Time dependent Extreme Mass Ratio inspiral rate in (anisotropic) Nuclear Star Clusters

PRESENTED BY:

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Collaborating with

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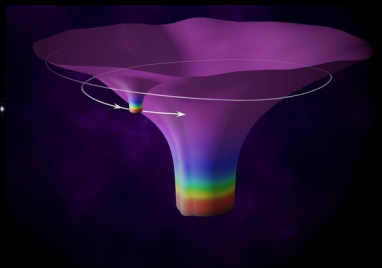
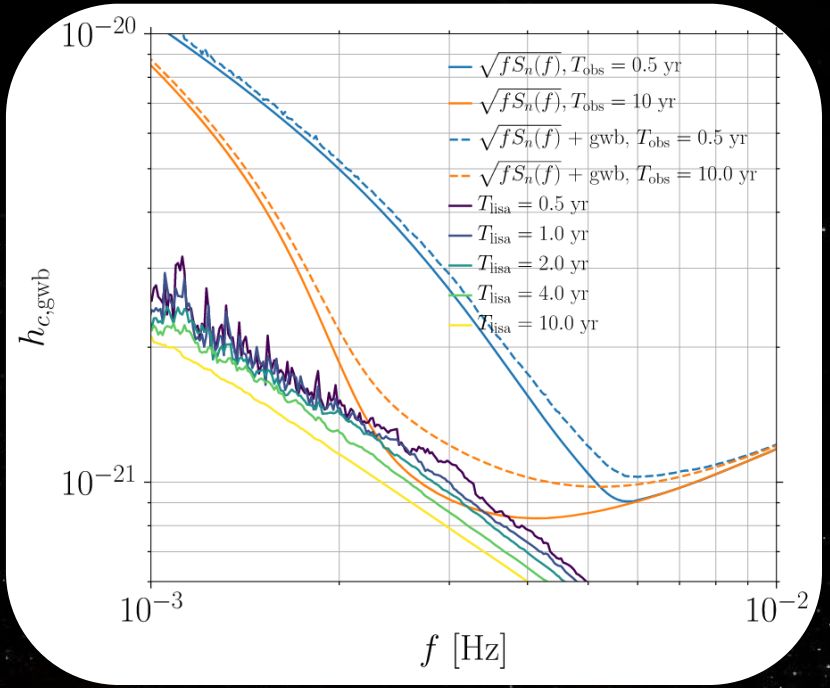
Lisa AstroWG 2024

EMRIs in LISA





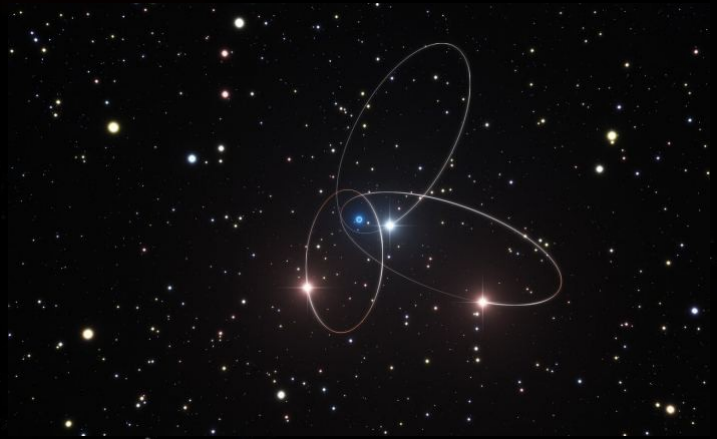
Credit: Bonetti & Sesana 20

- Many simultaneous sources.
- What is their distribution at formation?

