Detection of intermediate-mass black hole binaries with ground-based gravitational-wave observatories

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Do IMBHs exist?

Well... we don't know!

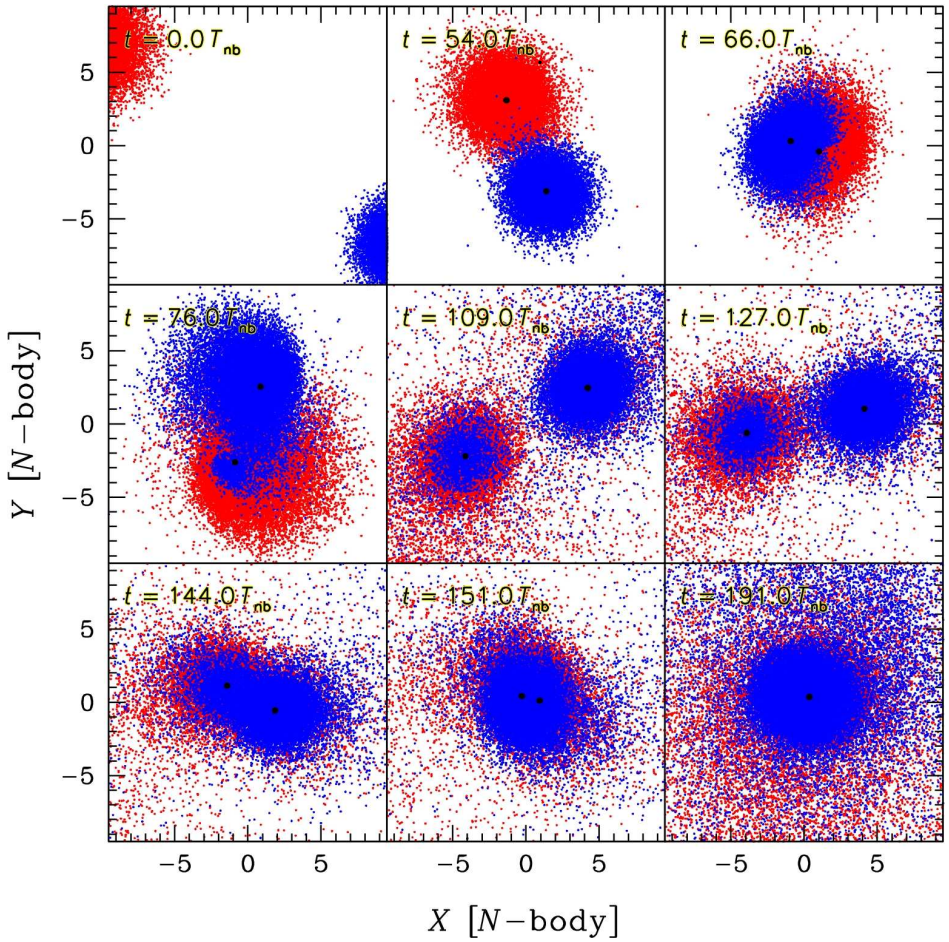
- **Supermassive BHs:** with $\sim 10^5 M_\odot < M < 10^9 M_\odot$, are thought to exist in the center of most galaxies, including the Milky Way.
- **Intermediate-mass BHs:** with $\sim 10^2 M_\odot < M < 10^4 M_\odot$, they have been proposed as a possible power source for ultraluminous X-ray sources. There is no known mechanism for them to form directly, so they likely form via collisions of lower mass black holes, either in the dense stellar cores of globular clusters or galaxies. No direct evidence
- **Stellar-mass BHs:** with $1.4 M_\odot < M <\sim 20 M_\odot$, created by the collapse of individual stars, or by the coalescence of binary neutron stars.

But if IMBHs exist...

- Formed after collapse of a Very Massive Star (with mass larger than $>> 100 M_{\odot}$)

- **Double-cluster channel:** in systems of two grav.-bound clusters, IMBHs sink down to the centers

- **Single-cluster channel:** in clusters with a fraction of primordial binaries $> 10\%$ *two* IMBH might form (Montecarlo simulations by Gürkan et al. (2006) - more evidence is needed)



N-body simulation of two stellar clusters by Amaro-Seoane & Freitag (2006).

Double cluster channel. Each of the merging clusters contains an IMBH.

