CATCHING BLACK HOLES WITH TIDAL DISRUPTION EVENTS

Martina Toscani

3rd year PhD student at University of Milano

Image credits: Martina Toscani

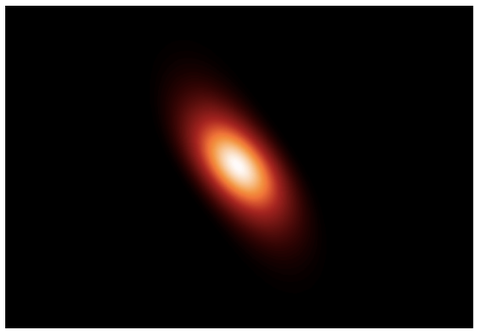
Gravitational waves: a new way to explore the Universe
Paris, March 1st-April 9th 2021

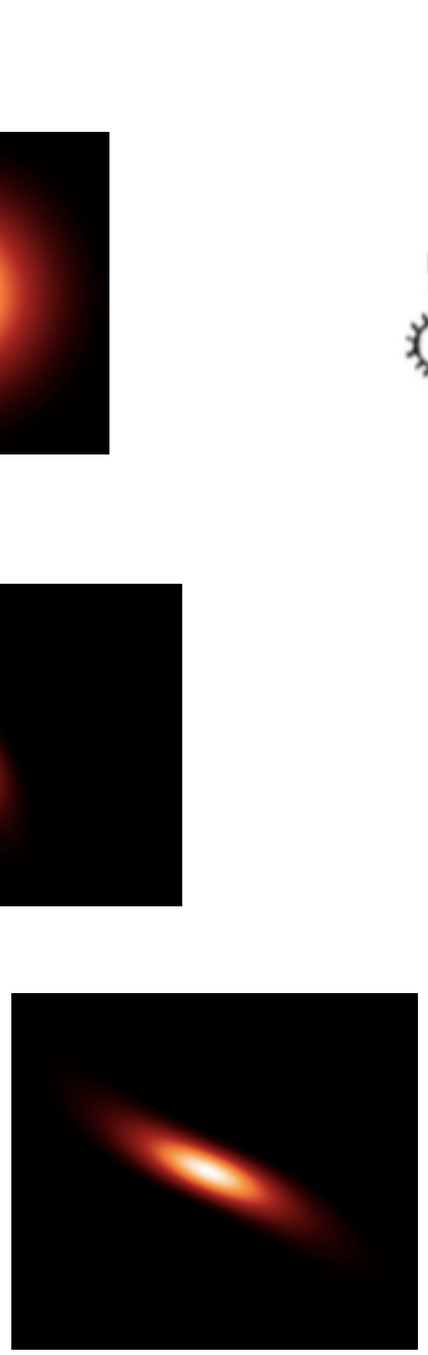
Supervisors: Rossi E.M. (UniLei) & Lodato G. (UniMi)