Ubiquitous formation channel: Nuclear Star Clusters

Motion in nuclear clusters

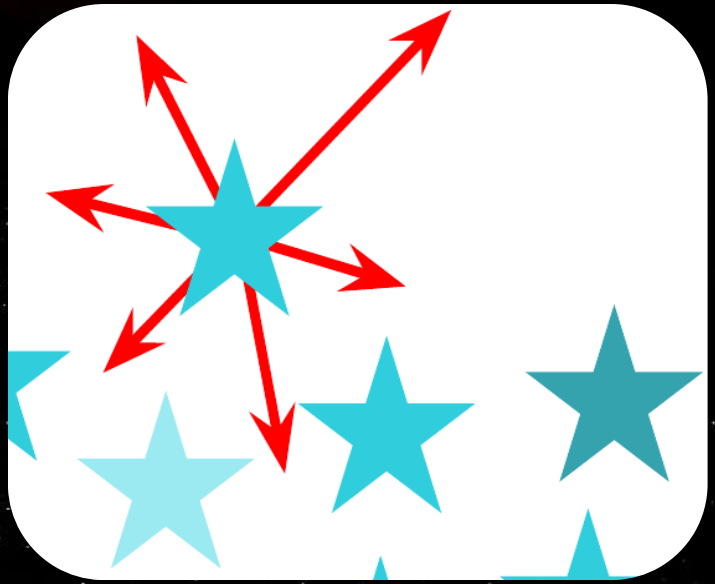
1. Stellar objects move in the potential of the system (stars + central Black Hole)



Credit: ESO/M. Parsa/L. Calçada
Artist Impression

Motion in nuclear clusters

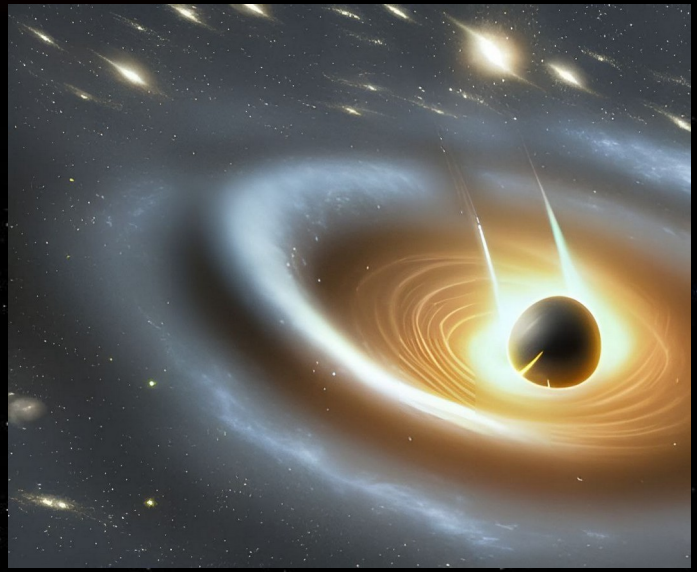
1. Stellar objects move in the potential of the system (stars + central Black Hole)
2. But they are perturbed by close interactions with other stellar objects