Event rates of IMBH binaries for AdvLIGO and ET

For Advanced LIGO:

$$\boxed{\Gamma^{\text{total}}_{\text{Adv. LIGO}} \in [(0)\,11,\ 300]\ \text{yr}^{-1}}$$

For the ET:

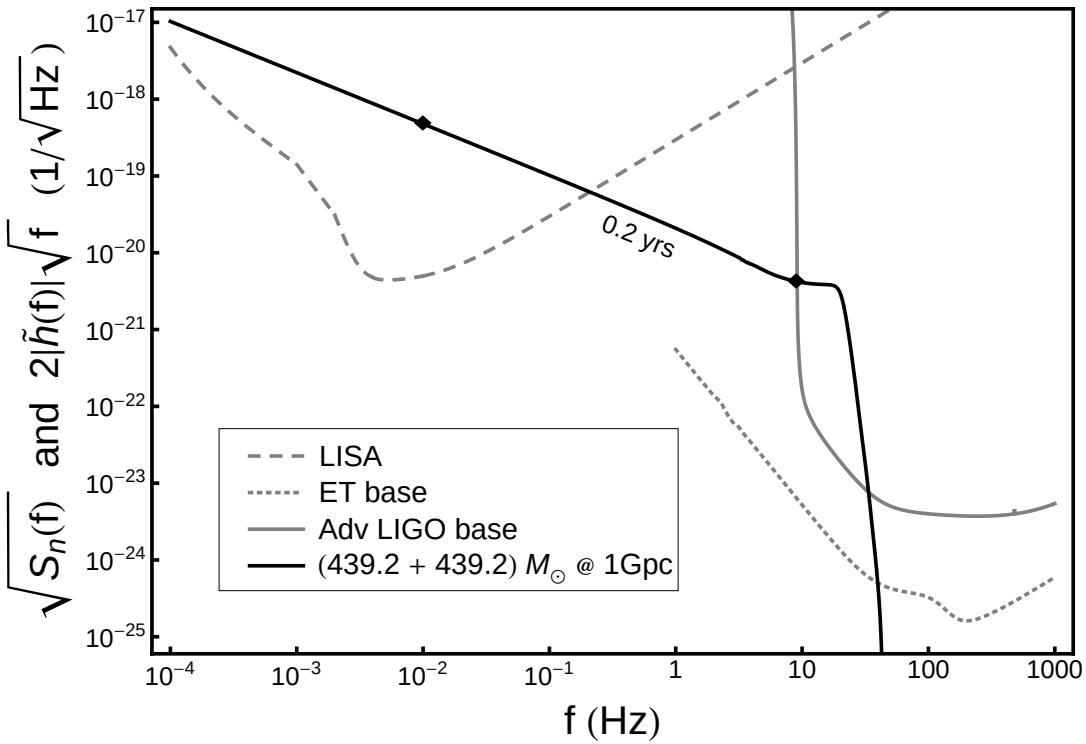
$$\boxed{\Gamma^{\text{total}}_{\text{ET}} \in [(0)\,4000,\ 6 \cdot 10^4]\ \text{yr}^{-1}}$$

For more info on how to compute these rates, see

`http://arxiv.org/abs/0910.0254`

This numbers are encouraging enough to address the problem of GW detection and characterization of IMBH systems with future generations of ground-based interferometers (advanced LIGO and the proposed ET)

