Speaking with one voice: simulations and observations discuss the common envelope α parameter

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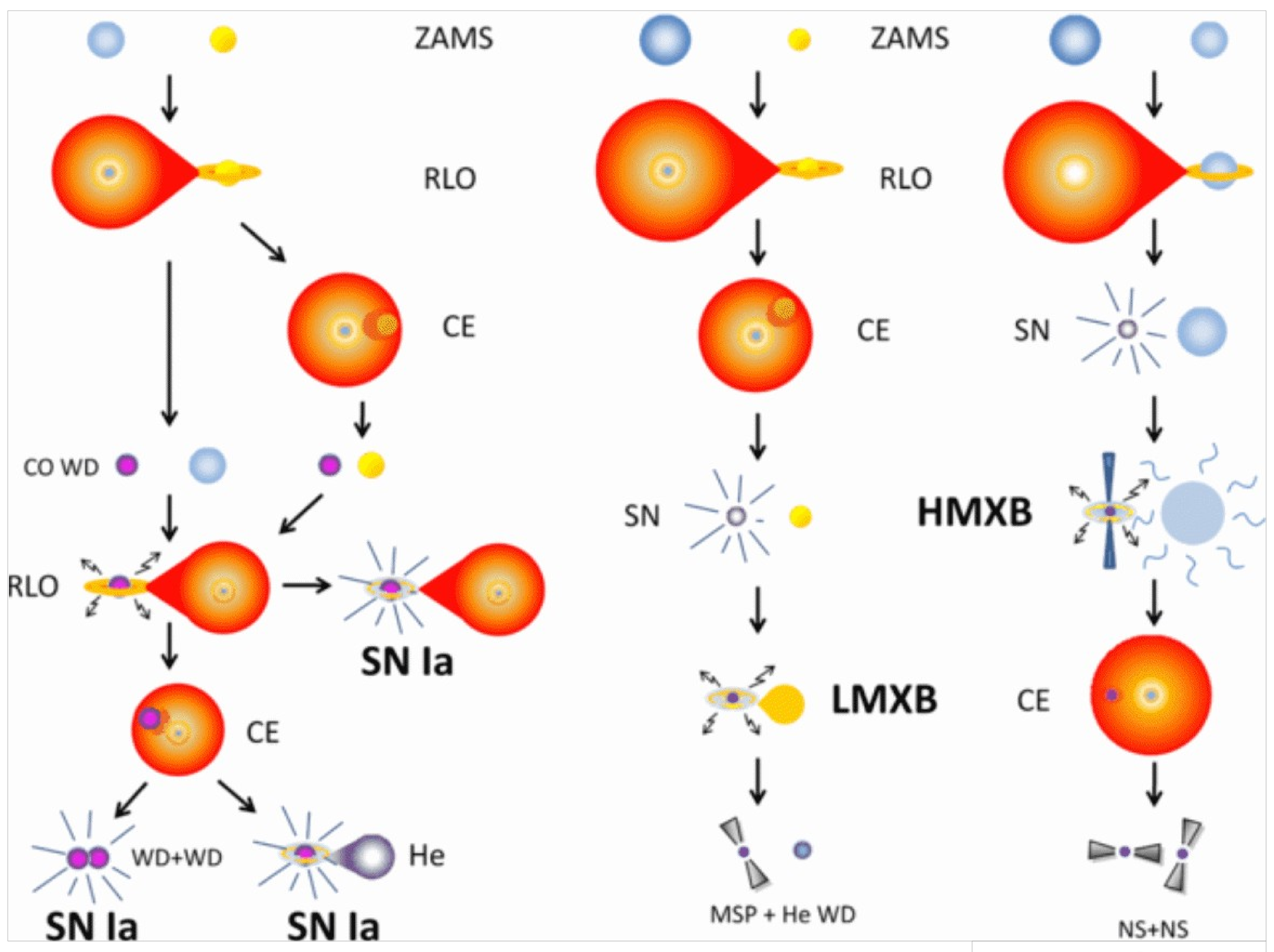
IMPORTANCE OF COMMON ENVELOPE (CE)



Ivanova et al. (2013)

CE is the channel to all evolved compact binaries and related phenomena:

-WD+WD, NS+NS, BH+BH

-SNIa, gamma-ray bursts

-sytems emitting detectable gravitational waves upon merging

α FORMALISM

-CE involves the shrinking of the orbital separation and the unbinding of the <u>entire</u> envelope of the larger star at the expenses of orbital energy

