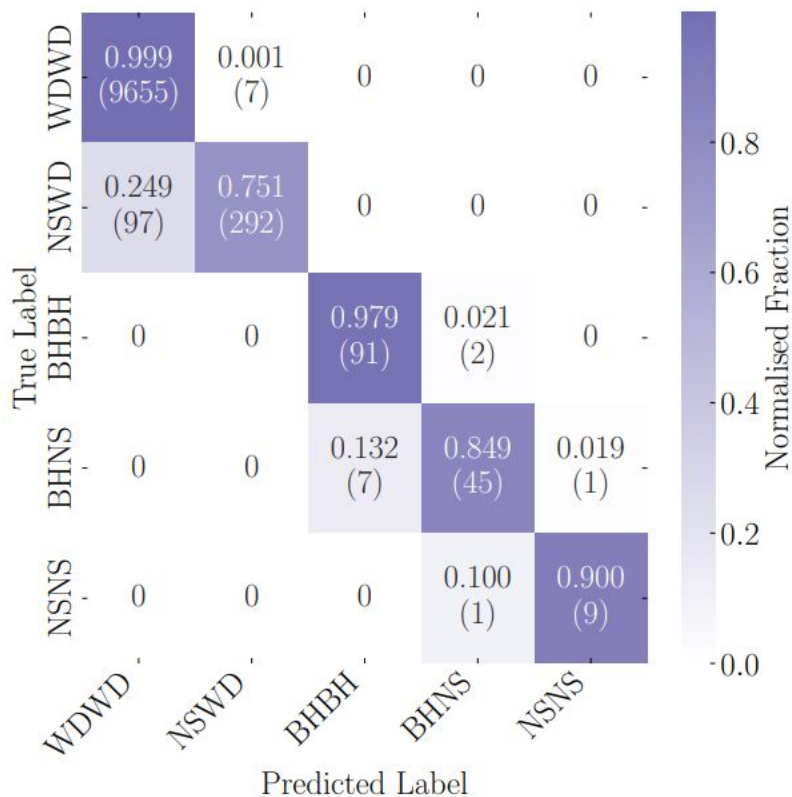


No single observable cleanly separates the binary classes.

low-mass: WDWD, NSWD from Korol et al. 2024

high-mass: BHBH, BHNS, NSNS from Wagg et al. 2022

Combining LISA observables separates most binary populations



High-mass binaries are separable

BHBH: 98%

BHNS: 85%

NSNS: 90%

WDWDs are almost perfectly

WDWD: 99.9%

NSWDs are the challenge

Only 75% correctly classified

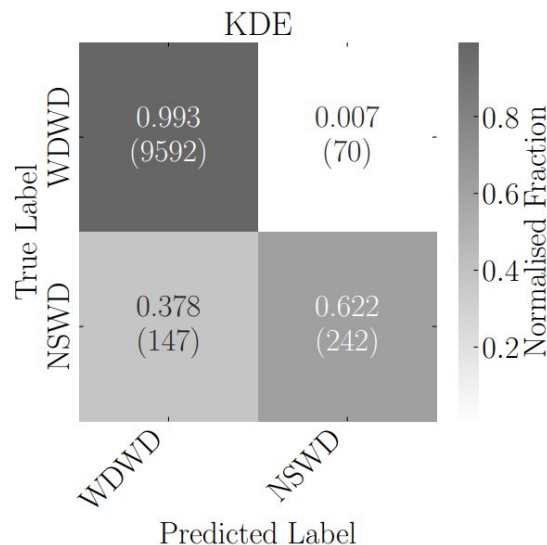
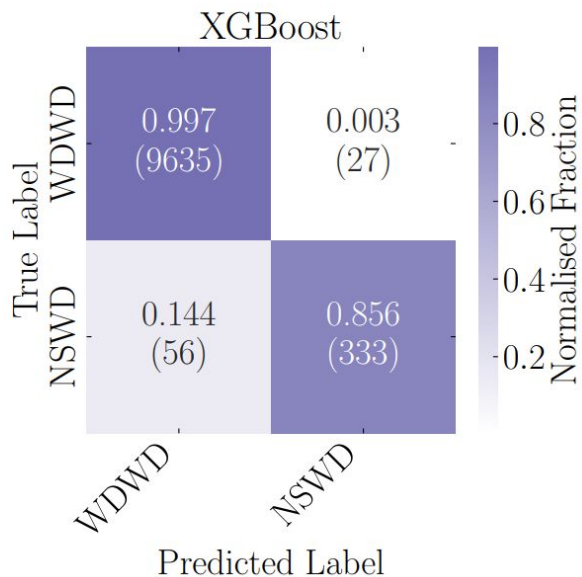
→ most misclassifications are as WDWDs