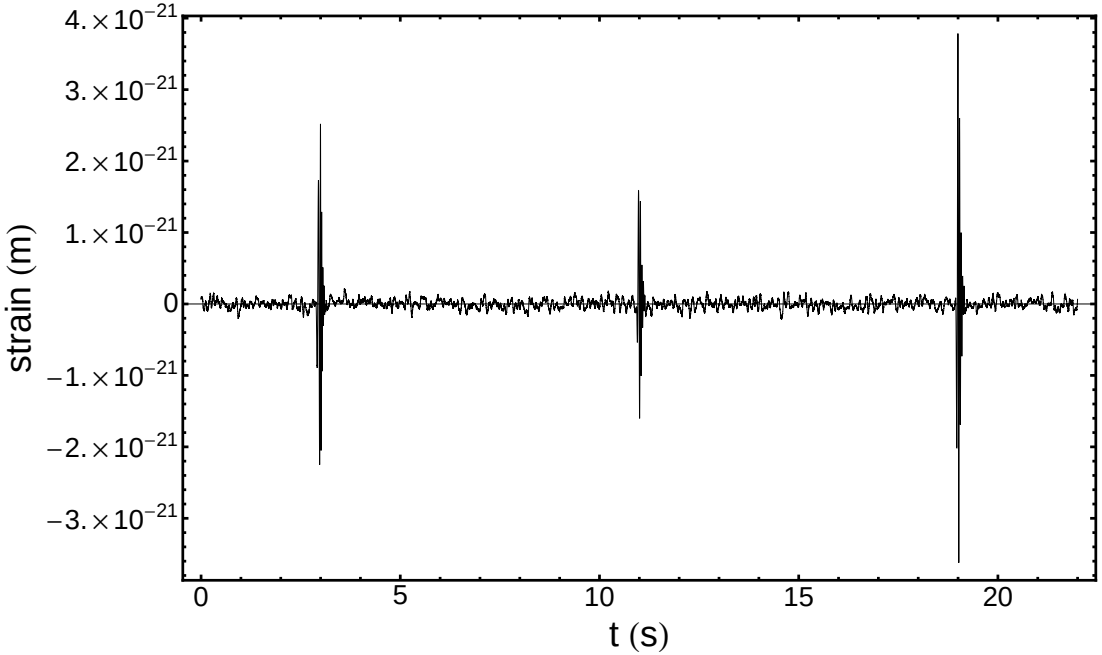
LISA and future ground-based detectors



IMBHs with masses of hundreds of $M_\odot$ could be seen by *both* LISA and the advanced ground-based detectors...

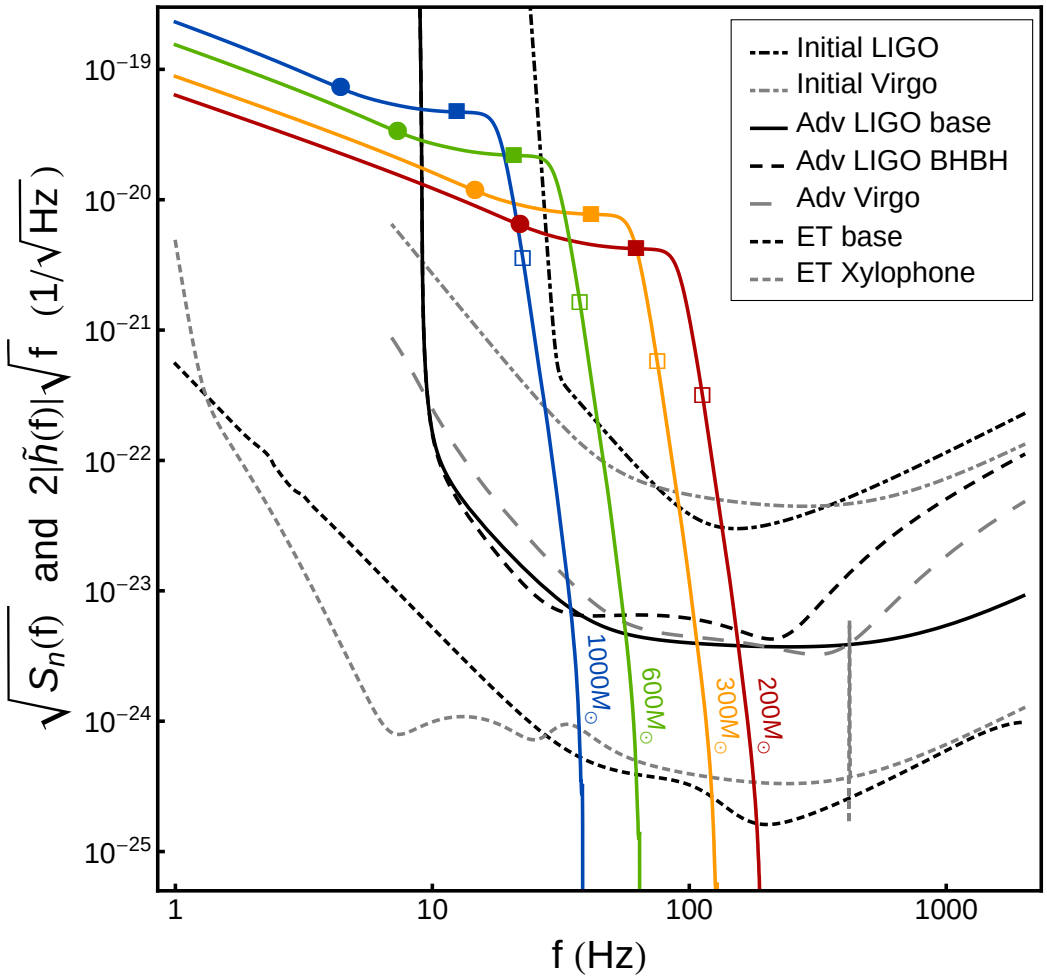
LISA and Ground-based detectors

...by eye!