-orbital shrinking and mass ejection can be parametrised by the alpha equation:

$$E_{\rm bin} = -\alpha_{\rm CE} G \left(\frac{M_{\rm c} M_2}{2 a_{\rm f}} - \frac{M_1 M_2}{2 a_{\rm i}} \right)$$

-the parameter α tells us how much of the orbital energy has been effectively spent to fully unbind the envelope

-α is a key parameter in BPS codes and the choice adopted for it can ultimately determine, e.g., the rate of SNIa predicted

PROBLEMS AND AIMS OF THIS WORK

-the value of α from observations is very uncertain:

1) from post-CE binaries data the properties at the moment of CE must be reconstructed and this method presents many uncertainties
2) with the observations available it is not possible to determine a dynamic value for α (α is fitted with a constant value for all the possible systems reconstructed)

-we cannot estimate α from simulations:

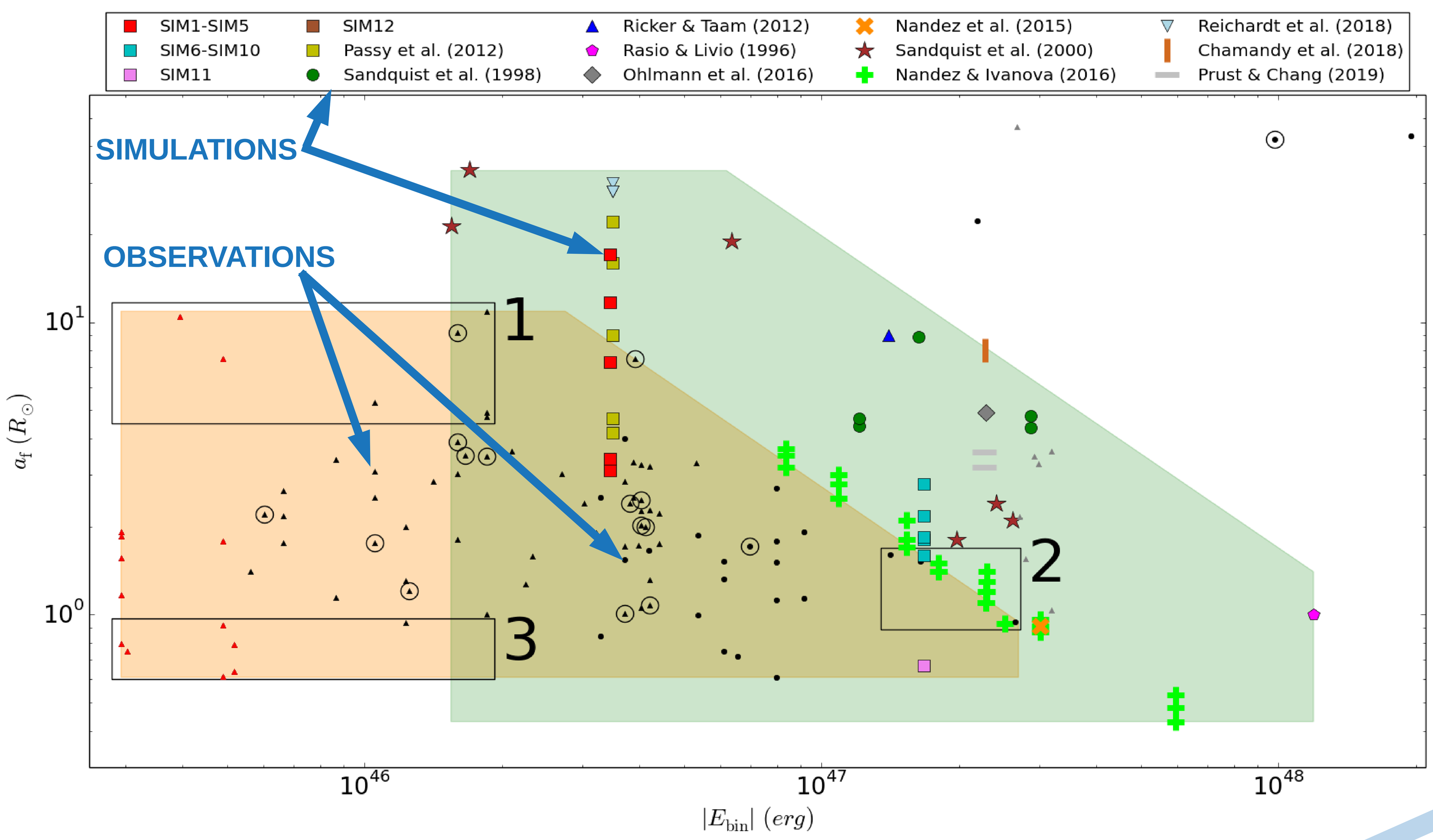
1) only a few simulations result in the full unbinding of the envelope (the biggest issue in the current CE simulations field!)
2) in simulations where the envelope is unbound the physical process responsible for the extra energy is recombination of the envelope gas and its effectiveness is still debated

