Exploring galactic black hole binaries with LISA

Rafia Sarwar

Collaborators: 
Florian Giraud, Simone S. Bavera, and Tassos Fragos

1Department of Space Science, Institute of Space Technology (IST), Pakistan.

2Geneva Observatory, University of Geneva, 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)

- **Dynamical formation**
  - e.g. Inayoshi et al. (2017)
  - Globular / open / nuclear star clusters
  - Pop - III
    - e.g. van den Heuvel et al. (2017), Pavlovskii et al. (2017), Inayoshi et al. (2017)
Formation channels of binary black holes:

- Stable mass-transfer
- Common Envelope
- Chemically Homogeneous evolution
The Gravitational-Wave Transient Catalogue 2 (GWTC-2)

36-37
*new* binary black holes (BBH)

1
*new* binary neutron star (BNS)

1-2
black hole - neutron star (BHNS)

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:

- Initial binary properties
- Synthetic BBH population
- Metallicity evolution
- Star-formation rate
- Detectors selection effects
- Detected BBH population

Models and codes:

- Kroupa (2001)
- Sana et al. (2012)
- Sesana et al. (2016)
- Lamberts et al. (2018)
- POSYDON - Fragos et al (in prep.), Bavera et al. (2019, 2020), Buisson et al. 2020
- COSMIC - Breivik et al. (2019)
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- COSMIC - Breivik et al. (2019)
FIRE: Feedback In Realistic Environments:

Wetzel et al (2016)
Hopkins (2015)

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

1. Have there been any merging black hole binaries in the Milky Way?
Metallicity dependent merger timescales:

- Common Envelope
- Stable Mass Transfer
- Chemically Homogeneous Evolution
Star formation rate (SFR) of the Milky Way Galaxy:
Questions:

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

2. Can we find merging binary black hole in the Milky Way with LISA?
Multiband gravitational-wave astronomy:

Sesana (2016)
Signal-to-noise ratio as a function of merger time:

See also Gerosa (2016)
Questions:

1. Are there 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?
Properties of BBHs:

Binaries that will merge within 20 years
Properties of BBHs:

Binaries that will merge within 20 years

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!