Ten Years to LISA at JPL (Pasadena, CA)
April 1-3, 2025

LISA Double White Dwarf Binaries as Galactic Accelerometers

[arXiv: 2405.13109; PRD (2025)]

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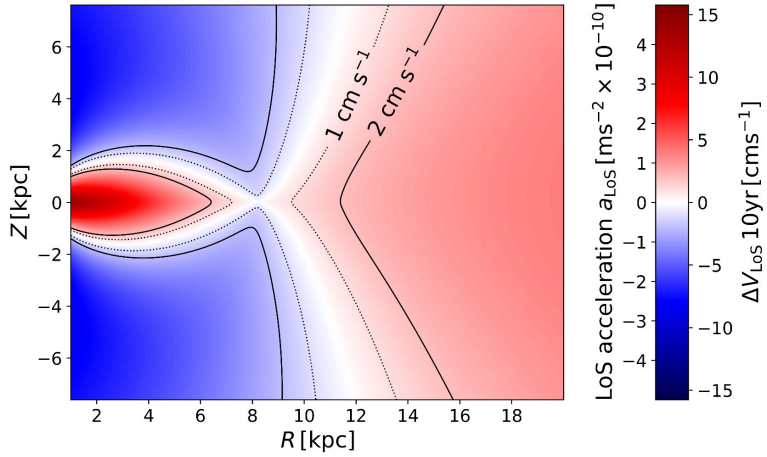
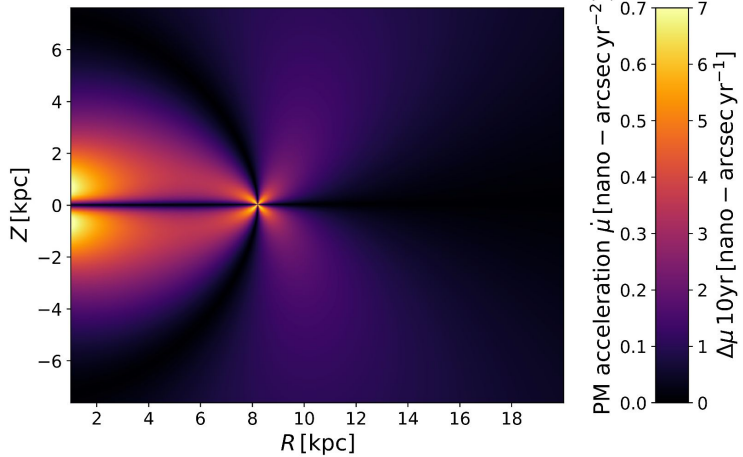
Outline

- Motivation
- Why DWDs?
- Are GW observations enough?
- Can EM observations help?
- Conclusions

