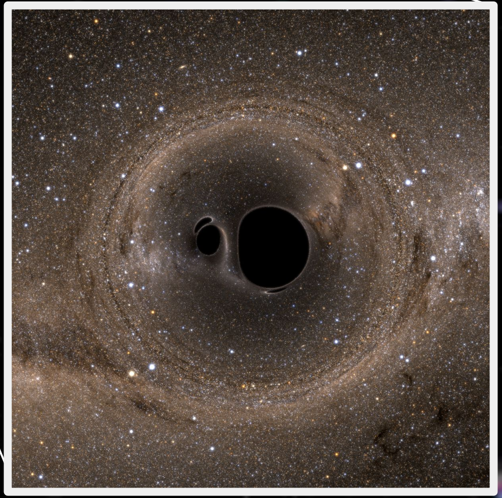
NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ
Faculty of Physics, Astronomy and Informatics

UNIVERSITÉ DE GENÈVE

Exploring galactic black hole binaries with LISA

Rafia Sarwar [1]

Collaborators:
Florian Giraud[2], Simone S. Bavera[2], *and* Tassos Fragos[2]



[1] Institute of Astronomy – Faculty of Physics, Astronomy and Informatics, *Nicolaus Copernicus University*, Toruń, Poland.
[2] Departement d'Astronomie, Université de Genève, Chemin Pegasi 51, CH-1290 Versoix, Switzerland.

Formation channels of binary black holes:

Isolated binary evolution

Common envelope phase

e.g.
den Heuvel (1976), Tutukov & Yungelson (1993), Kalogera et al. (2007), Postnov & Yungelson (2014), Belczynski et al. (2016), Mapelli et al. (2017)

Chemically homogeneous evolution

e.g. Maeder (1987), de Mink et al. (2009), Mandel & de Mink (2016), Marchant et al. (2016)

Stable mass transfer

e.g. van den Heuvel et al. (2017), Pavlovskii et al. (2017), Inayoshi et al. (2017)

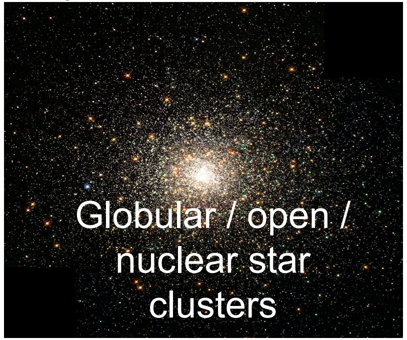
AGN-disks

e.g. Antonini & Perets (2012),
Tagawa et al. (2020)

Pop - III

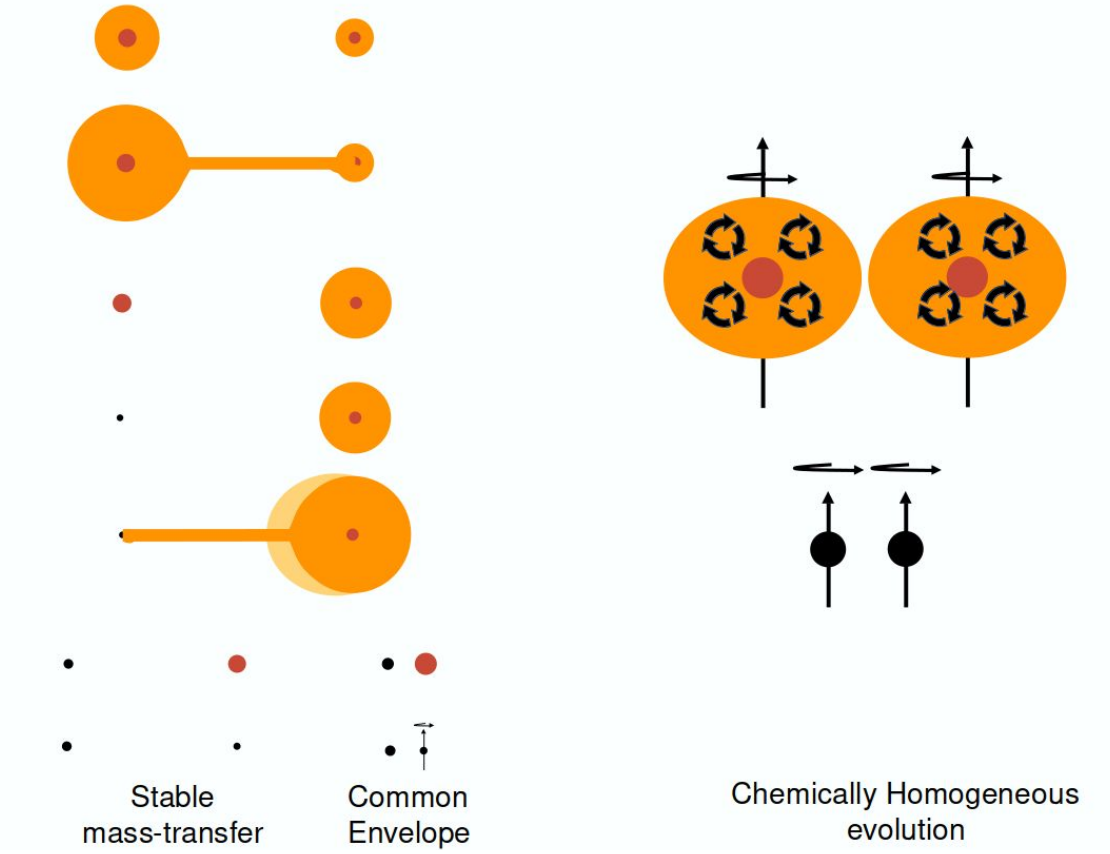
e.g. Inayoshi et al. (2017)