Credit: Bortolas

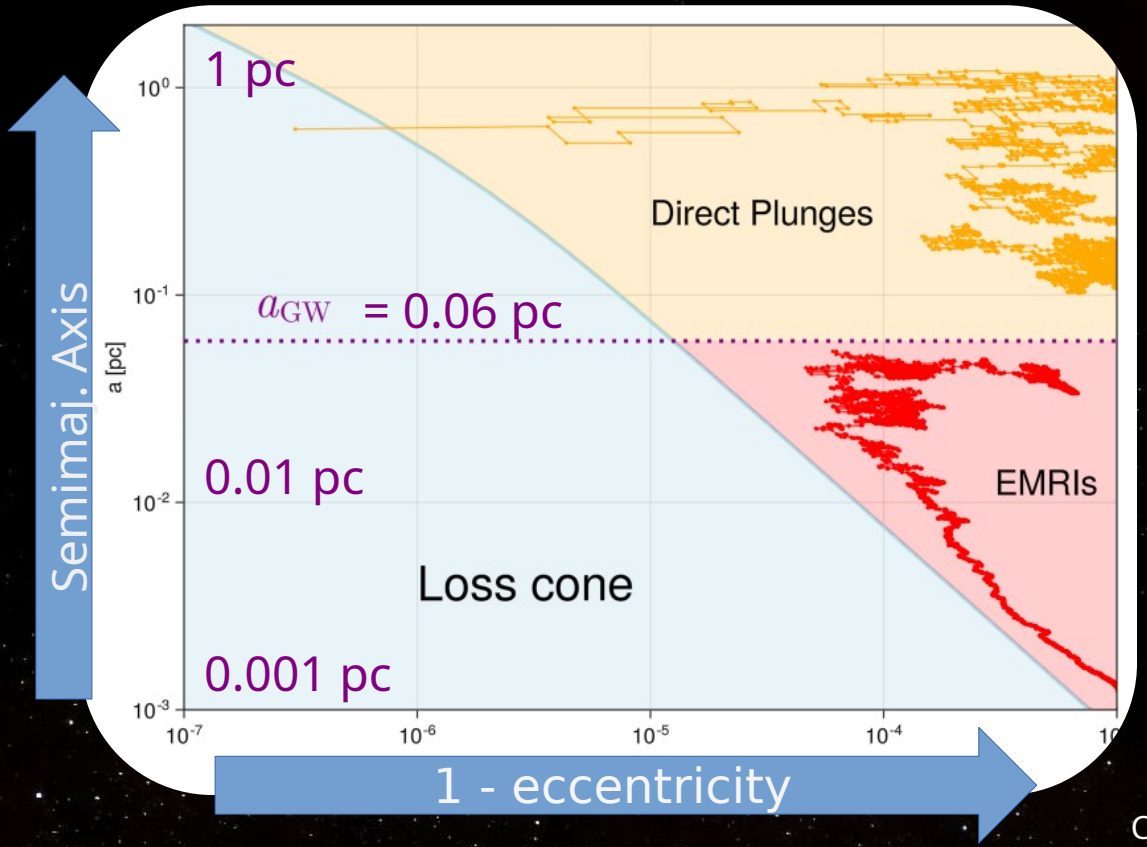
Motion in nuclear clusters

1. Stellar objects move in the potential of the system (stars + central Black Hole)
2. But they are perturbed by close interactions with other stellar objects
3. And sometimes they pass too close to the central Black Hole



Credit: Stable Diffusion AI
AI fantasy

STOCHASTIC 2-BODY RELAXATION



- A compact object can result in
  - Direct Plunge
  - Extreme Mass Ratio Inspiral (EMRI)

  Based on the effects of General Relativity.
- Stars, on the other hand, generally result in a tidal disruption event (TDE).