Goal: Mapping the Milky Way's Gravitational Potential



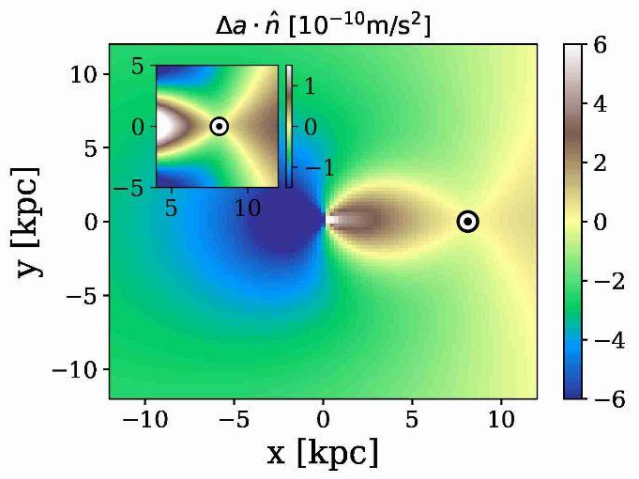


$$a \sim \frac{1\ \mathrm{cm/s}}{10\ \mathrm{yr}}$$

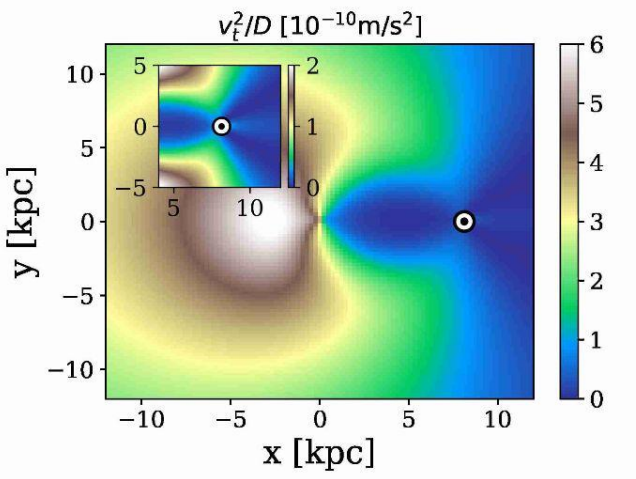
[Silverwood & Easther, 2018]

Goal: Mapping the Milky Way's Gravitational Potential

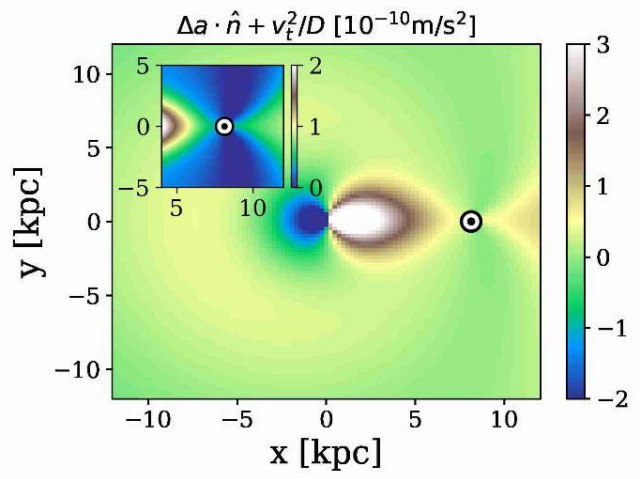
line-of-sight



perspective



total

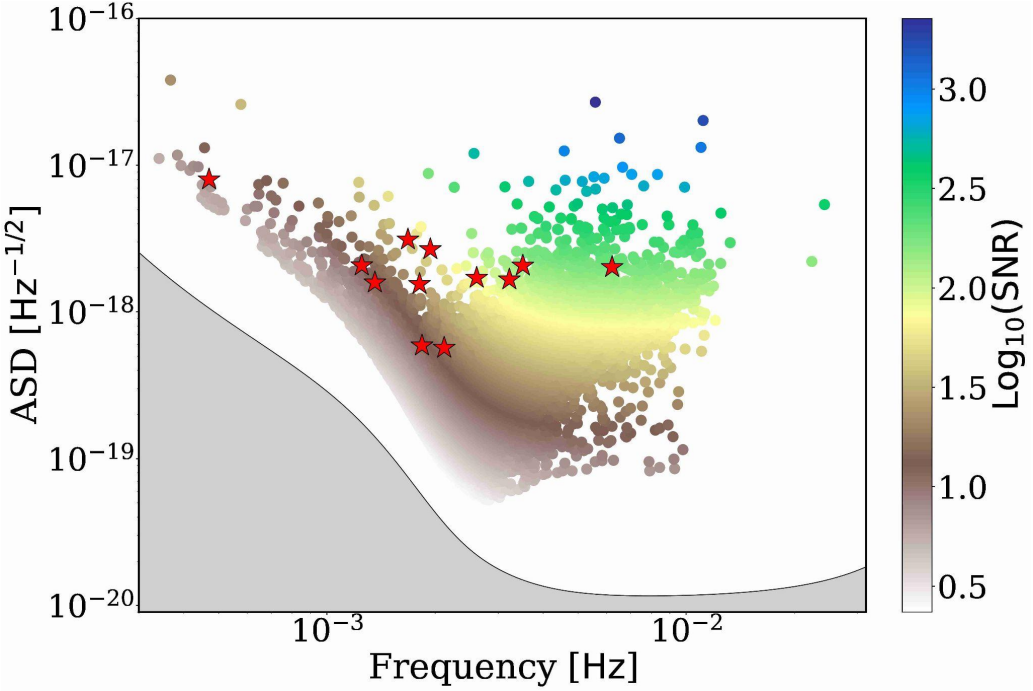


Goal: Mapping the Milky Way's Gravitational Potential

- Galactic accelerometry:
  - Velocities of stars [e.g. Silverwood & Easther 2018]
  - Pulsar timing [Phillips et al. 2020; Donlon et al. 2024; Arora et al. 2024]
  - Double white dwarfs in LISA: this work

