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Cosmic Archaeology with black hole binaries

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The existence of massive stellar black hole binaries, with primary black hole (BH) masses greater than 30 -35 Msun was proven by the detection of the gravitational wave (GW) event GW150914 during the first LIGO/Virgo observing run (O1), and successively confirmed by seven additional GW signals discovered by independent analyses of the O1 and O2 data. Recently reported O3 alerts suggest that similar events may have been detected. Building on well established observed galaxy scaling relations and on our current understanding of stellar evolution at different metallicities, we find that these systems may be the relics of stellar populations forming in low-mass dwarf galaxies before the end of cosmic reionization. At the other extreme of the mass spectrum of astrophysical black holes, the existence of a population of almost 200 bright quasars at z > 6 poses crucial questions about their formation and growth processes. Observationally, the most distant quasars provide joint constraints on the mass of black-hole 'seeds'and their accretion efficiency. Depending on their birth environmental conditions in the first halos collapsing at very high redshifts, black hole seeds can be light, heavy or with intermediate masses. Using ab-initio structure formation models, we investigate the relative role of different populations of black hole seeds in the formation histories of the first super-massive black holes and how these formation scenarios may be constrained by future electromagnetic and gravitational wave observations. In particular, future gravitational wave facilities, such as LISA and the Einstein Telescope, will be able to improve our knowledge of these ancient systems, fully exploiting their potential as cosmic archaeology probes.

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