Where do binary black holes come from?

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The number of gravitational-wave detections approaches the 100 mark and starts revealing the big picture of binary black hole populations. Several detected black holes have mass in the lower (2-5 Msun) or upper (~60-120 Msun) mass gap, challenging models of stellar and binary evolution. Furthermore, evidence for unequal-mass systems and non-negligible spin misalignment advocate for unconventional scenarios of binary black hole formation. We recently proposed that the mass function of the LIGO-Virgo black holes evolves with redshift. This result, if confirmed, favours scenarios in which the properties of black hole progenitors and their birth environment change across cosmic time. One key aspect is the metallicity of the progenitor star: a metal-poor environment enhances the formation of massive black holes (>20 Msun) and boosts their merger rate via stable mass transfer. Moreover, formation in a globular cluster environment leads to a great variety of unconventional features in binary black holes: hierarchical mergers favour the formation of oversize black holes and close gravitational encounters randomize their spin orientations. Next-generation gravitational-wave detectors will mark a turning point to interpret the formation of binary black holes, by observing their mergers at cosmic dawn.