Why DWDs?

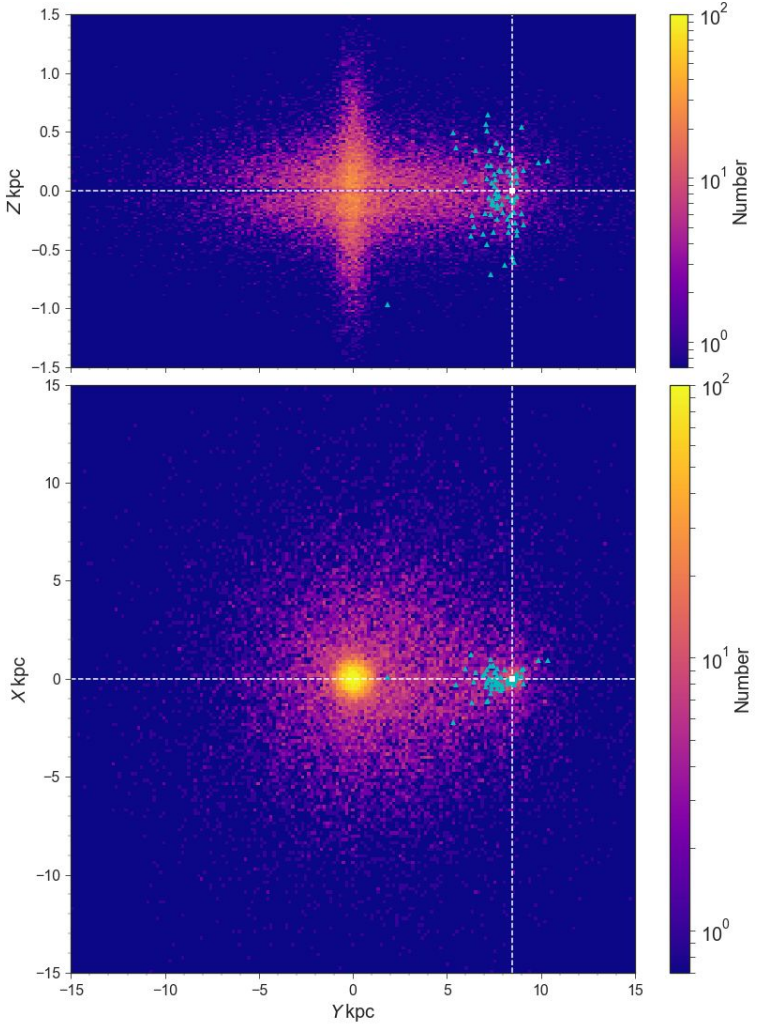
- The sheer number to be detected by LISA: ~10,000
- Throughout the Galaxy (even behind the Galactic Center!)



Synth population: [Thiele et al., 2023]

Example: Number counts

parameters of the disk and halo $\Leftarrow$



[Korol et al., 2018]

Why DWDs?

- One one hand: individual CoM accelerations must be small
- On the other hand: the accelerations are correlated
- Can we exploit that correlation to reduce the measurement error?

Are GW observations enough?