Credit: Davide Mancieri

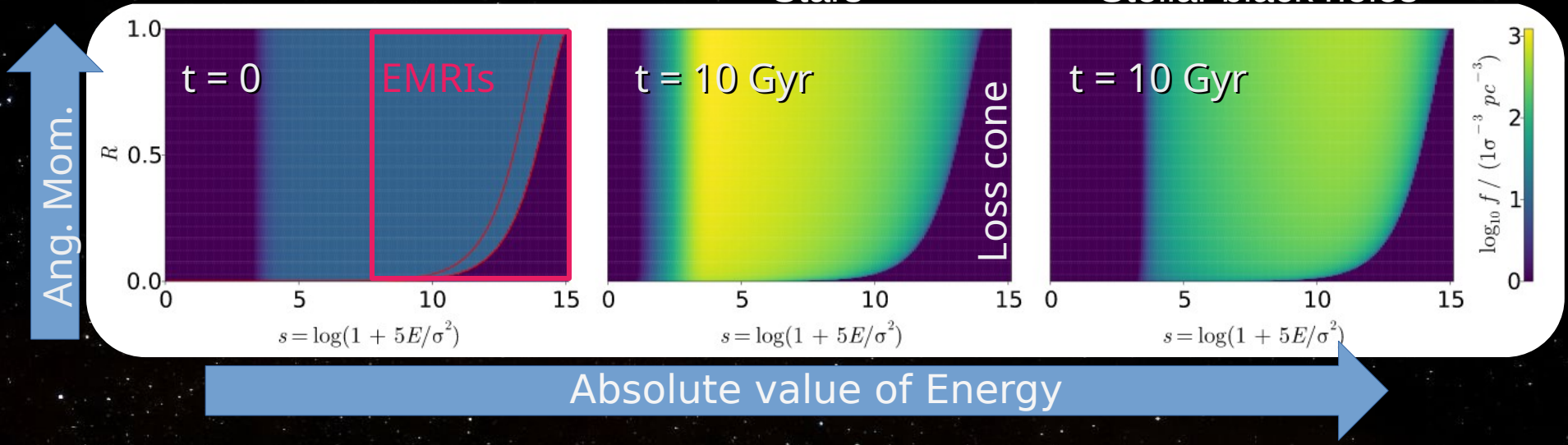
Orbit averaged Fokker Planck

J

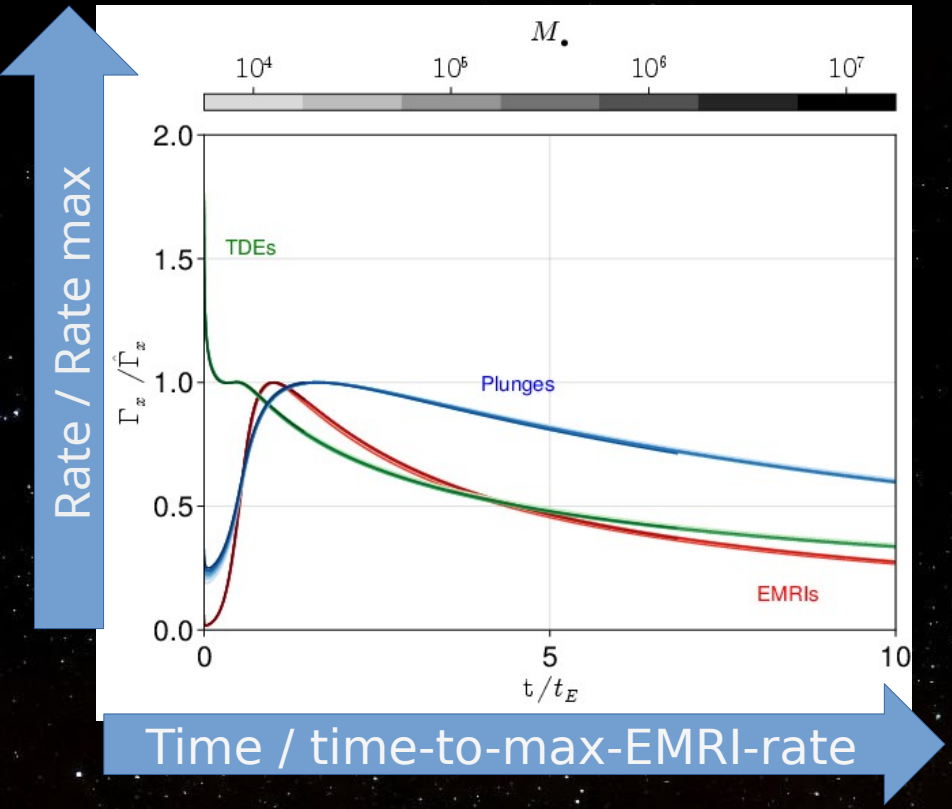
juliafokkerplanck

Project ID: 35847015

Our **public code** to solve the complete Fokker Planck evolution in time