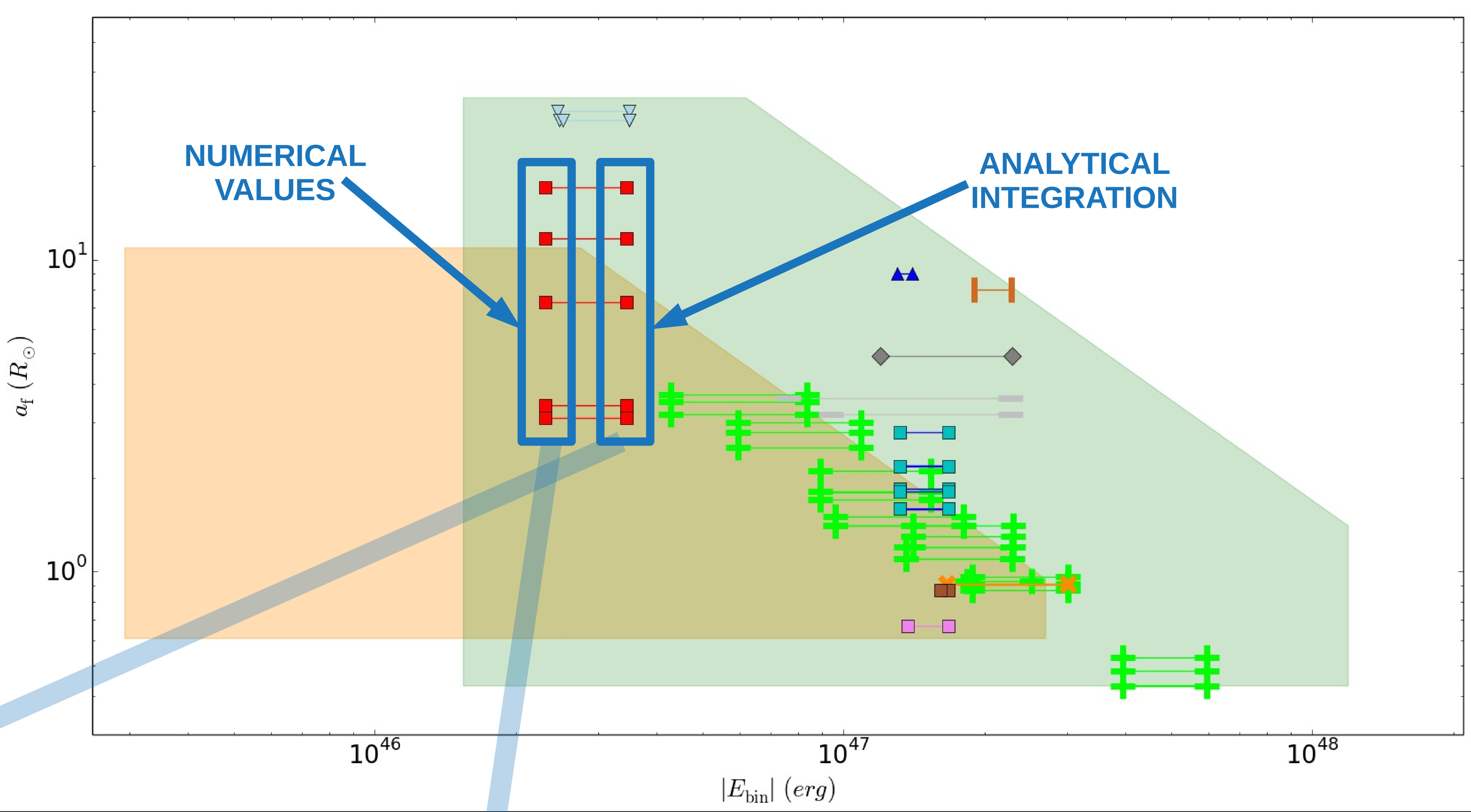
-in this work we compare a set of CE simulations from the literature with several datasets of post-CE observations to try and understand bulk properties of the two populations and how they can be connected