Dynamical formation

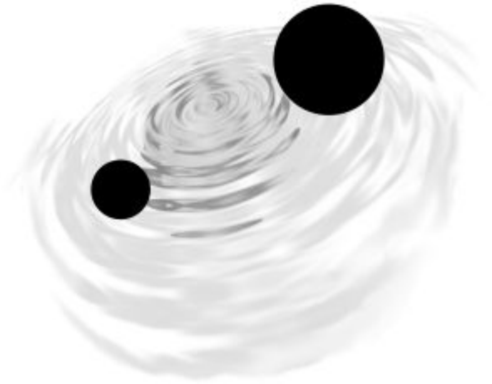


e.g. Sigurdsson & Hernquist (1993), Zwart & McMillan (2000), Miller & Lauburg (2009), Rodriguez et al. (2015), Antonini et al. (2016), Mapelli (2016), Askar et al. (2017)

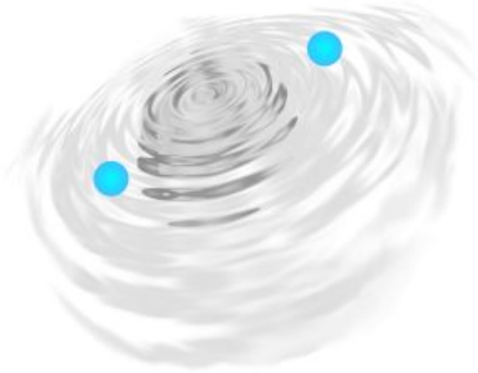
Formation channels of binary black holes:



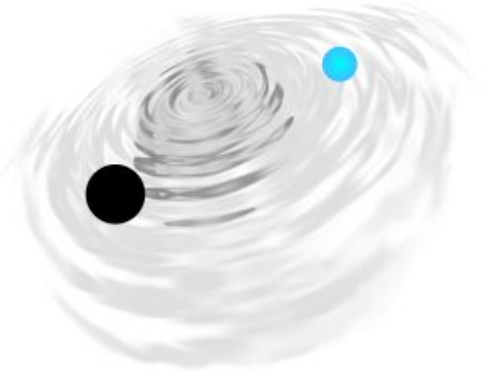
The Gravitational-Wave Transient Catalogue 2 (GWTC-2)



46-47
new binary black holes (BBHs)



1
new neutron star binary (BNSs)



1-2
new black hole-neutron star pair (BH-NS)

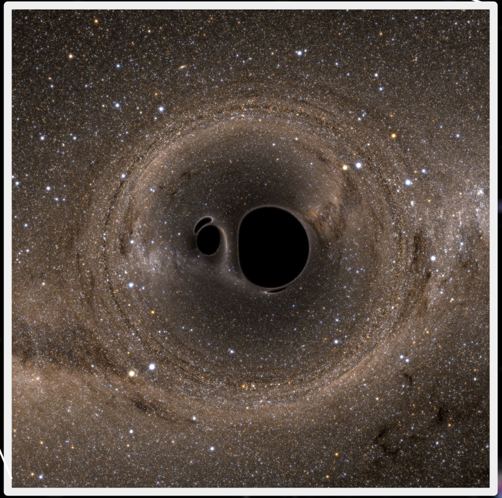
Abbot et al. arXiv: 2010.14527(2021)

Questions:

1. Have there been any merging black hole binaries in the Milky Way?

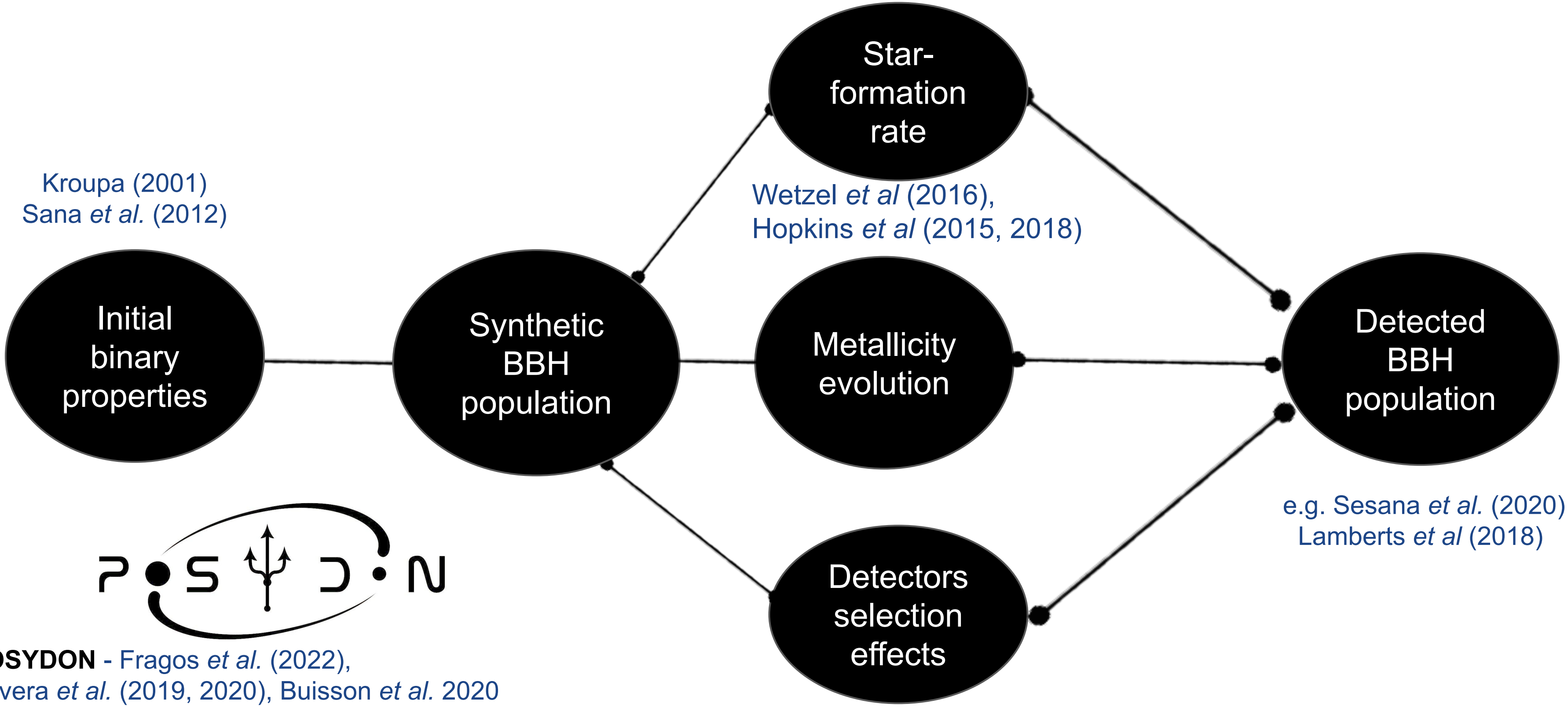
2. Can we find merging binary black hole in the Milky Way with LISA?