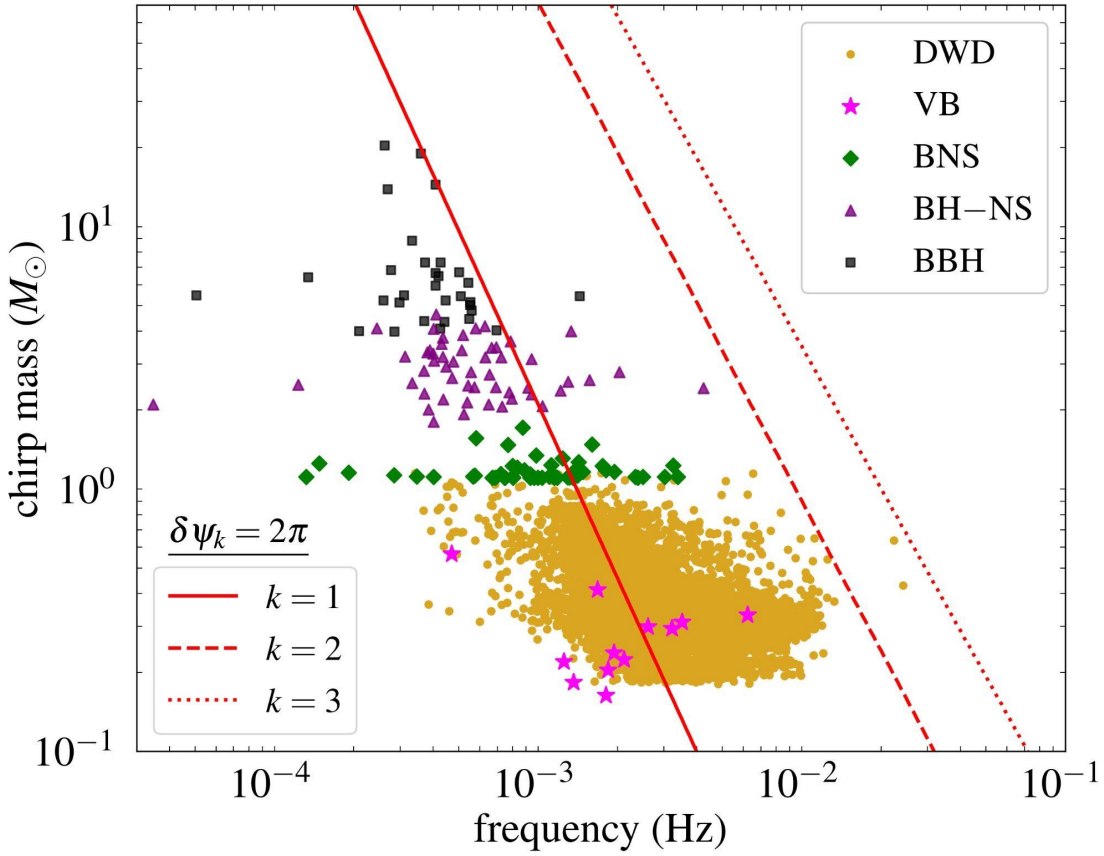
emitted: $$f_{\rm s}(\tau) = f_{\rm s0} + \dot{f}_{\rm s0}\tau + \ddot{f}_{\rm s0}\tau^2/2 + \dots$$