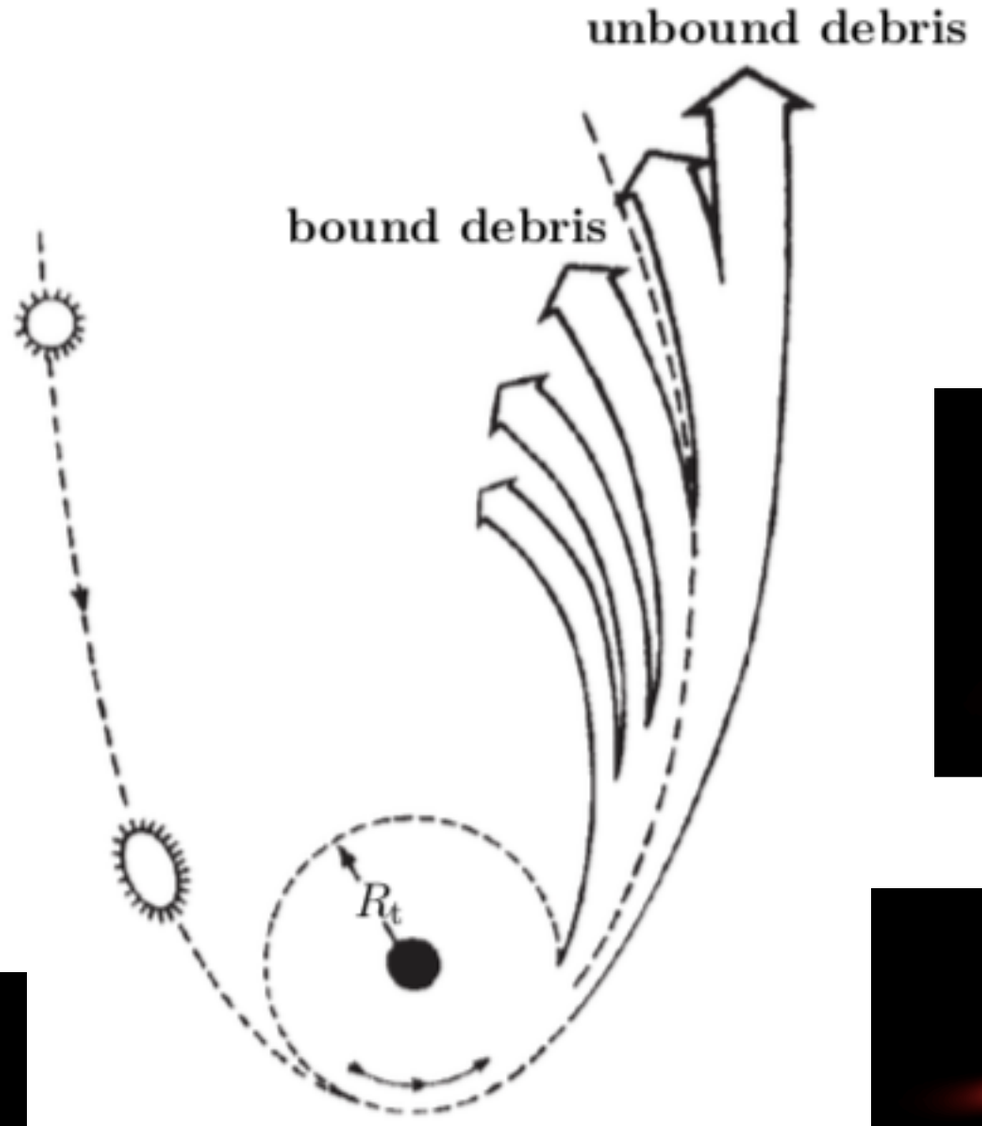
Collaborators: Price D.J. (MOCA), Pfister H. (DARK-HKU), Tiengo A. (UniPv), Esposito P. (UniPv)

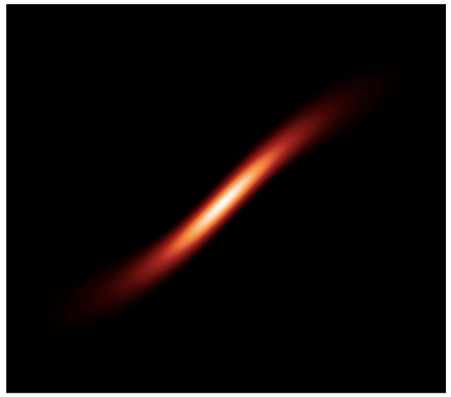
What are Tidal Disruption Events (TDEs)?