Irwin Tay
2024/2025
LMU/MPA

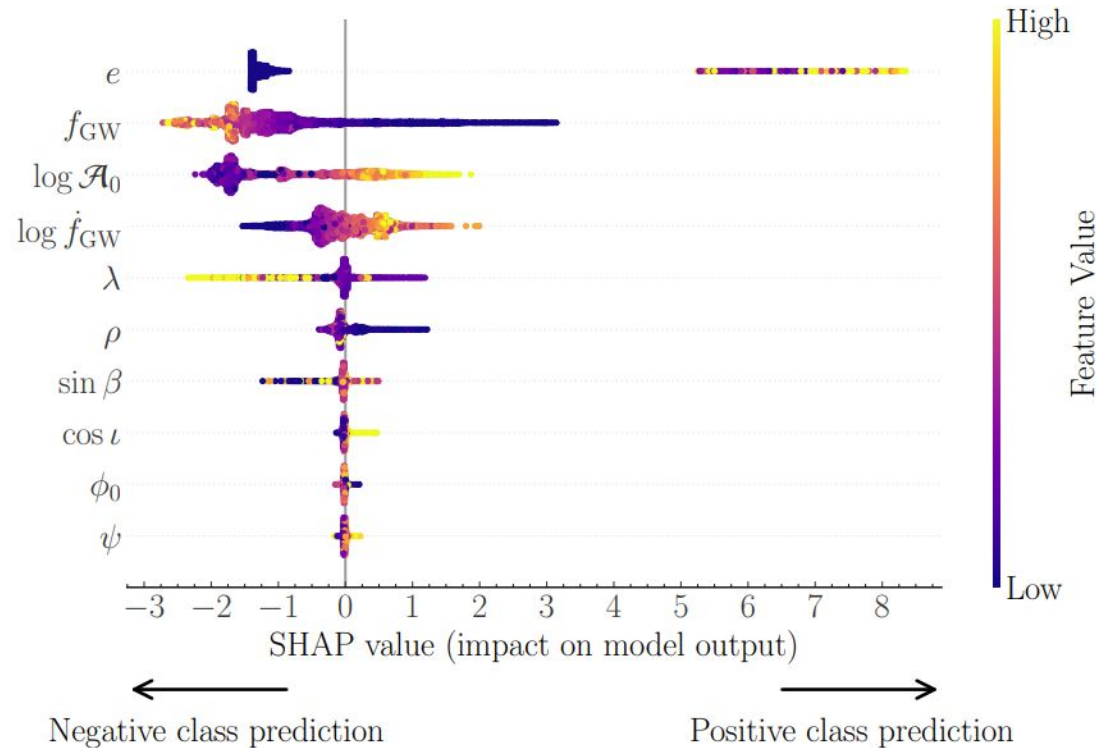
Tay, Korol, Lechien 2026, arxiv:2603.06341

Nonlinear classifiers capture information missed by simpler density-based methods



Tay, Korol, Lechien 2026, arxiv:2603.06341

What information is the classifier using?