3. Do the properties of these binaries will enable us to distinguish between their formation channels?



Preliminary results

Predicting the properties of binary black hole population:



Kroupa (2001)
Sana *et al.* (2012)

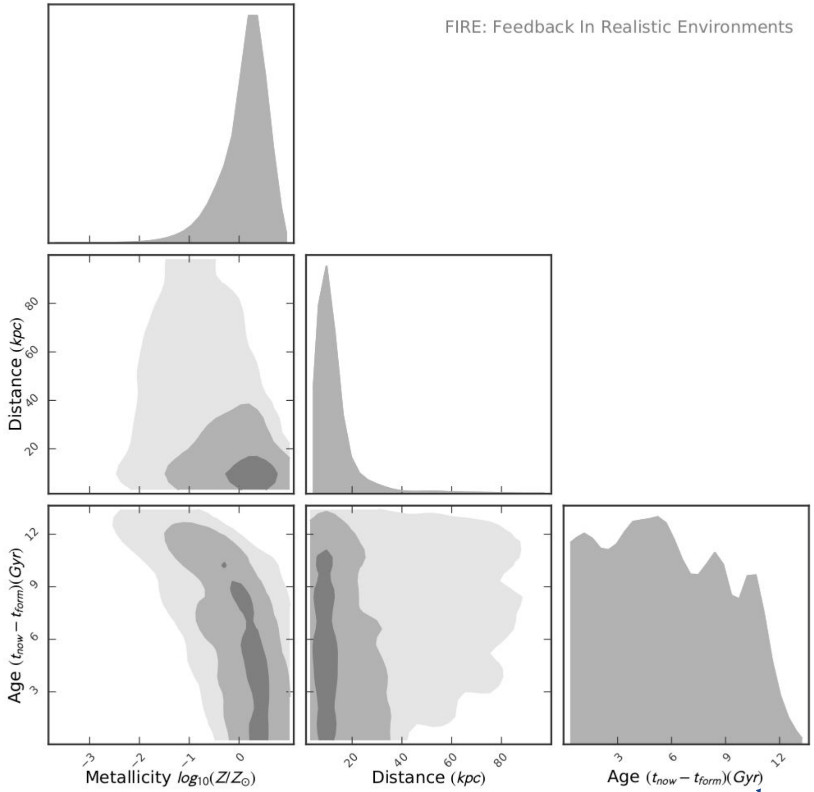
Wetzel *et al* (2016),
Hopkins *et al* (2015, 2018)

e.g. Sesana *et al.* (2020)
Lamberts *et al* (2018)

e.g. Sesana *et al.* (2016)
Gerosa (2019), Robson *et al* (2019)

POSYDON - Fragos *et al.* (2022),
Bavera *et al.* (2019, 2020), Buisson *et al.* 2020
COSMIC - Breivik *et al.* (2019)
MESA - Paxton *et al.* (2009, 2013, 2015, 2017, 2019)