Luminet, Carter, Rees, Frank, Phinney









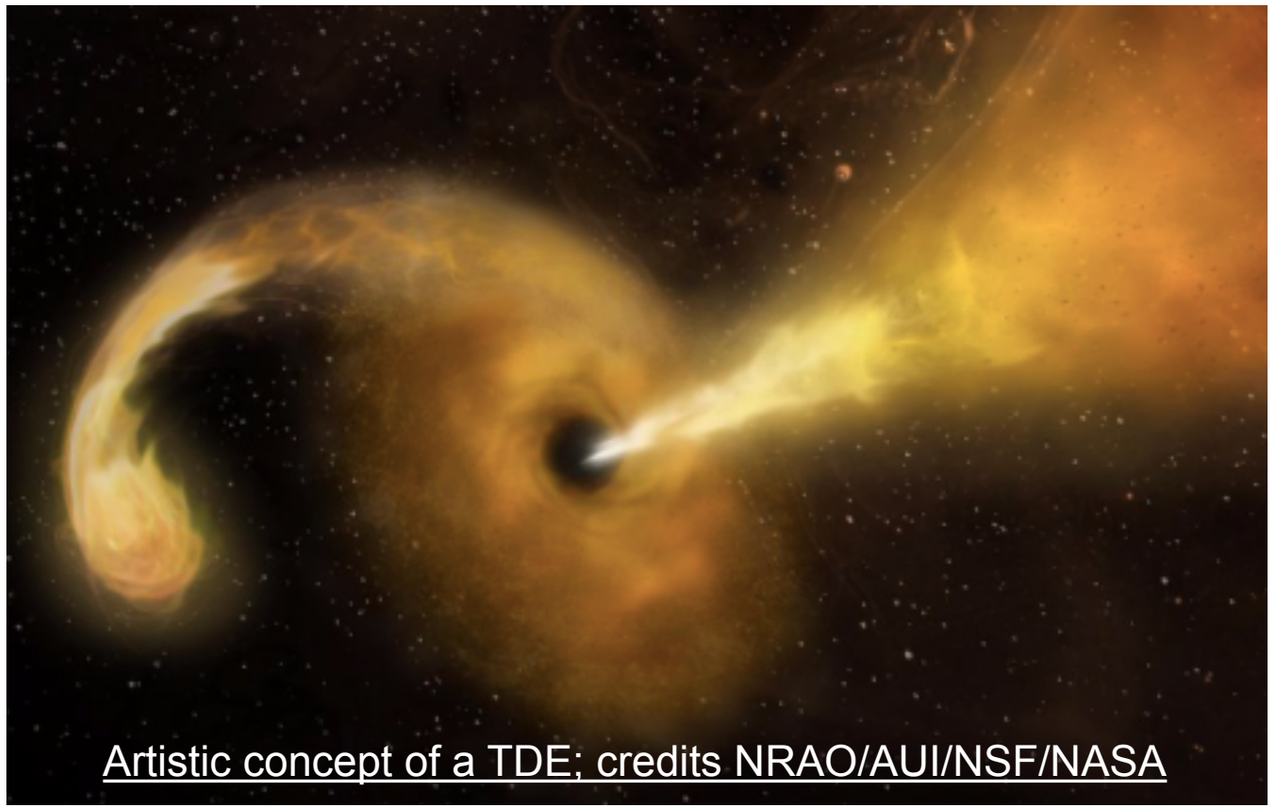
TDE sketch: Rees 1988 (re-adapted)
TDE snapshots: Toscani et al. in prep.

Recent reviews: Rossi et al. 2020, Stone et al. 2020, Lodato et al. 2020

How can we see TDEs?

- debris falls back
- lightcurve $\propto t^{-5/3}$
- super-Eddington
- X-ray, optical and radio
- detected since 90s

see Lodato and Rossi 2011



Artistic concept of a TDE; credits NRAO/AUI/NSF/NASA

Recent reviews: Saxton et al. 2020, van Velzen et al. 2020, Alexander et al. 2020, Roth et al. 2020

with the accretion of material,
after the disruption,
TDEs can enlight **dormant** black holes

How can we see TDEs?

