Evolution of galaxies hosting GW150914-like events

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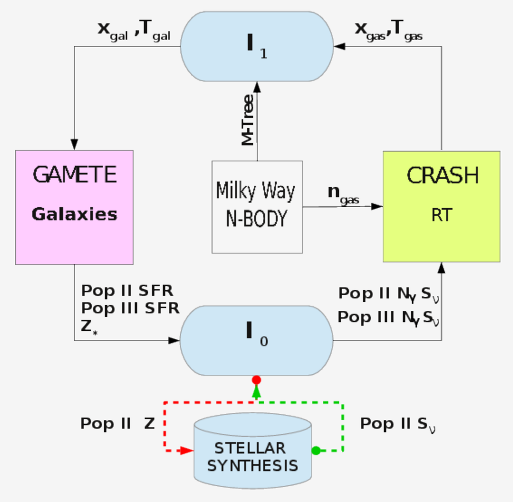
★ ABSTRACT

Adopting a novel theoretical model described in Schneider 2017 we have been able to characterize the formation and the coalescence sites of compact binaries in a cosmological context. We couple the binary population synthesis code SeBa with a simulation following the formation of a Milky Way-like halo in a well resolved cosmic volume of 4 cMpc, performed with the GAMESH pipeline. We used this technique to investigate when and where GW150914- like systems form and where they are more likely to reside when they coalesce. In this complementary study we perform a detailed analysis of the evolutionary pathways and the statistical properties of galaxies hosting GW150914-like events.

★ COUPLING GAMESH WITH SeBa

GAMESH = GAMETE + CRASH

+ Nbody simulation of Milky Way galaxy formation

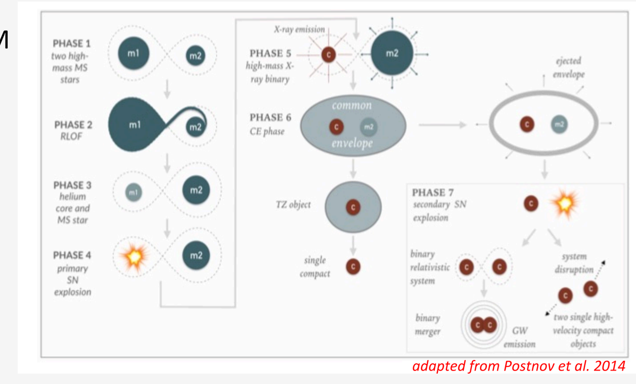


N-body simulation: dynamical evolution of DM halos
GAMETE simulation: Star formation, metal production
CRASH simulation: RT, gas ionization heating

GAMESH can follow both mergers and spatial evolution of structures

GAMESH implements self-consistent radiative and chemical feedback

SeBa
Pop-synthesis code

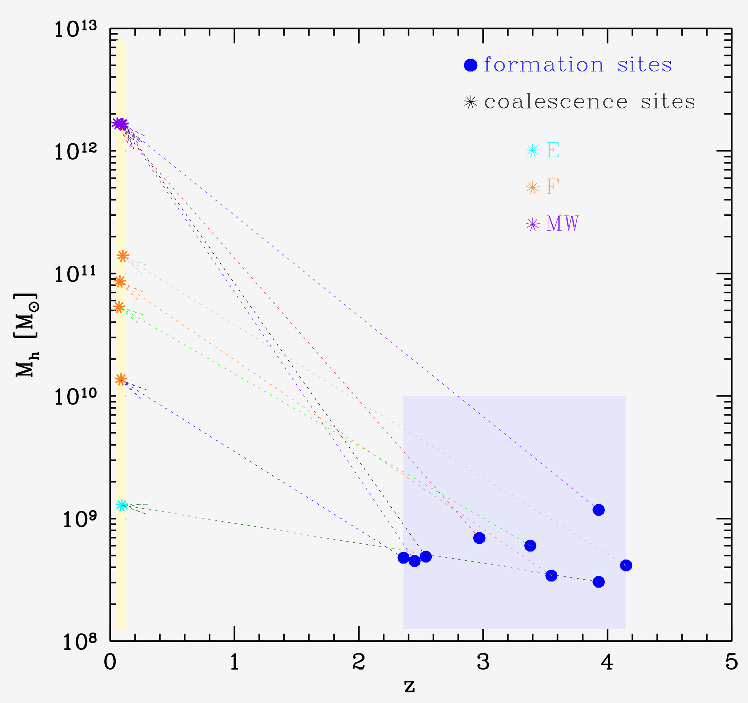


Typical evolutionary track of high-mass binary systems as the ones reproduced in SeBa

★ EVOLUTION OF GALAXIES FROM BLACK HOLE BINARIES FORMATION TO COALESCENCE

Halo/Galaxy - Properties

We find only 9 halos capable to host GW150914-like events over more than ~ 13.000 simulated galaxy hosts in the redshift range predicted by LIGO and with the right mass ratio

