Understanding the stellar progenitors of binary black holes

The black holes detected by the LVK gravitational wave (GW) detectors have masses (typically 20-50 $M_\odot$) that are systematically heavier than those detected in X-ray binaries (5-20 $M_\odot$). This mass discrepancy suggests different progenitor stellar environments, especially metallicity, between X-ray binary and GW black holes. We have built a model Universe that represents star formation for different redshift **z**, host galaxy mass $\mathbf{M_{gal}}$, stellar metallicity **Z** and in which we incorporate a binary evolution model under different conditions (stellar-wind, mass-transfer, supernova kicks). In this presentation, I will discuss our results on simulated binary black hole merger rates and binary evolution models with black hole mass distribution that is consistent with the LVK population. Our analysis shows that the majority of astrophysical binary black holes are small ($<15M_\odot$), typically at large z (2-3), in galaxies heavier than the Milky way with a high Z ($0.5\text{-}0.9Z_\odot$) environment. In contrast, the GW detectable population is predominantly comprised of larger black holes ($>20M_\odot$) at $z< 1$, in dwarf galaxies with a low Z ($0.02\ Z_\odot$) environment. The number of GW observations will increase in the following years and will further constrain the comparison.