observed: $$f(t) = f_0 + \dot{f}_0 t + \ddot{f}_0 t^2/2 + \dots$$

degeneracy: $$\dot{f}_0 = \dot{f}_{\rm s0} - a f_{\rm s0}$$

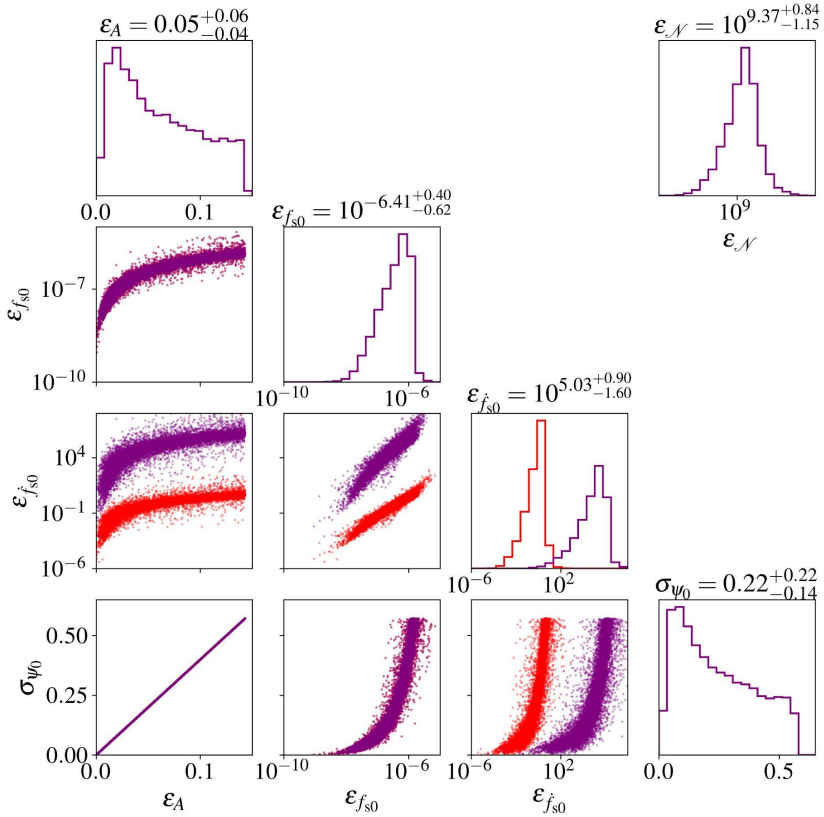
$$\ddot{f}_0 = ?$$

Are GW observations enough?



Synth population: [Thiele et al., 2023]

Are GW observations enough? No.



Correlations

$$a \to \mathcal{N}$$

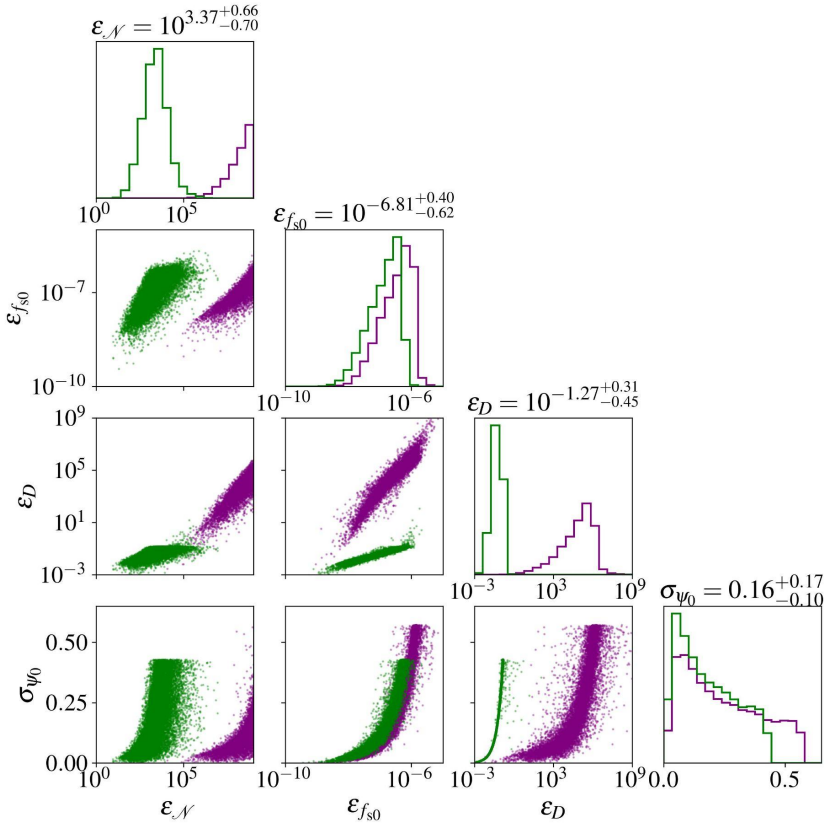
$$\Phi = \mathcal{N}\Phi_{\rm model}$$

(grav potential)

Improvement

$$\propto 1/\sqrt{n} \sim 10^{-2}$$

Can EM observations help? Yes!