Gravitational wave (GW) emission from tidal disruptions

See for more about TDEs and GWs: Kobayashi et al. 2004, Guillochon & Ramirez-Ruiz 2009, Stone et al. 2013

Sun-like star disrupted by a $10^6 M_\odot$ BH at 20 Mpc

$$h \approx 10^{-22},$$

$$f \approx 10^{-4}\,\mathbf{Hz}$$

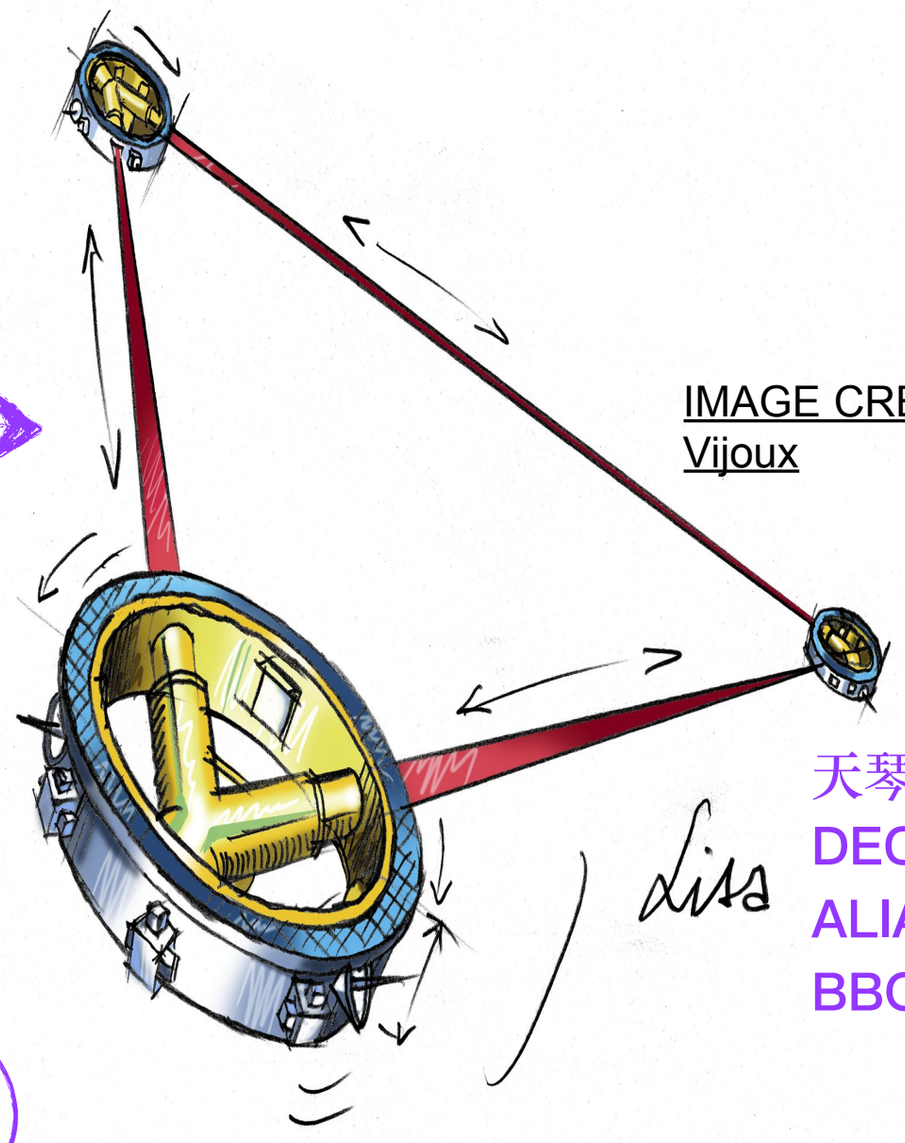


IMAGE CREDITs: ESA-C. Vijoux

天琴计划（TianQin）
DECIGO
ALIA
BBO

GWs from disruption
+
EM radiation from circularization

What is the GW signals from TDEs?

