Observational properties of massive black hole binary progenitors

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The first directly detected gravitational waves (GW 150914) were emitted by two coalescing black holes (BHs) with masses of ~36Msun and ~29Msun. Several scenarios have been proposed to put this detection into an astrophysical context. The evolution of an isolated massive binary system is among commonly considered models. Various groups have performed detailed binary-evolution calculations that lead to BH merger events. However, the question remains open as to whether binary systems with the predicted properties really exist. The aim of this paper is to help observers to close this gap by providing spectral characteristics of massive binary BH progenitors during a phase where at least one of the companions is still non-degenerate. Stellar evolution models predict fundamental stellar parameters. Using these as input for our stellar atmosphere code (PoWR), we compute a set of models for selected evolutionary stages of massive merging BH progenitors at different metallicities. The synthetic spectra obtained from our atmosphere calculations reveal that progenitors of massive BH merger events start their lives as O2-3V stars that evolve to early-type blue supergiants before they undergo core-collapse during the Wolf-Rayet phase. When the primary has collapsed, the remaining system will appear as a wind-fed high-mass X-ray binary. Based on our atmosphere models, we provide feedback parameters, broad band magnitudes, and spectral templates that should help to identify such binaries in the future. While the predicted parameter space for massive BH binary progenitors is partly realized in nature, none of the known massive binaries match our synthetic spectra of massive BH binary progenitors exactly. Comparisons of empirically determined mass-loss rates with those assumed by evolution calculations reveal significant differences. The consideration of the empirical mass-loss rates in evolution calculations will possibly entail a shift of the maximum in the predicted binary-BH merger rate to higher metallicities, that is, more candidates should be expected in our cosmic neighborhood than previously assumed.

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