Massive black hole binary catalogues used in Klein et al. 2016

This directory contains the catalogues used in Klein et al. (2016), generated by using the model described in Barausse (2012). **(Please reference both.)**

The three models features different prescriptions for seed formation mechanism and timescale for massive black hole (MBH) binary (MBHB) mergers, as detailed in Klein et al. 2016 and are labelled

- PopIII
- Q3 delays
- Q3 no-delays

Detailed file content:

- column 1: z of the merger
- column 2: m_1, black hole mass in solar masses
- column 3: m_2, black hole mass in solar masses
- column 4: a_1, spin parameter
- column 5: a_2, spin parameter
- column 6: α, defined so that $a_1 \cdot a_2 = \cos\alpha$
- column 7: β, defined so that $a_1 \cdot l = \cos\beta$ (l is the orbital angular momentum)
- column 8: γ, defined so that $a_2 \cdot l = \cos\gamma$
- column 9: ψ, defined as the angle between the projections of a_1 and a_2 onto the binary orbital plane.
- column 10: a_r, merger remnant spin parameter
- column 11: m_r, merger remnant mass in solar masses
- column 12: v_{kick} kick, velocity in km/s
- column 13: $v_{\text{esc,halo}}$, escape velocity from the dark matter (DM) halo in km/s

- column 14: $v_{\rm esc,bar}$, escape velocity only considering baryonic matter in km/s
- column 15: $M_{\rm cluster}$, mass of the DM halo in solar masses
- column 16: $M_{\rm disk,stars}$, mass of the stellar component of the galactic disk in solar masses
- column 17: $M_{\rm disk,gas}$, mass of the gas component of the galactic disk in solar masses
- column 18: $M_{\rm bulge,stars}$, mass of the stellar component of the galactic bulge in solar masses
- column 19: $M_{\rm bulge,gas}$, mass of the gas component of the galactic bulge in solar masses
- column 20: $M_{\rm NSC}$, mass of the nuclear star cluster in solar masses
- column 21: $M_{\rm reservoir}$, mass of the gas reservoir feeding the MBH in solar masses
- column 22: $M_{\rm halo,final}$, mass of the DM halo in which the system is hosted at $z = 0$ in solar masses
- column 23: comoving number density of the DM halo in which the merger is hosted at $z = 0$ per Mpc^3 of comoving volume, divided by the number of realization of the halo with that specific mass (i.e. W_{PS}: weight on the PS mass function divided by the number of realizations)

Using the files

The files can be used to construct the distribution of merging MBHBs in the universe. To do so, the entries of each file must be weighted according to the halo number density (column 23) and integrated over the volume shell at the corresponding redshift, given in column 1. For example, to construct the merger rate as a function of redshift, one can simply numerically set a grid of Δz and sum all the events falling in each Δz interval according to the following prescription:

$$\frac{d^2N}{dzdt} = \frac{4\pi c}{\Delta z} \sum_{N\in\Delta z} W_{PS} \left(\frac{D_L(z)}{1+z}\right)^2 \tag{1}$$

Then one has

$$\int_z \frac{d^2N}{dzdt}dz = \frac{dN}{dt} \tag{2}$$

i.e. the merger rate (per second) of massive black hole binaries in the universe. For example, by setting grids on m_1 and m_2, the same prescription can be used to construct numerically the distribution of merging MBHBs per unit masses and redshift. One can then perform a Monte Carlo sampling from the distribution to simulate a population of merging MBHBs in a random realization of the universe.

References

Barausse 2012, MNRAS, 423, 2533
Klein et al. 2016, Phys. Rev. D, 93, 4003