Toscani et al. in prep

SPH code with general relativity by Liptai and Price 2019

$$h^{\mathrm{TT}}(t,\mathbf{n}) \propto \ddot{M}^{\mathrm{kl}}$$

$$M^{\mathrm{kl}} = \frac{1}{c^2}\int d\mathbf{x} T_{00} x^{\mathrm{k}} x^{\mathrm{l}} \Rightarrow M^{\mathrm{kl}} = \sum_{\mathrm{a}} m_{\mathrm{a}} x^{\mathrm{k}}_{\mathrm{a}} x^{\mathrm{l}}_{\mathrm{a}},$$

M: inertia moment of the system

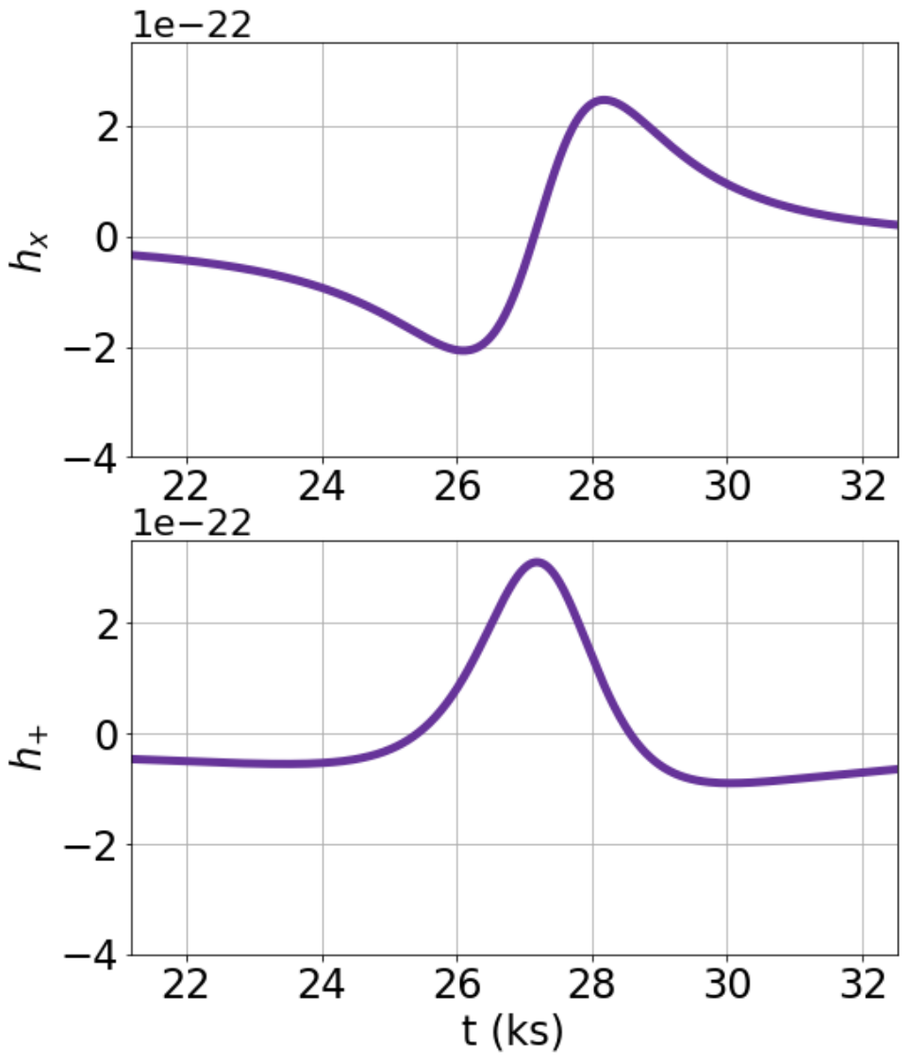
a: index that runs over the number of particles