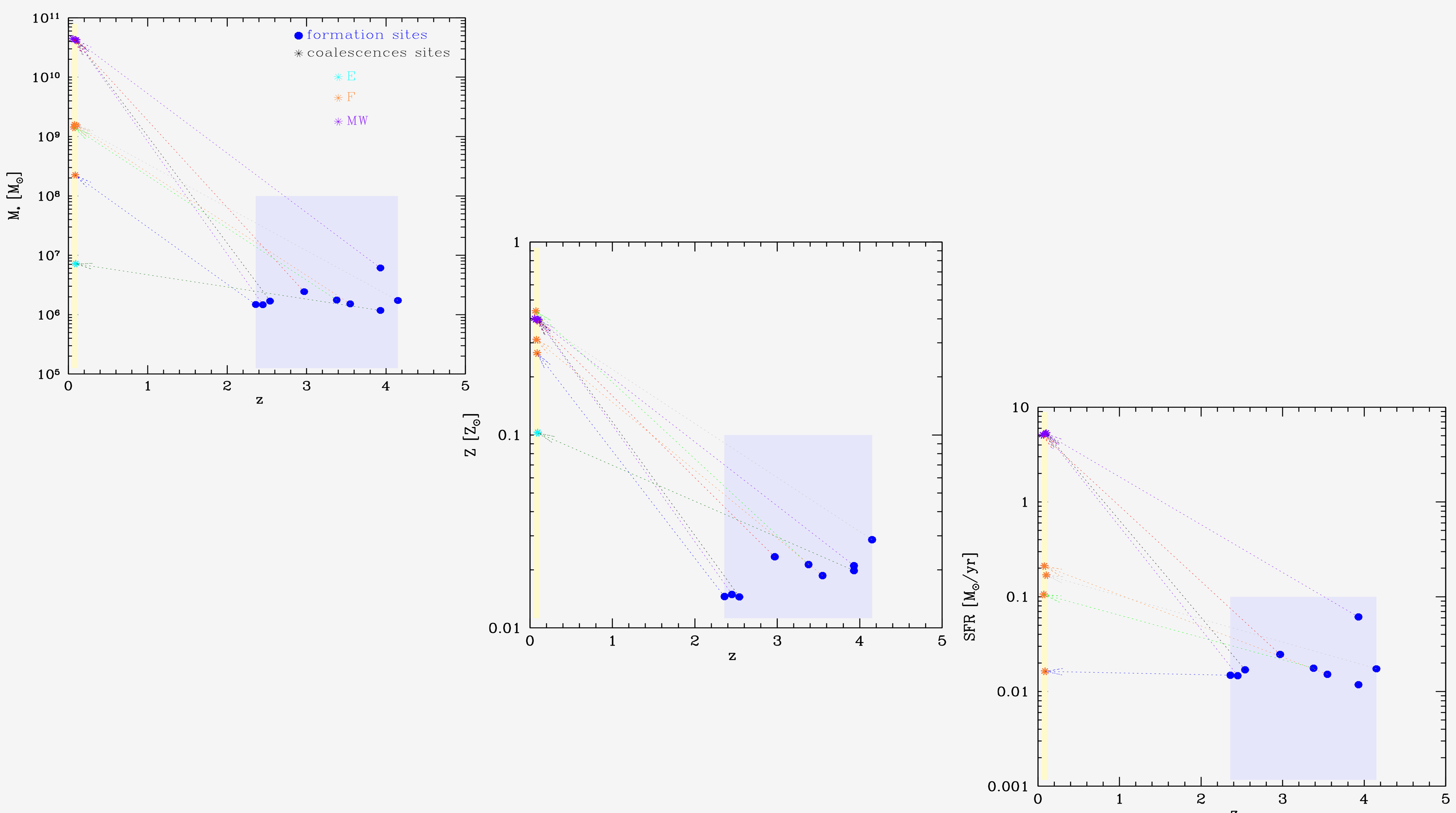


Dark matter mass of halos hosting the BHB formation (blue dots) and coalescence (star-like points), as function of redshift.