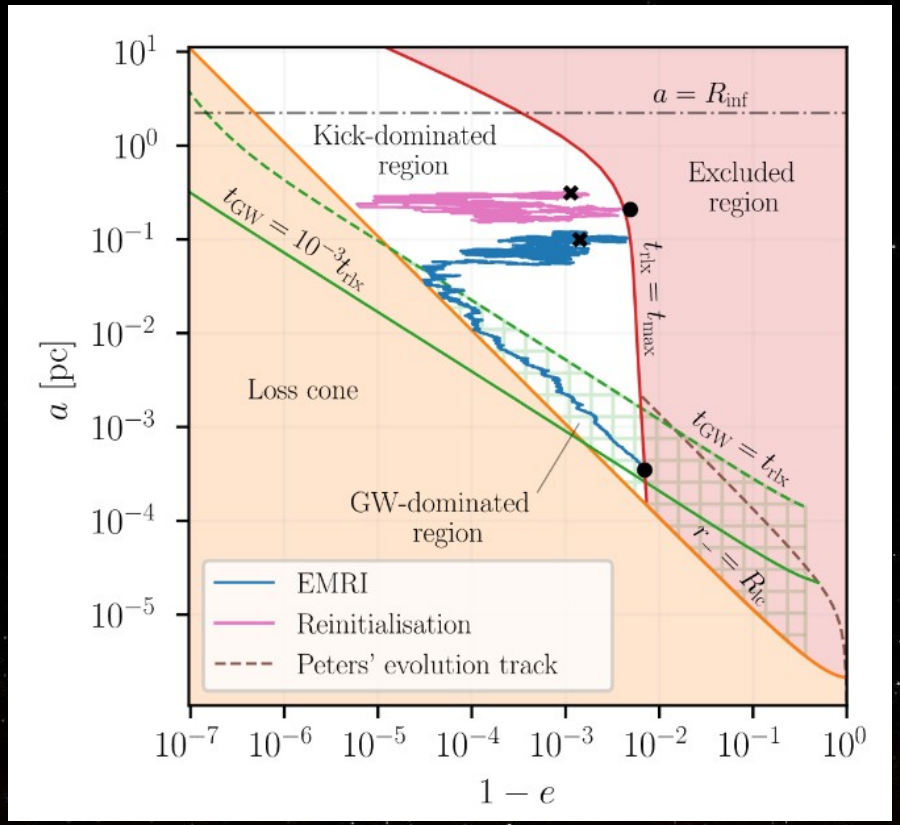
SELF SIMILAR → SCALING RELATIONS



- The trend of Direct Plunges, EMRIs and TDEs can be rescaled to self-similar trends

- This reflects in the emergence of power-law trends of related quantities: number of events, peak rates, time-to-peak.