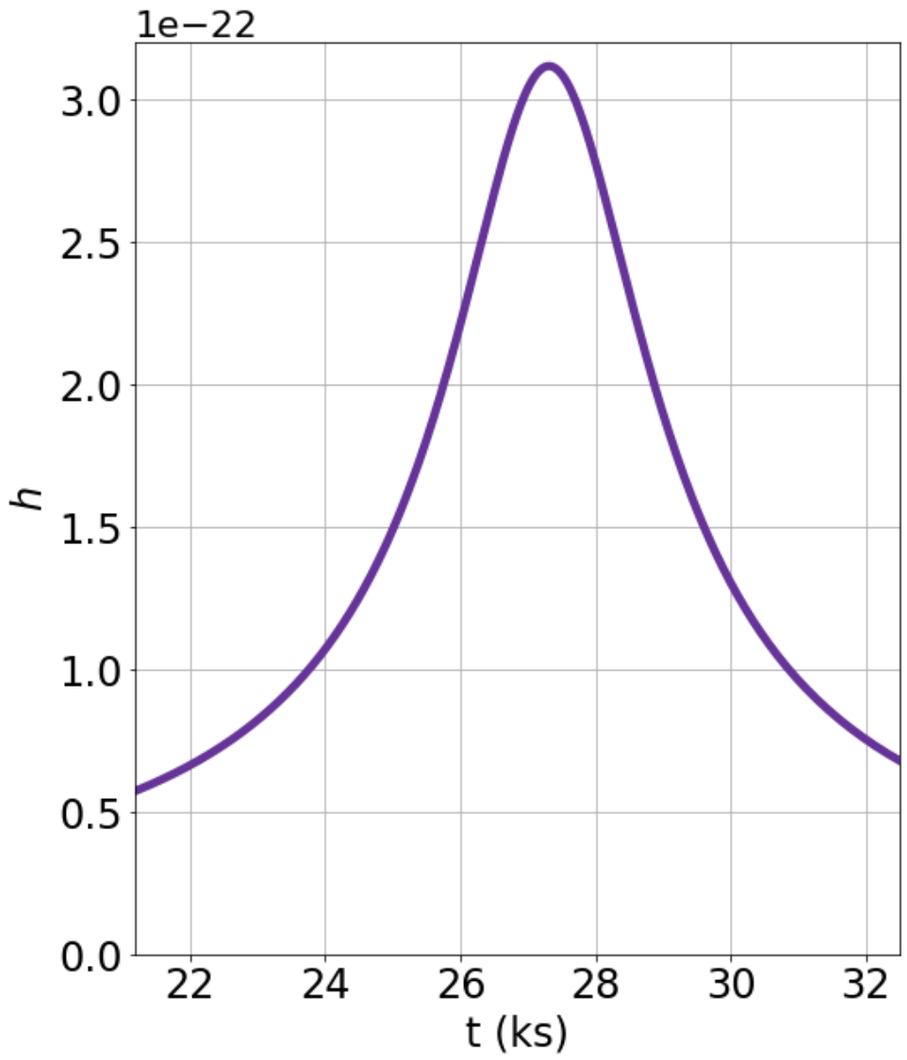
$$\ddot{M}^{\mathrm{kl}} = \sum_{\mathrm{a}} m_{\mathrm{a}} (\ddot{x}^{\mathrm{l}} x^{\mathrm{k}} + 2\dot{x}^{\mathrm{k}}\dot{x}^{\mathrm{l}} + x^{\mathrm{l}}\ddot{x}^{\mathrm{k}})_{\mathrm{a}}$$

$$h_+ \, h_\times, h$$

What is the GW signals from TDEs?