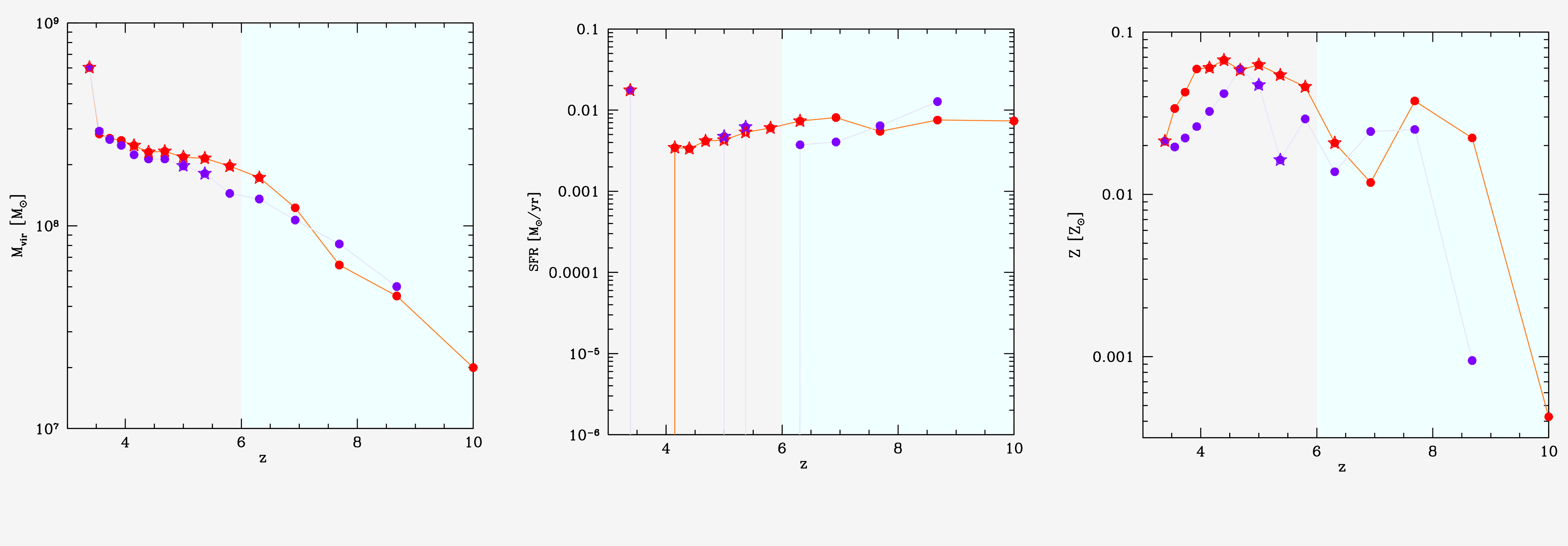
gID	$z_f \to z_c$	$\sim T_{vir}$ [10^4 K]	$\sim d_{MW}$ [100 kpc]
F1	$3.93 \to 0.095$	$2.20 \to 1.50$	$24.2 \to 7.4$
F2	$2.36 \to 0.087$	$2.05 \to 7.23$	$19.9 \to 4.4$
F3	$3.55 \to 0.080$	$2.20 \to 24.5$	$21.5 \to 11.6$
E1	$3.38 \to 0.072$	$3.10 \to 17.66$	$25.0 \to 27.4$
E2	$4.15 \to 0.103$	$2.83 \to 34.20$	$24.7 \to 34.4$
MW1	$2.45 \to 0.095$	$2.01 \to 176$	$7.2 \to 0.0$
MW2	$3.93 \to 0.095$	$5.43 \to 176$	$11.6 \to 0.0$
MW3	$2.97 \to 0.057$	$3.81 \to 174$	$7.1 \to 0.0$
MW4	$2.54 \to 0.103$	$2.18 \to 177$	$10.0 \to 0.0$

Properties of dark matter halos in which the formation and coalescence of BHBs occur.

Stellar mass, SFR and metallicity of Galaxies hosting the birth and coalescence events of BH binary systems candidate to have properties as predicted for the observed GW150914-like events



★ EVOLUTION OF A CHANNELS ENDING IN THE GALAXY/DM HALO E1



Observational counterpart: for example the descendants of E1 have PGC1446233 analogue (from the ALLSMOG survey)

gID/Obs.	$z_c \to z_s; z_{obs}$	Z [12+log(O/H)]	log(M_*) [$M_\odot$]	log(SFR) [$M_\odot$/yr]
F1/UGC4483 [b]	$0.095 \to 0.0; 0.0005$	$? \to 7.68; 7.46 \pm 0.02$ [d]	6.8[illegible] $\to 6.87; 6.89 \pm 0.22$	(quenched)→(quenched); -2.21 ± 0.18
F2	0.087	? → ?	$5.90 \to 8.35$	$-1.82 \to -1.79$
F3	0.080	? → ?	$6.26 \to 9.19$	$-1.82 \to -0.68$
E1/PGC1446233 [a]	$0.072 \to 0.02; 0.023$	$? \to 8.39; 8.38$ [c]	$9.15 \to 9.19; 9.11 \pm 0.09$	$-0.98 \to -1.05; -0.94 \pm 0.28$
E2	0.103	? → ?	$6.36 \to 9.18$	$-1.77 \to -0.77$
MW1	0.095	? → ?	$5.90 \to 10.63$	$-1.82 \to 0.72$
MW2	0.095	? → ?	$6.69 \to 10.63$	$-1.21 \to 0.72$
MW3	0.057	? → ?	$6.38 \to 10.64$	$-1.60 \to 0.71$
MW4	0.103	? → ?	$6.08 \to 10.62$	$-1.77 \to 0.73$

★ MAIN RESULTS AND CONCLUSIONS

- We perform a detailed analysis of the evolutionary pathways and the statistical properties of galaxies hosting GW150914-like events.
- We find three classes of halos hosting coalescence events: systems belonging to the main MW progenitor (MW-systems), systems belonging to MW satellites (F-systems), halos hosting dwarf galaxies that can dynamically escape the global infall onto the central Milky Way (E- systems).
- Measurements of the physical properties of the host galaxy provide constraints on the formation mechanism of the binary.
- Our analysis open the possibility to search in observational catalogs comparing the physical properties of the simulated GW150914-like event hosting galaxies and give access to build a more efficient detection strategy.

★ REFERENCES

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