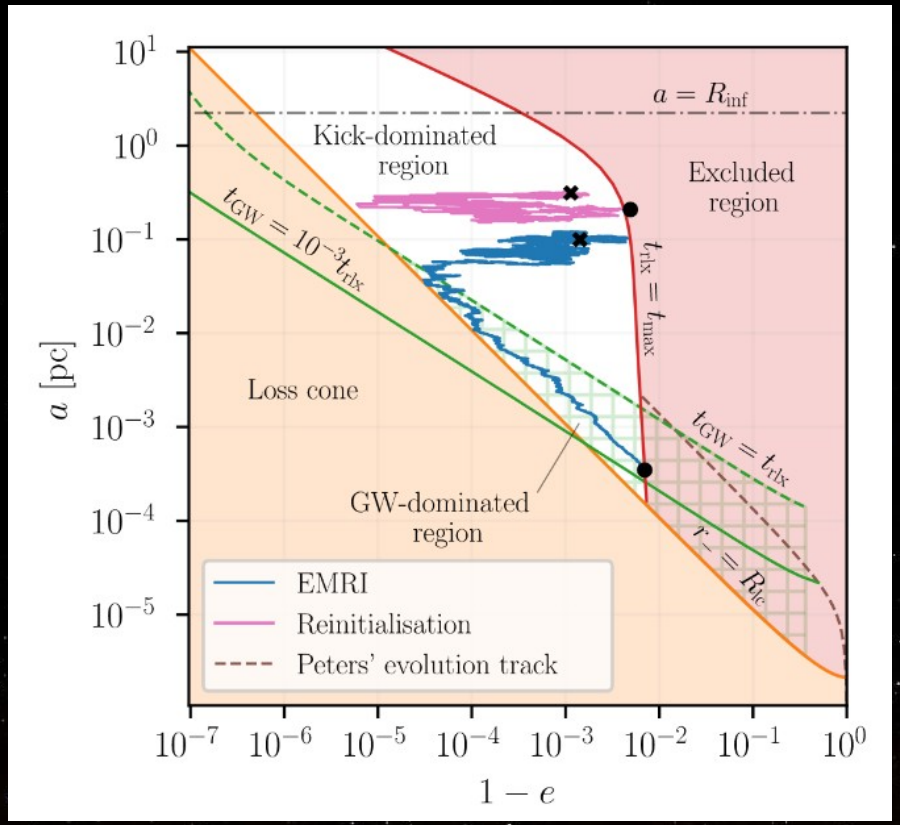
CURRENT STATE



- At the moment we compute the rate of EMRIs crossing the green line.

Mancieri+ 2024

Current state



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- Coalescence time can be very large.

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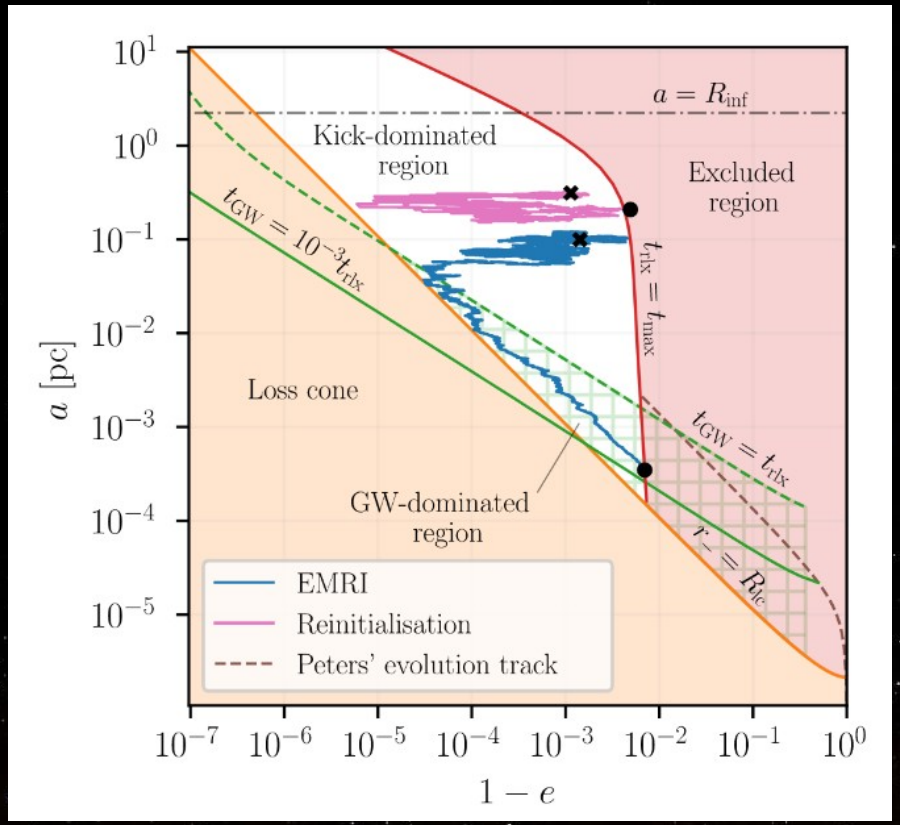
CURRENT STATE



- At the moment we compute the rate of EMRIs crossing the green line.
- Coalescence time can be very large.
- New relevant phenomena (see Davide Mancieri's talk) cannot be included.