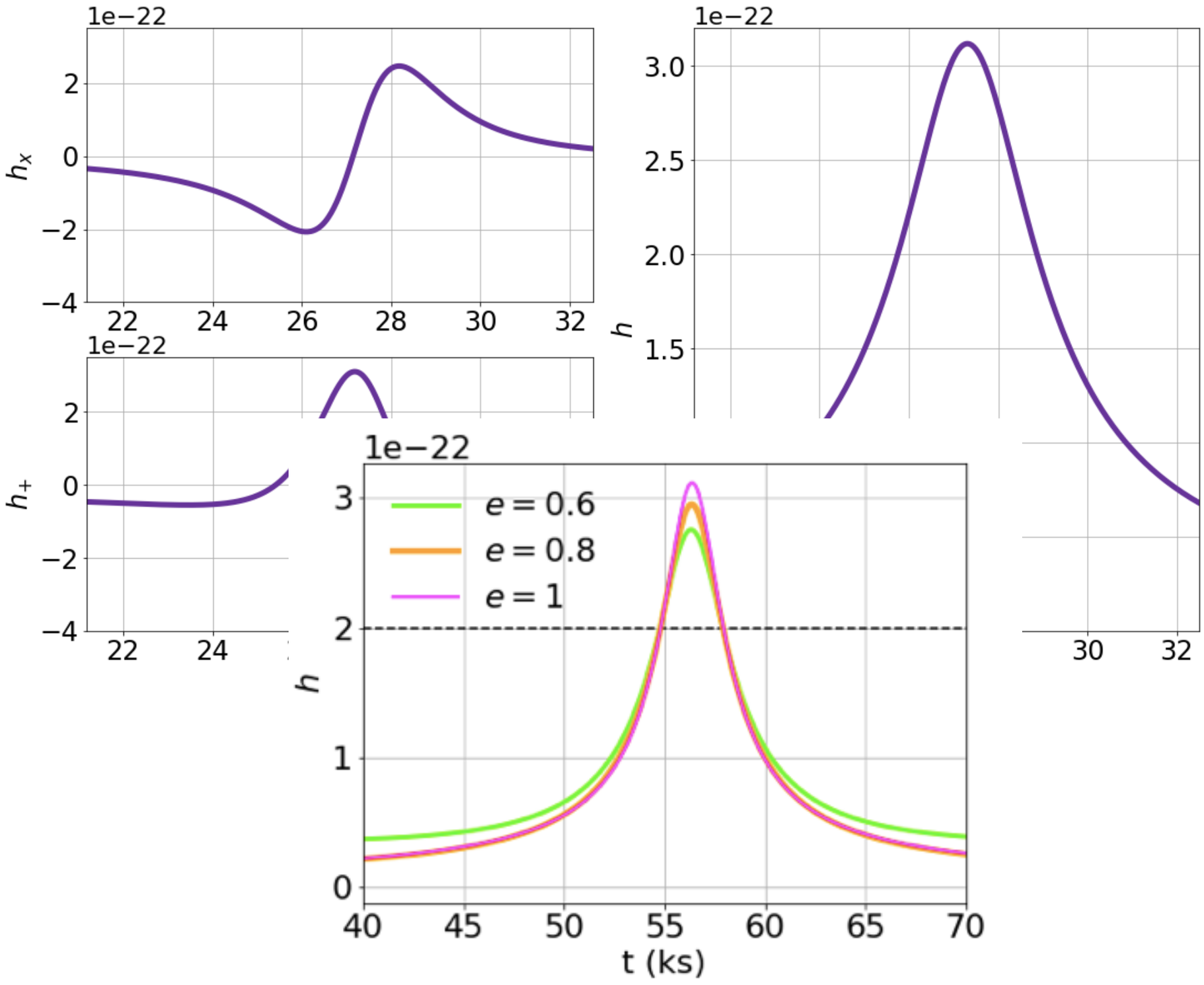
Toscani et al. in prep





What is the GW signals from TDEs?

Toscani et al. in prep



spanning all the parameters space

- eccentricity
- BH spin
- orbital inclination
- penetration factor

SOON available online for everyone

Building a GW wave catalogue !!

What is the GW background from TDEs?

GW signal from single TDE not very strong → unlikely single detection (at least for LISA)

Pfister et al. 2021 (submitted), already on the ArXiv (2103.05883)