Most informative features

- eccentricity
- frequency
- amplitude
- chirp

Less informative

- orientation-related parameters

Tay, Korol, Lechien 2026, arxiv:2603.06341

WDWD

NSWD

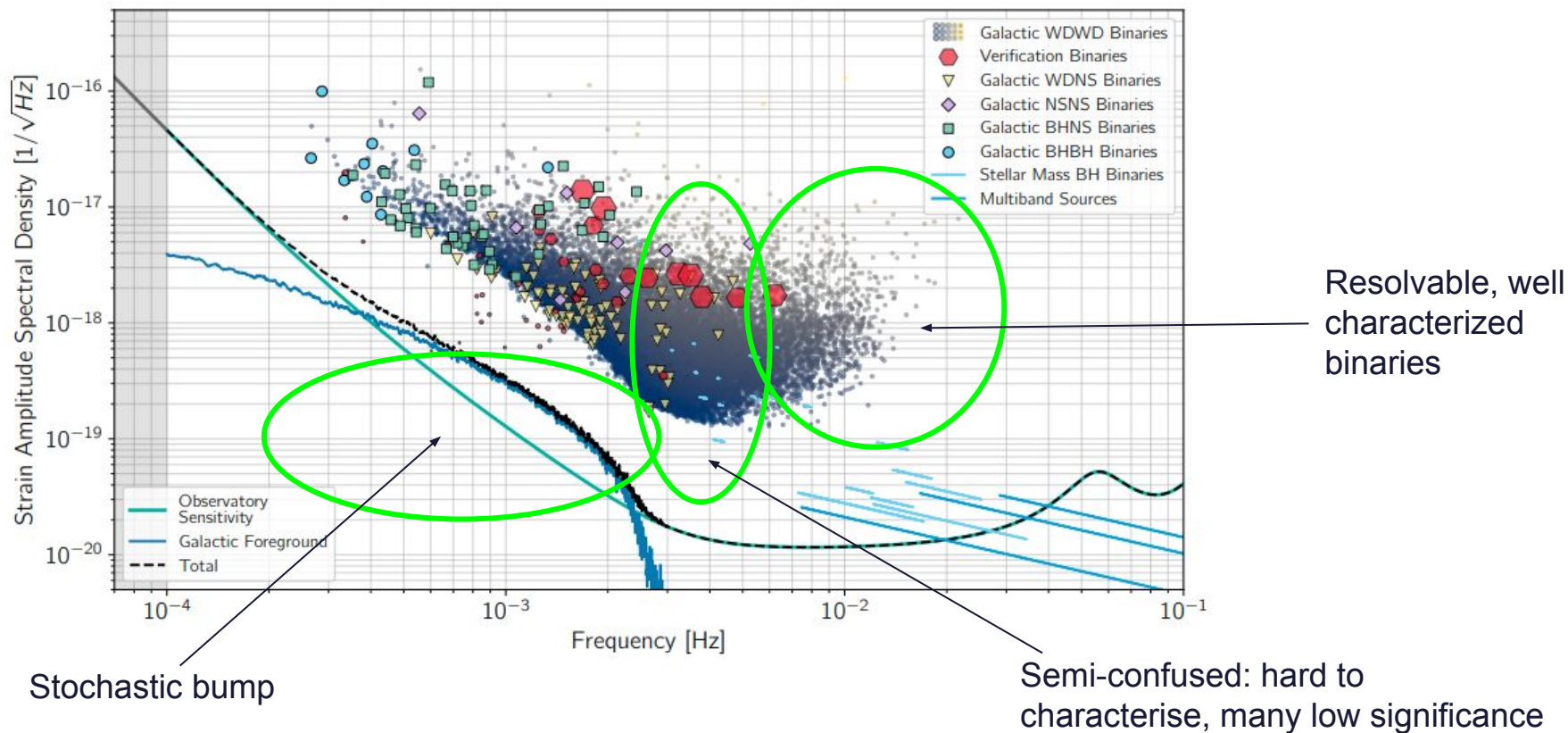
SRON

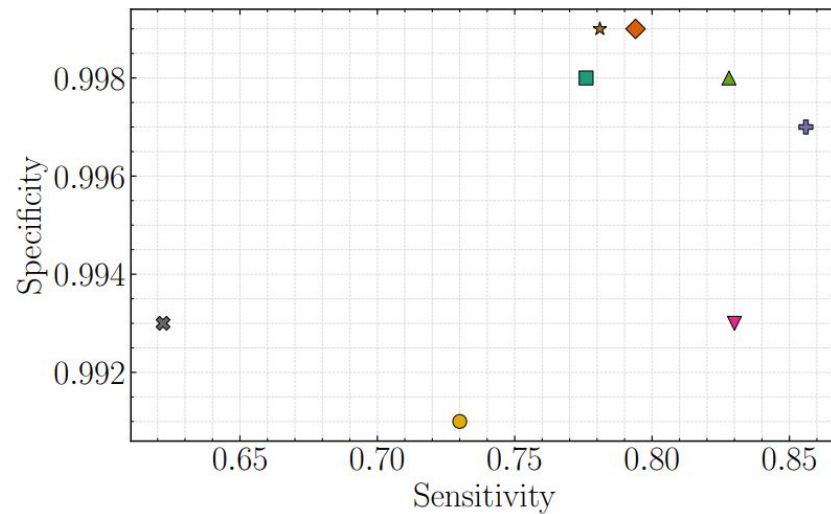
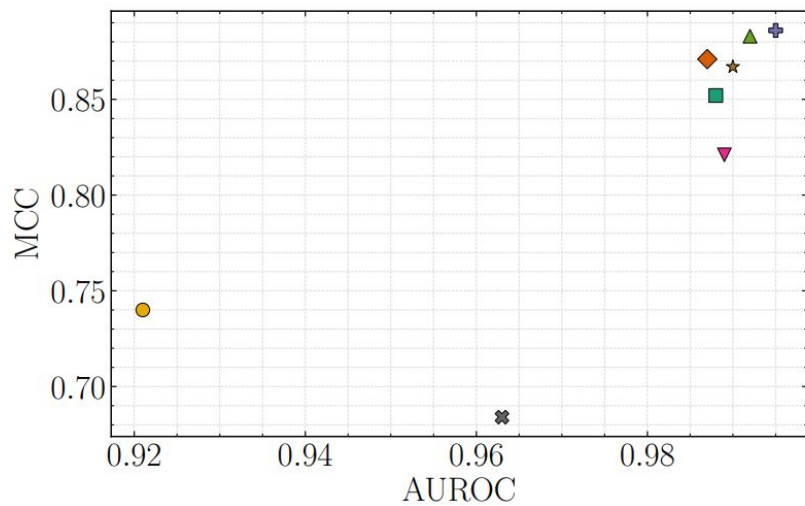
Can LISA reveal the nature of Galactic binaries?