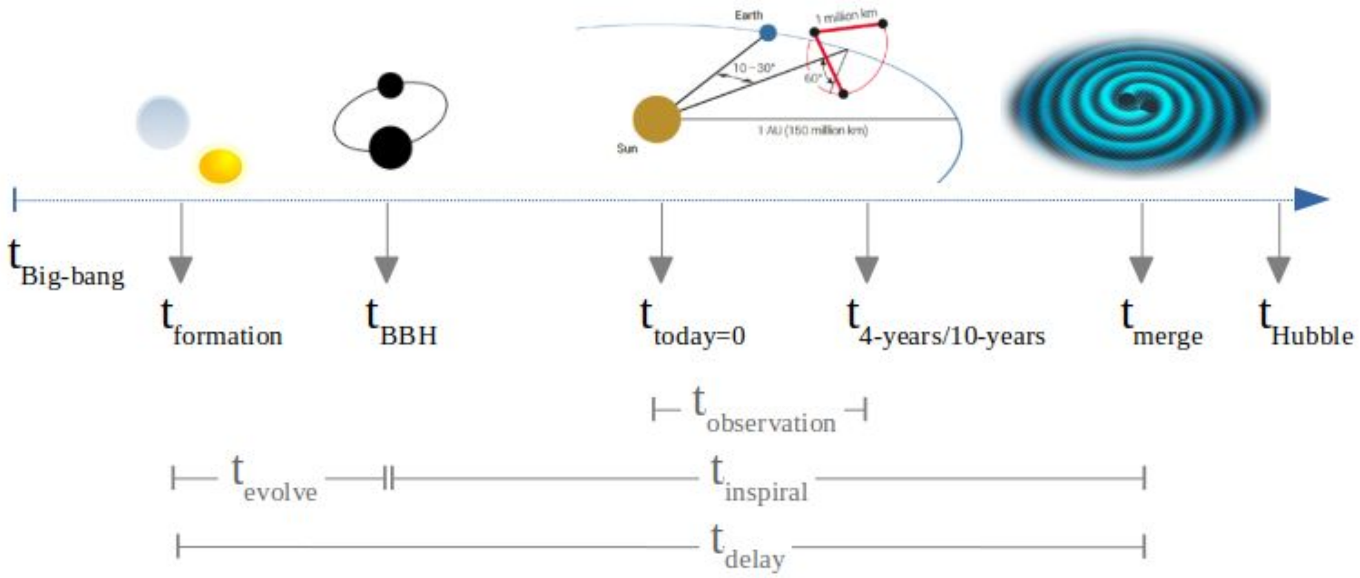
FIRE: Feedback In Realistic Environments:



Wetzel *et al* (2016)
Hopkins (2015)
Hopkins *et al* (2018)

https://fire.northwestern.edu/milky-way/

Conventional Timescales:



Questions:

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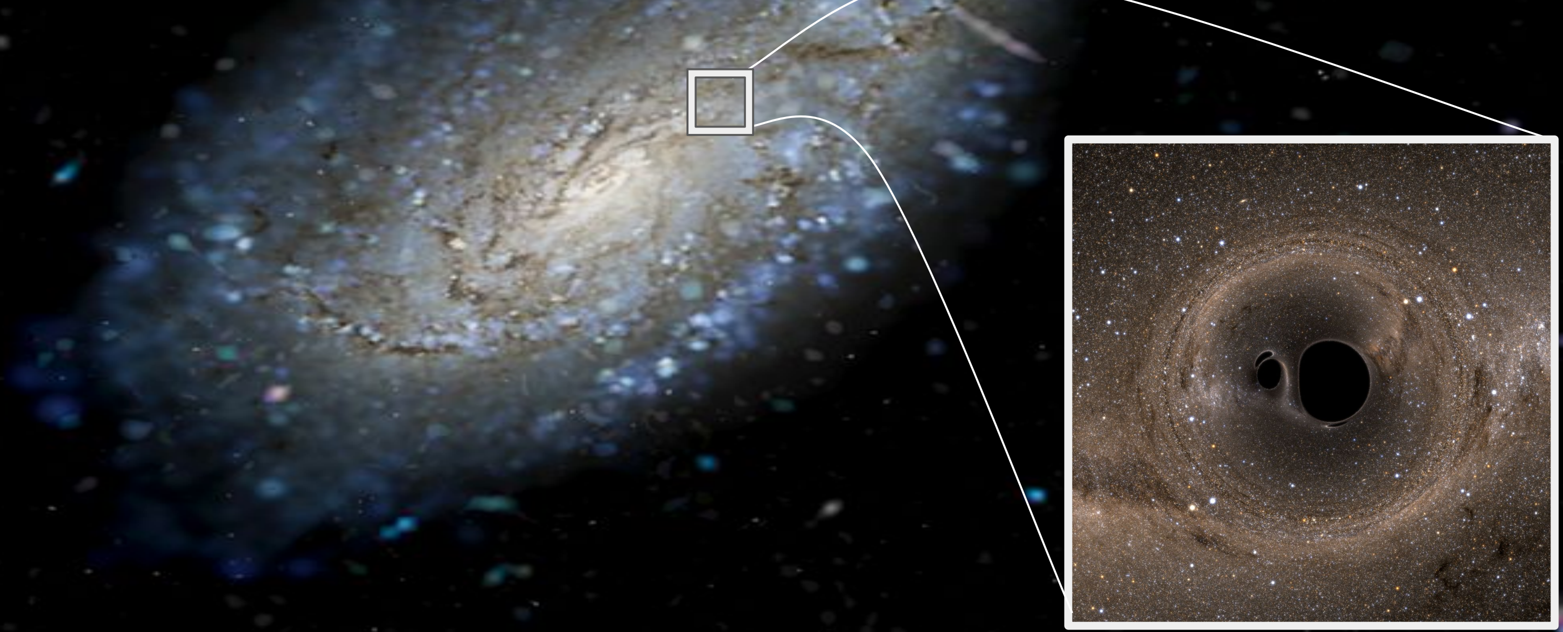
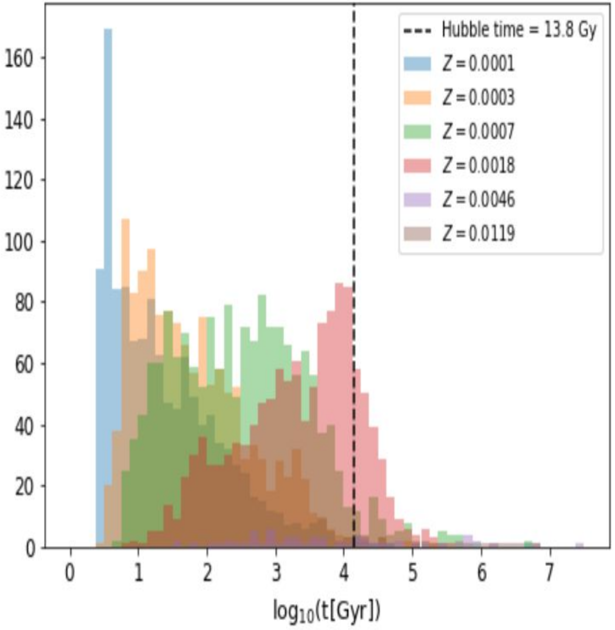
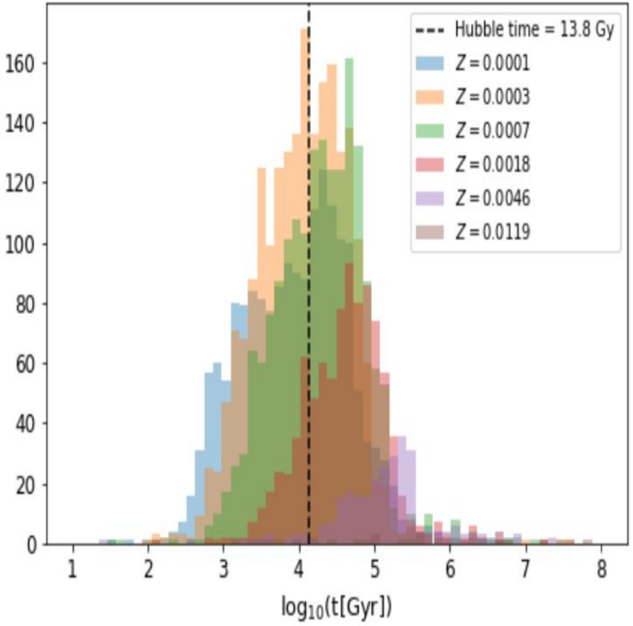