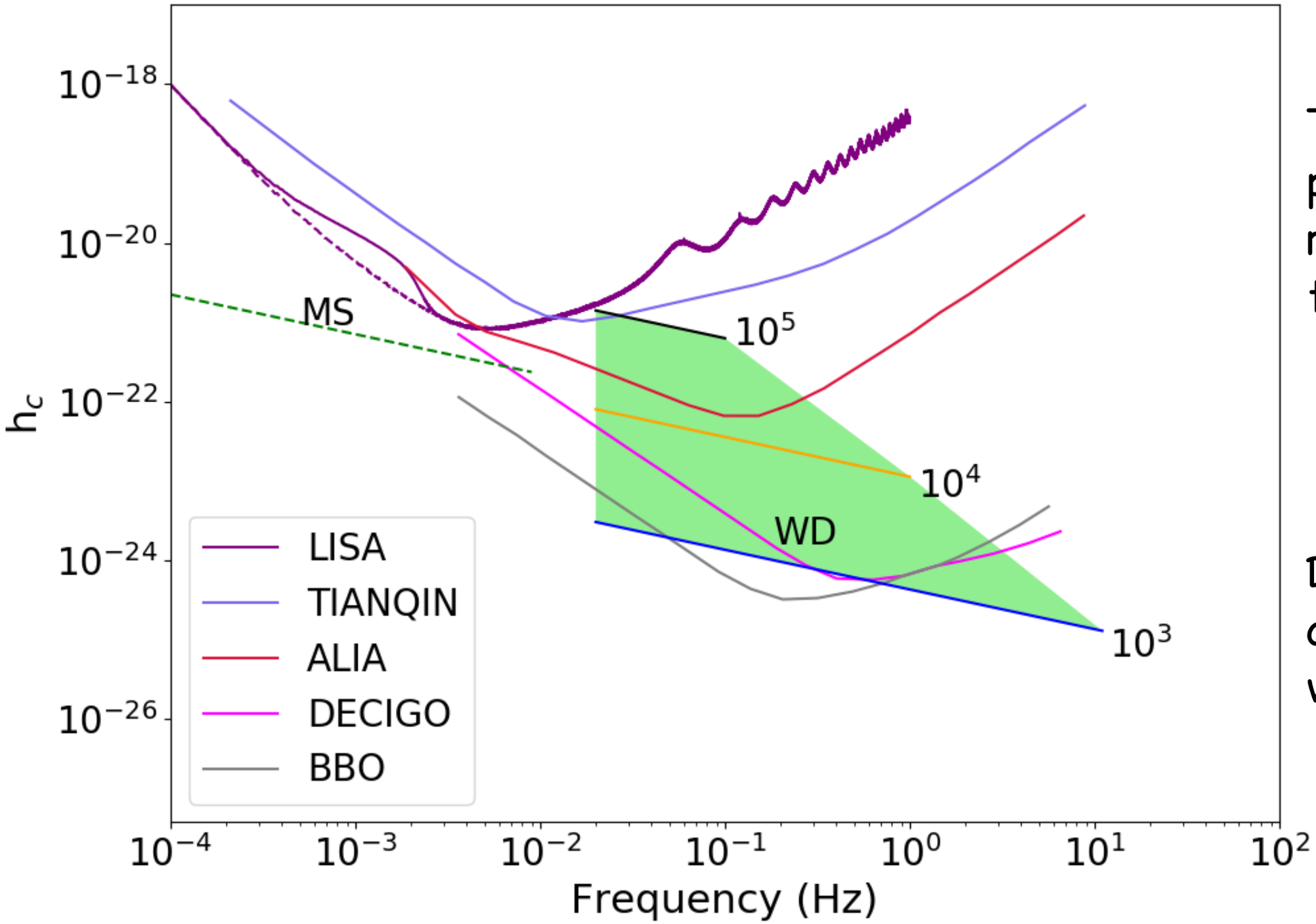
gravitational wave background from the entire population of TDEs

- nuclear TDEs
- globular TDEs

Toscani et al. 2020

What is the GW background from TDEs?

Toscani et al. 2020



TDEs of WDs promising to map IMBHs up to redshift 3

Deci-Hertz observatories will be crucial

Conclusions

TDEs → electromagnetic radiation → very luminous

electromagnetic radiation → lightcurve proportional to $t^{-5/3}$

TDEs → gravitational waves → GW catalogue online soon → reference for LISA, TianQin ...

gravitational waves → background promising source of information → Deci-Hertz observatories crucial

Thanks for your attention

Image credits: Martina Toscani

Merci pour votre attention