Yes — for most populations.

- **WDWDs are identified with near-perfect accuracy.**
- **High-mass binaries are classified with high efficiency**
BHBH: 98% · BHNS: 85% · NSNS: 90%
- **NSWDs are the most challenging population to identify**
because they overlap strongly with WDWDs and are severely outnumbered
- **Decision-tree-based classifiers perform best among the methods tested**
with XGBoost giving the strongest performance.

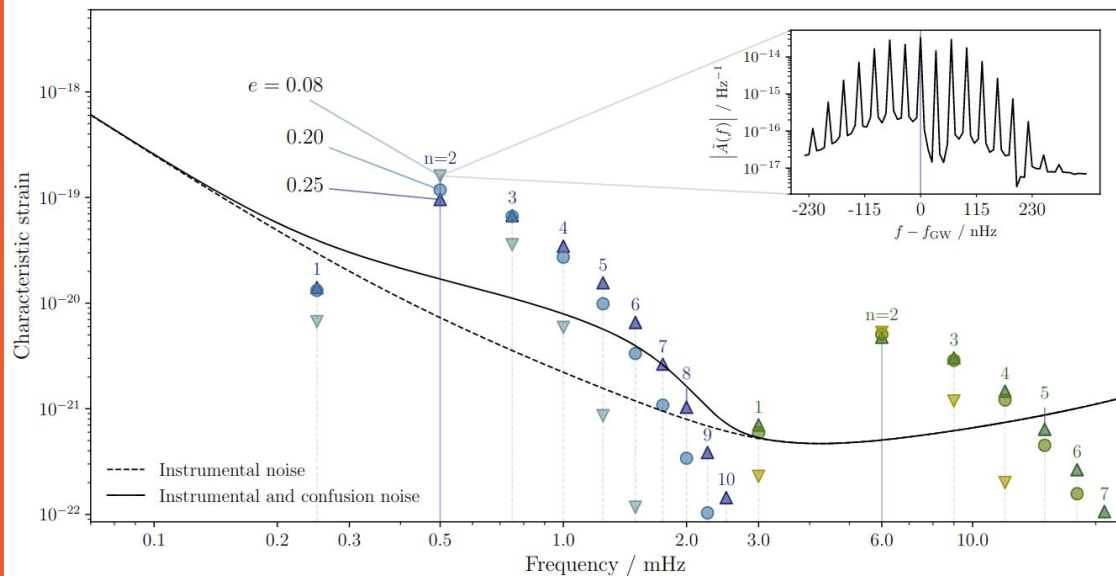
Backup slides





Can we identify NS binaries in the LISA data?

Moore et al. 2024



- **Signal emission:** An eccentric quasi-monochromatic NS+WD binary emits over discrete number of harmonics.
- **Signal detection:** Each harmonic, if sufficiently strong, adds to the signal-to-noise ratio enhancing the overall detectability of the binary.
- **Potential confusion:** These harmonics might be misinterpreted as being produced by a number of separate circular quasi-monochromatic binaries.