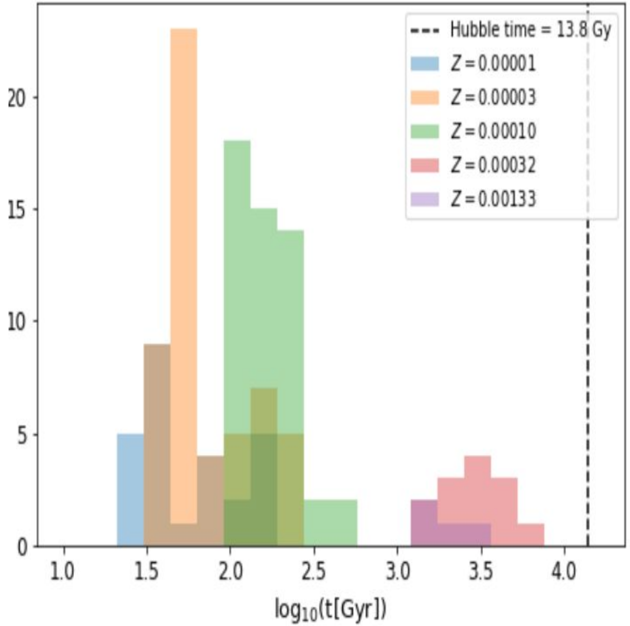
Metallicity dependent merger timescales:



Common Envelope

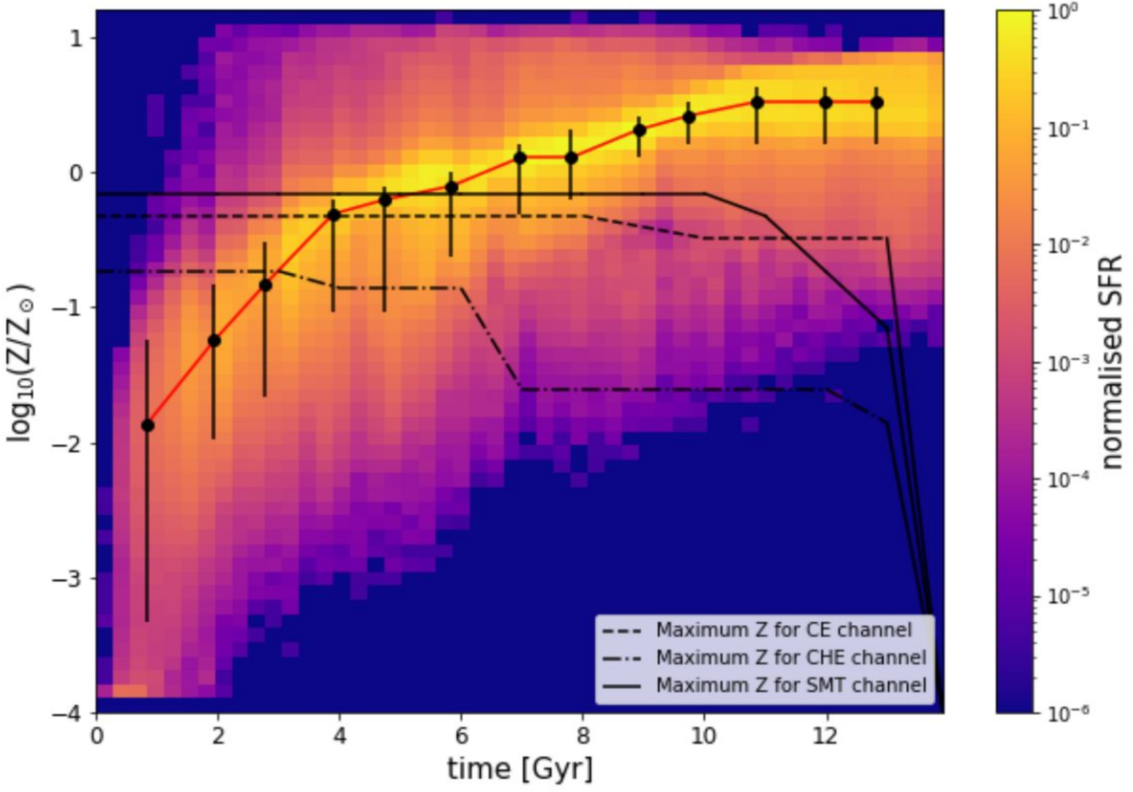


Stable Mass Transfer



Chemically Homogeneous Evolution

Star formation rate (SFR) of the Milky Way Galaxy:



Questions:

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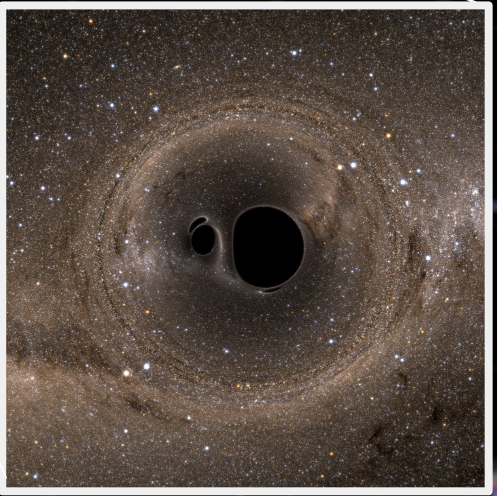
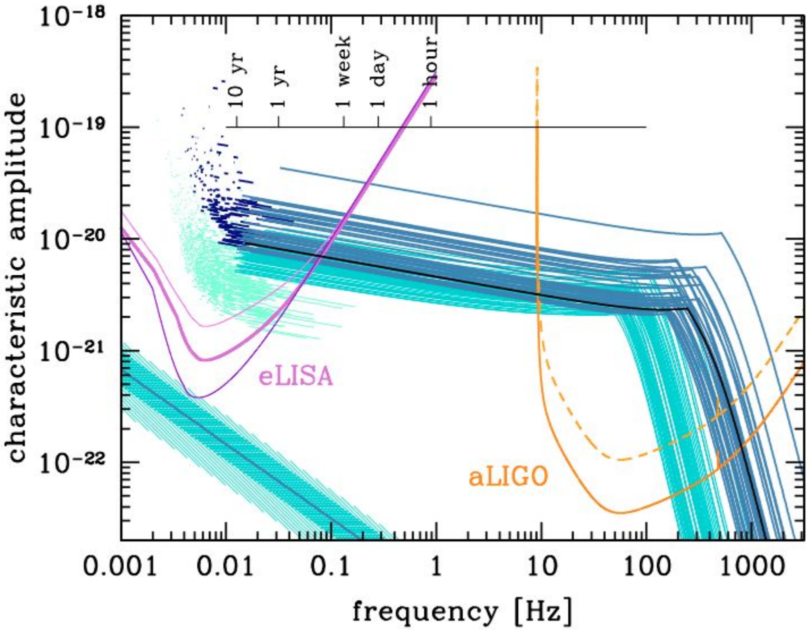
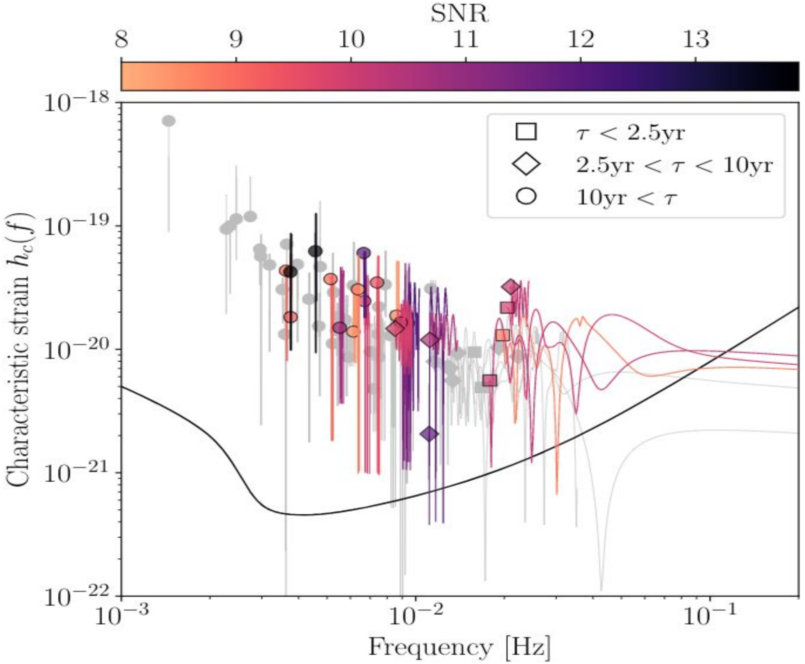
2. **Can we find merging binary black hole in the Milky Way with LISA?**



Multiband gravitational-wave astronomy:

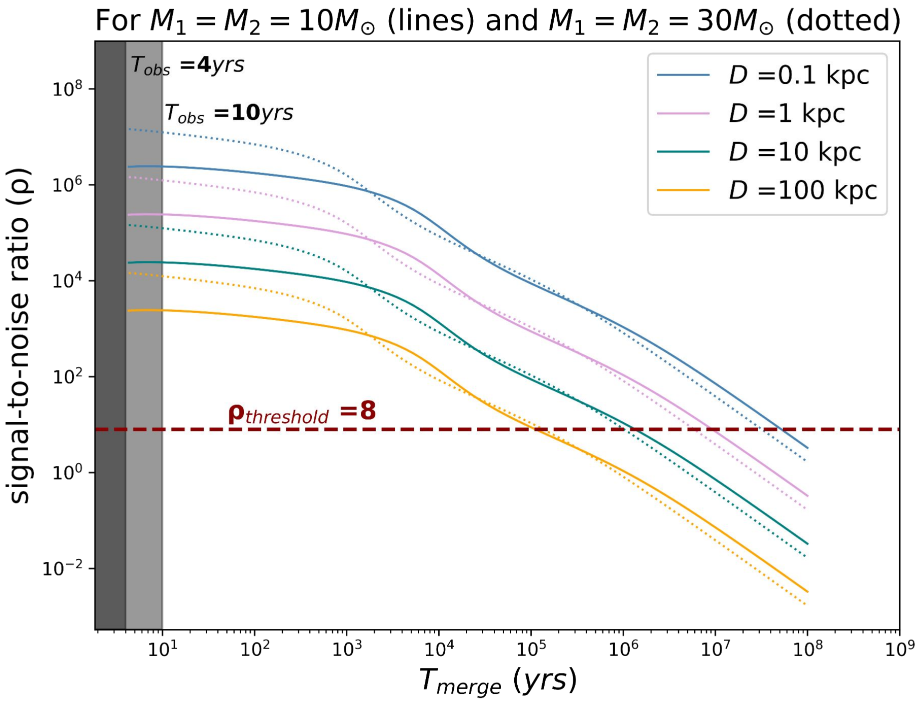


Sesana (2016)



Buscicchio *et al.*, (2021)

Signal-to-noise ratio as a function of merger time:



$$f(t_{\mathrm{merger}}) = \frac{5^{3/8}}{8\pi}[M_c(1+z)]^{-5/8} t_{\mathrm{merger}}^{-3/8}$$

See also Gerosa *et al.*, (2019)

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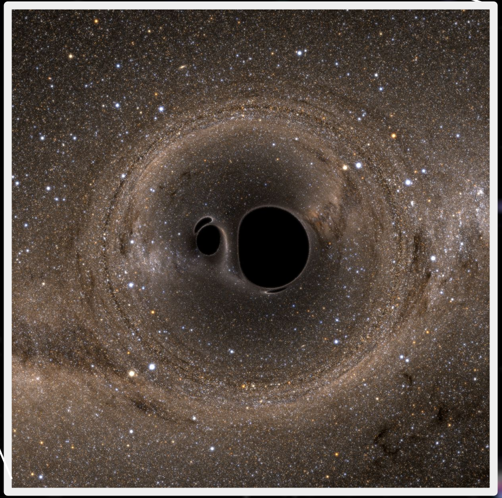
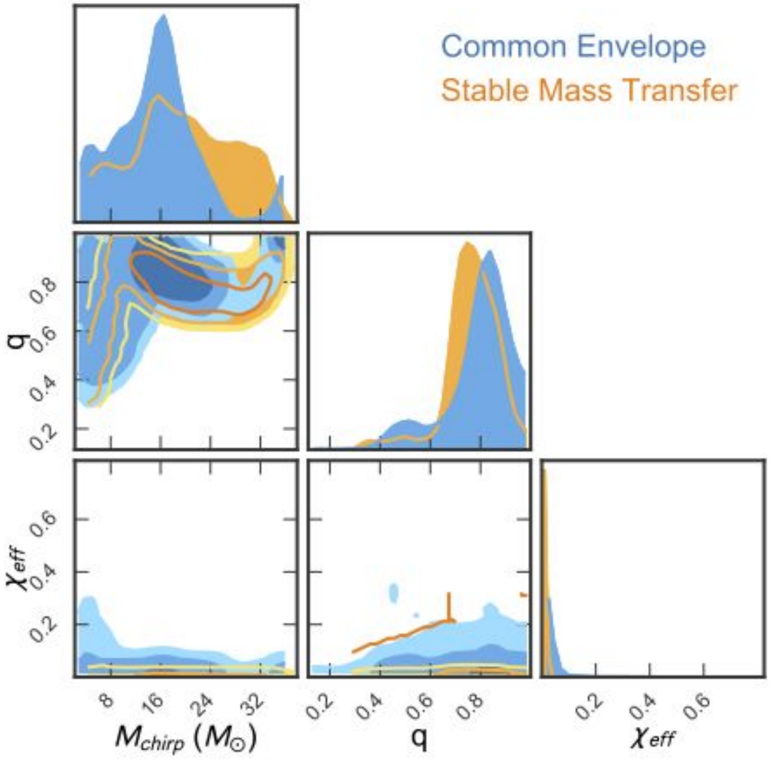


Properties of BBHs:

