Galactic Binaries

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What are galactic binaries (GB)

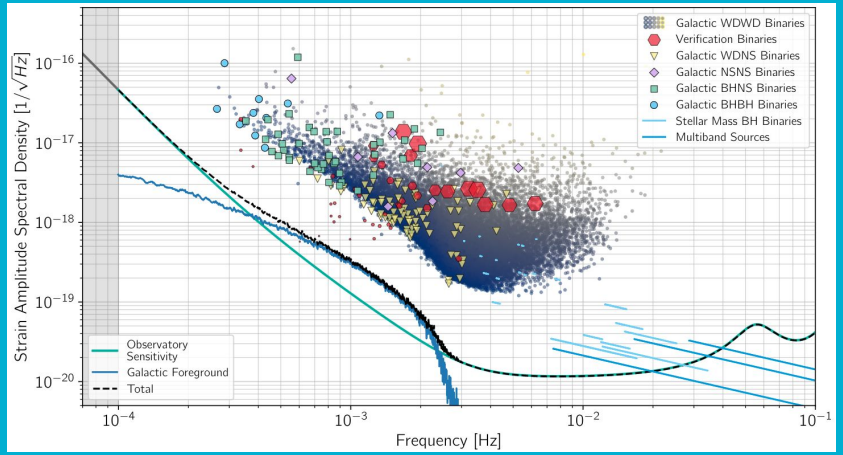
Galactic binary systems composed by two white dwarfs, a Black Hole / Neutron Star with a White Dwarf, or in general any close-enough pair of stars.

About 10^7 expected sources in our Galaxy, 10^4 of which are expected to be resolvable.

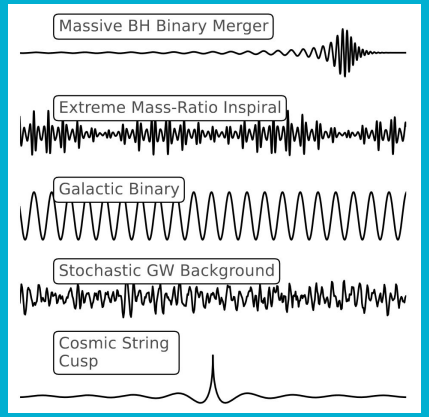
A significant fraction will only be detectable using GWs (i.e. no EM information!)

LISA will allow us to understand these compact systems: how they form, how often they merge… These measurements will lead to a better understanding of the composition of our Galaxy.

Source: LISA Definition Study Report



Expected signal from a galactic binary



GB are expected to emit long-lasting quasi-monochromatic GWs.

Slow evolution allows for a Taylor-expanded frequency evolution:
The model itself is simple; physics are contained in coefficients.

$$f_{\rm gw}(t) = \frac{1}{8\pi\mathcal{M}}\left(\frac{5\mathcal{M}}{t_c - t}\right)^{3/8} \longrightarrow f_{\rm gw} = f + \dot{f}t + \frac{1}{2}\ddot{f}t^2 \ ,$$

These signals will be further modulated by the motion of LISA.

On a practical level, the signal is similar to that expected from rapidly-spinning non-axisymmetric neutron stars (NS) in the LIGO band:

- 4 Amplitude parameters:
  - Nominal amplitude, inclination and polarisation angle, and initial phase.
- 4-ish frequency-evolution parameters:
  - position, initial frequency and extra Taylor terms.

$$h_+ = \frac{2\mathcal{M}}{D_{\rm L}}\left(\pi f_{\rm gw}(t)\right)^{2/3}\left(1+\cos^2\iota_1\right)\cos\Psi_{\rm gw} \ ,$$
$$h_\times = -\frac{4\mathcal{M}}{D_{\rm L}}\left(\pi f_{\rm gw}(t)\right)^{2/3}\cos\iota_1\sin\Psi_{\rm gw} \ ,$$

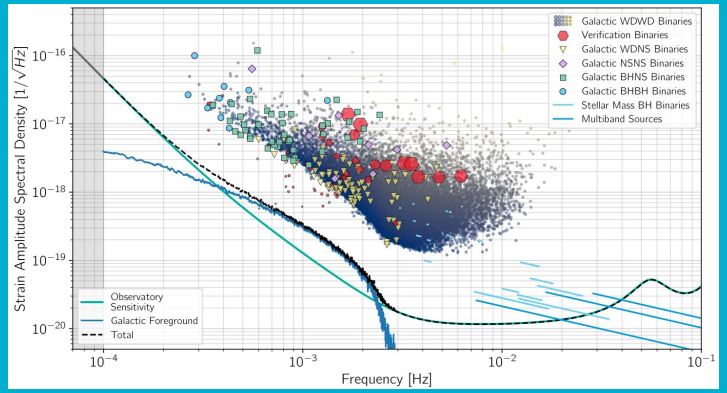
Many sources, a problem

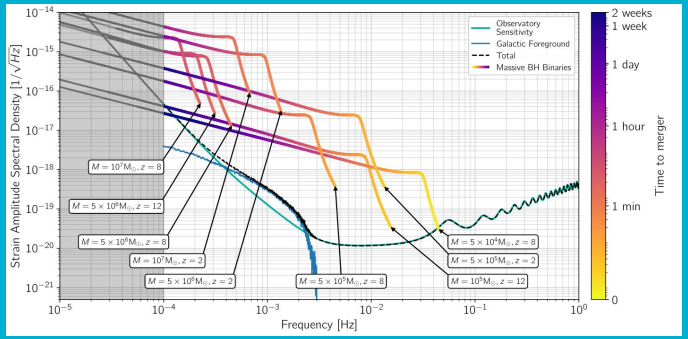
About 10^7 expected sources in our Galaxy, 10^4 of which are expected to be resolvable.

Non-resolvable sources will generate a non-isotropic GW foreground that will have to be subtracted in order to analyse other sources.

Resolvable sources, whose number we don't know in advance, will also need to be subtracted!

Despite the simplicity of their signal, the shear number of GB will pose a formidable data analysis problem to be solved.





Summary

- Galactic Binaries: “Relatively simple sources” which will allow us to further understand the composition of our Galaxy, as well as the dynamics of close stellar systems.

- Despite of their simplicity, the shear (and unknown!) amount of sources is expected to pose a formidable problem to LISA data analysis.