Loss cone physics is intrinsically hard to use for EMRIs as it is

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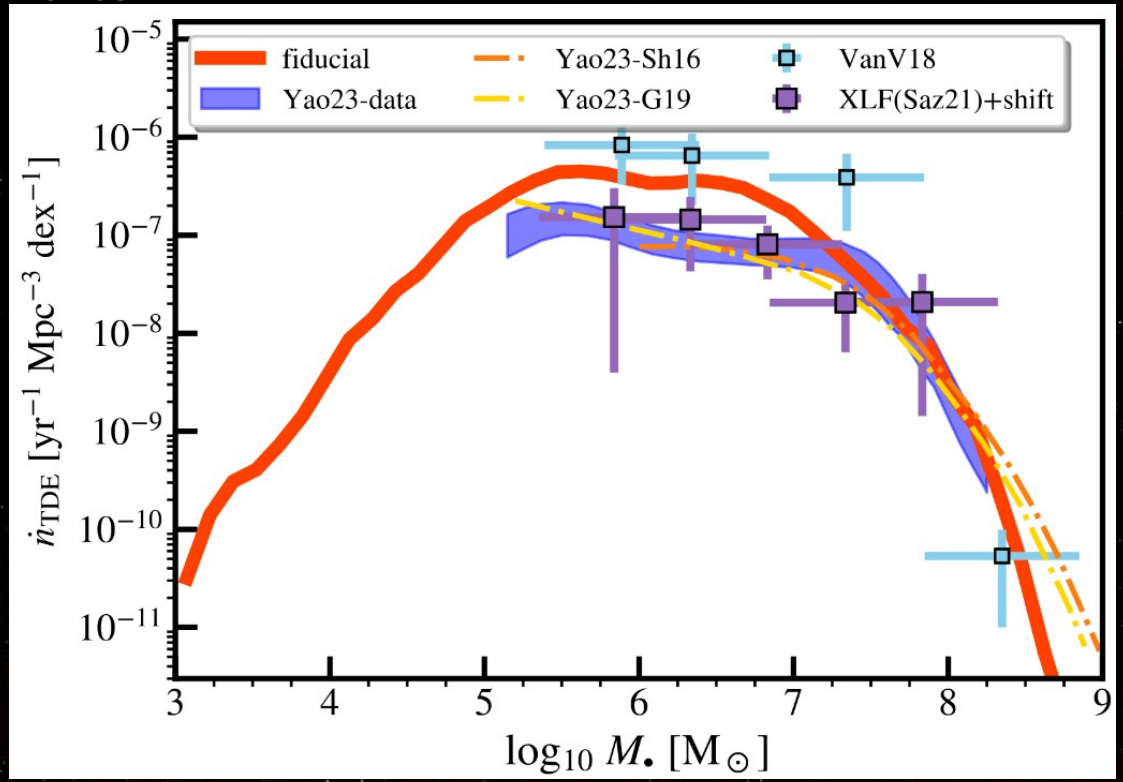
TARGET

Polkas + **LB 24**



Computation of the rate of loss cone events that we expect to detect, especially EMRIs by LISA.

Example: inclusion of 1D TDE rates in

L-GALAXIES

Izquierdo-Villalba+ 2020, 2022

- EMRIs have a stochastic formation channel in Galactic Nuclei fueled to two-body encounters
- You can model it in a Fokker-Planck model, (and we provide a code to work with it).
- The rate of EMRIs requires a more detailed treatment of loss cone physics
- Relation between the number of EMRIs, TDEs, DPs
- These ingredients will be crucial to directly relate LISA observations with models

THANKS FOR YOUR ATTENTION!