Contribution ID: **95** Type: **not specified**

Could Population III binary stars be the progenitors of massive stellar black hole binaries?

Tuesday, 17 September 2024 11:30 (20 minutes)

Massive stellar black hole binaries (MBHBs) descendent from population III (Pop. III) binary stars are dark sirens that could play an extremely important role in improving our understanding of the high-redshift Universe. The coalescences of these binaries will be detected by the next generation of ground-based gravitational-wave (GW) detectors; however it is possible that some of the MBHBs observed by LIGO-VIRGO interferometers
may have had metal-free or metal-poor stellar progenitors. The statistics of these MBHBs have become not negligible and we believe that their number will increase with the arrival of the O4 run data. For this reason, the right time has come to carry out studies on BH populations and figure out which are their formation channels.
In order to predict the birth and merger rate of MBHBs originated by Pop. III binary stars in a Local Group-like volume, we couple the semi-numeric galaxy evolution simulation GAMESH (Graziani et al. MNRAS, 2015,17) and the binary population synthesis (BPS) codes (Spera et al. MNRAS, 2019; Tanikawa et al. ApJ, 2021b). We adopt a self-consistent galaxy formation model, which includes a full radiative feedback treatment, to provide accurate predictions on the physical properties of the native and coalescence environments of MBHBs across the entire cosmic evolution of the Milky Way-like halo up to redshift z=0. Furthermore, we investigate the role of the stellar initial mass function, which is still unknown for the first stars without metals, to understand how our predictions depend on its uncertainties.
Taking into account the BHs from Pop. III binary stars, we obtain a completely different stellar BH mass distribution with respect to the models that consider only Pop. II stars. We find many coalescences of MBHBs that had Pop. III stars as stellar progenitors within the LIGO-VIRGO-KAGRA observation window. This confirms the possibility of detecting a similar event with the current interferometers and it does not exclude that these coalescences are already hidden among the current detections. Indeed, our analysis reveals that many MBHBs from metal-free stars have the masses of the primary and secondary BHs and the coalescence redshift within the error bars of the O3 candidates.
Finally, we have studied the birth and merger sites of the MBHBs predicted by our galaxy formation model. From our work, it seems that almost all the currently detected MBHBs could have formed at high redshift in extremely metal-poor ($Z < 10^{-2} Z_{\odot}$) halos, namely inside mini-halos belonging to the Local Group. Nevertheless, two MBHBs of the LIGO-VIRGO catalogs (GW190426 and GW190521) are too massive to have been originated by Pop. III binary stars. This means that they could have been born by a different formation pathway, such as a hierarchical BH merger scenario. To conclude, we show the differences in the birth and merger rate density of MBHBs when we assume different IMFs for Pop. III stars.

Primary author: ANGELONI, Federico (Tor Vergata University, Sapienza University, INFN, INAF)

Co-authors: Dr GRAZIANI, Luca (Sapienza University, INFN); Prof. SCHNEIDER, Raffaella (Sapienza University, INFN)

Presenter: ANGELONI, Federico (Tor Vergata University, Sapienza University, INFN, INAF)

Session Classification: TEONGRAV Session 2