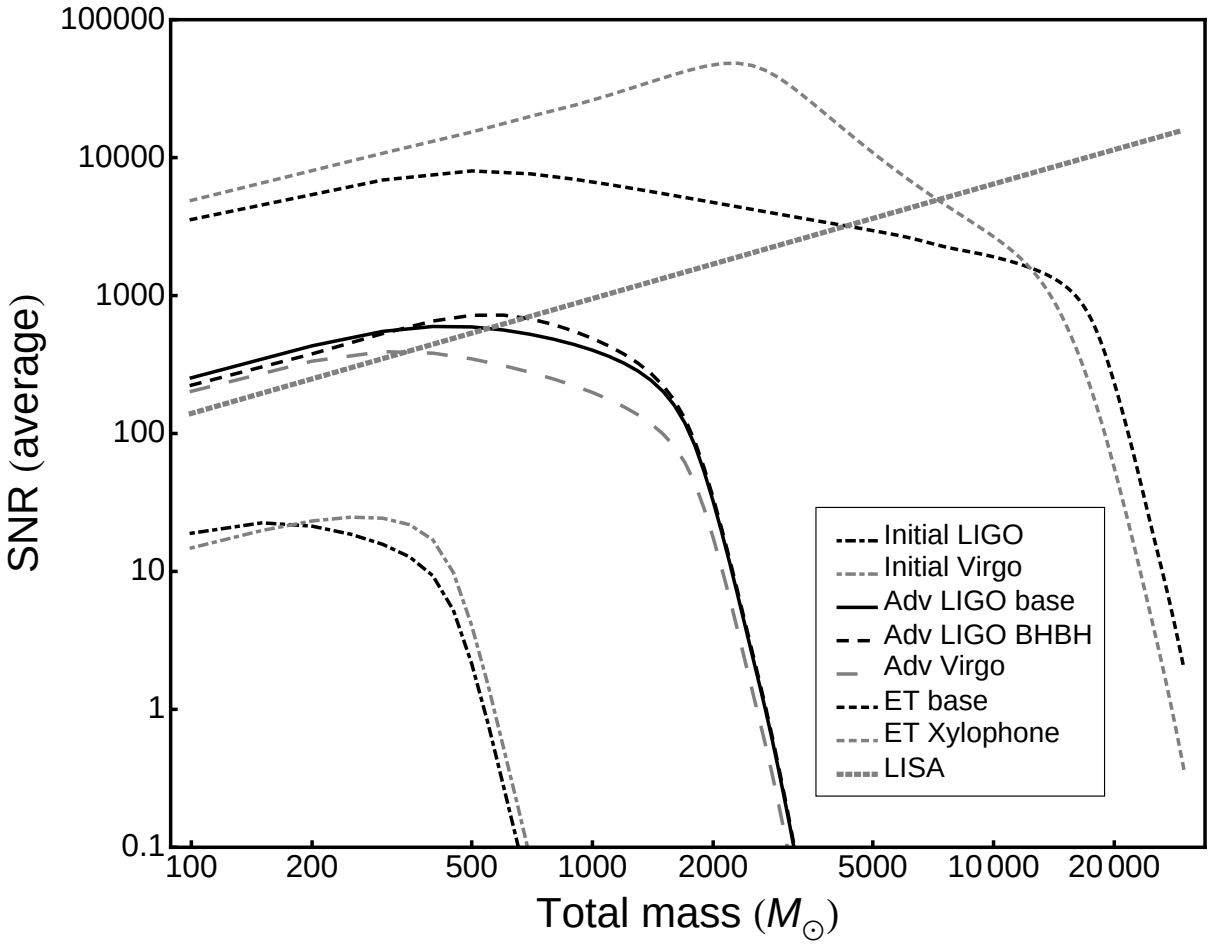
IMBHs of masses $400\,M_\odot \leq M_{\text{total}} \leq 700\,M_\odot$ and random orientations at 1 Gpc of the Advanced LIGO.
These events would produce a high-SNR response in the advanced detectors.

IMBH binaries as possible sources for future GW detectors



IMBH binaries with total mass **200, 300, 600** and **1000** $M_\odot$ at 100 Mpc

Expected Signal-To-Noise Ratios



Sky-averaged SNR at 100 Mpc vs total mass of the system

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- Large SNR events will be associated to the merger and ringdown of IMBH binary systems within the sensitivity bands of future-generation GW interferometers
- Prospects for detection and characterization of IMBH binaries (should they exist) with the advanced detectors look very encouraging. Complement to X-ray observations and future generations of optical telescopes (VSI/GRAVITY).