Binaries that will merge within 20 years



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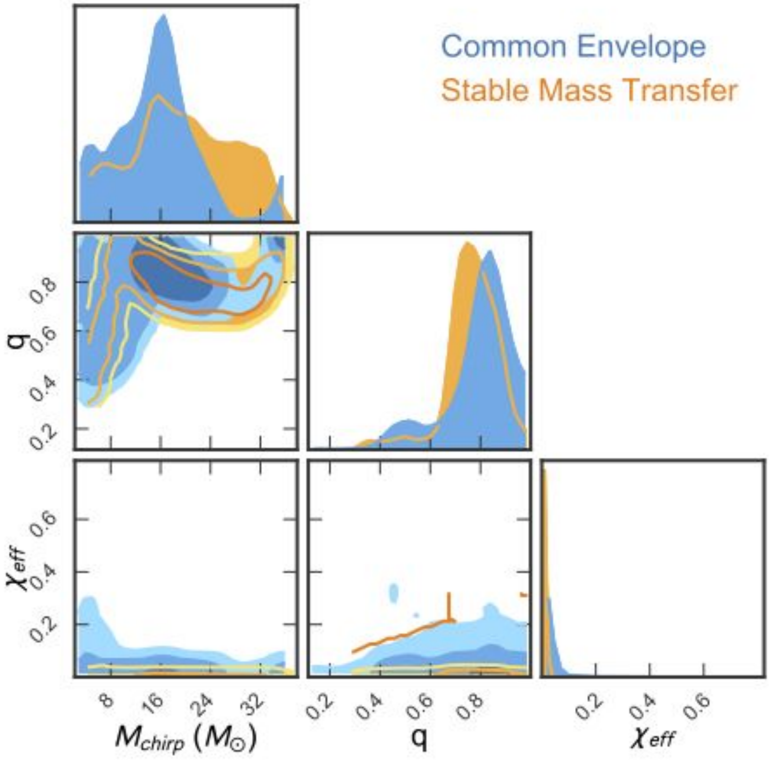
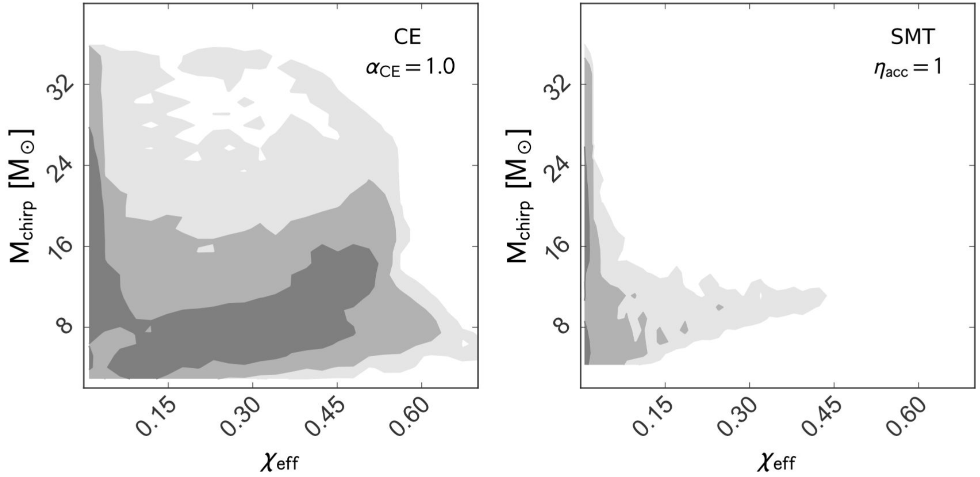
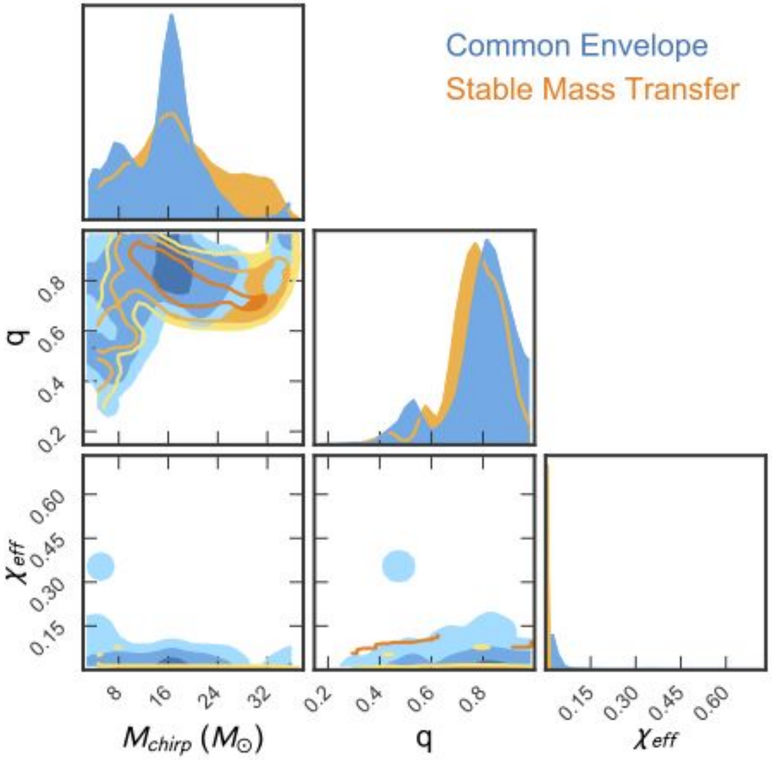


Merging BBH in the entire Universe



Bavera *et al.*, (2020b)

Properties of BBHs:



All binary black holes detectable by LISA

Orbital periods less than a few hours

BBHs with estimated SNR>8, following Robson et al (2019)

"Tens to hundreds of BBHs will be detectable by LISA"

Lamberts *et al* (2018)

Conclusion:

Merging binary black holes can form in the Milky Way Galaxy via isolated binary evolution

Their property distributions is not the same as the binary black holes of the whole Universe

Preliminary results show that disentangling formation channels with LISA can be challenging. Observed eccentricity might be the key!