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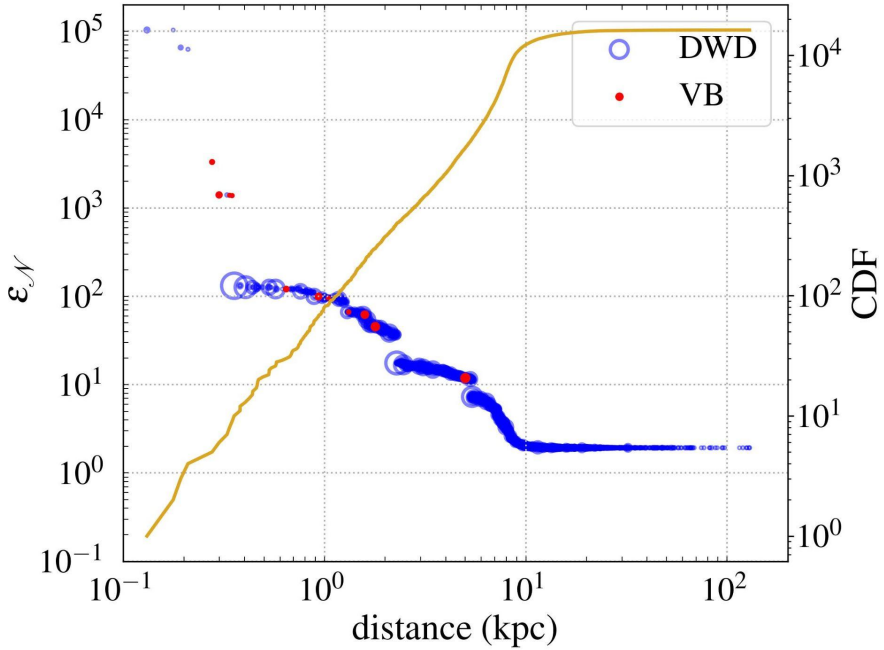

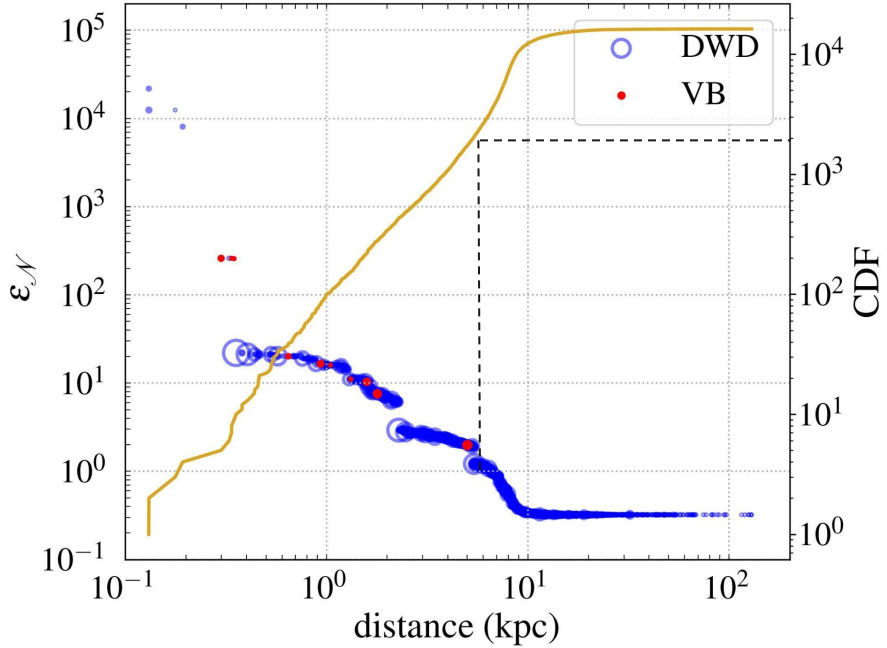

Conclusion

- Multimessenger effort: indispensable for Galactic accelerometry with LISA DWDs
- “Salami slicing” approach: improving the measurement by incremental steps
- Systematics: same as with other techniques (perspective acc contribution, tertiary perterbers, etc.)

“coin clipping” [nofreelunch.co.uk]