RESULTS 1: COMPARING SIMULATIONS AND OBSERVATIONS IN THE FINAL SEPARATION VS BINDING ENERGY PLANE

-the simulations data do not cover well the parameter space of the observations:
1) CE simulations involving AGB stars are almost absent and we sorely need them to match the area covered by observations
2) the binding energies of the simulated CEs systematically exceed the observed values

-there is a net difference between the binding energies of simulated stars if computed with an analytical integration (like it is done for observational models) and as obtained from the numerical values, this difference helps reducing the gap in binding energy observed

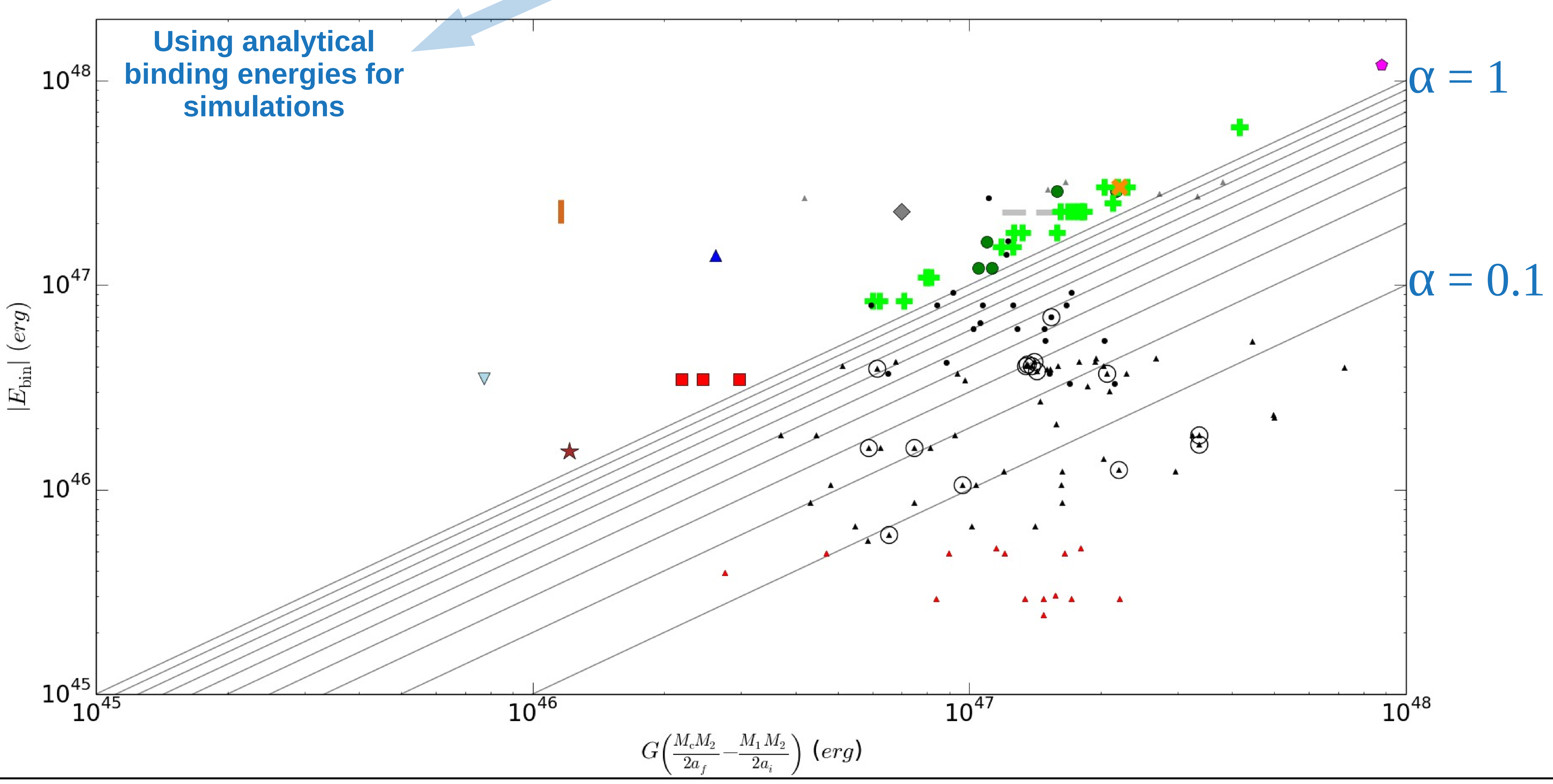


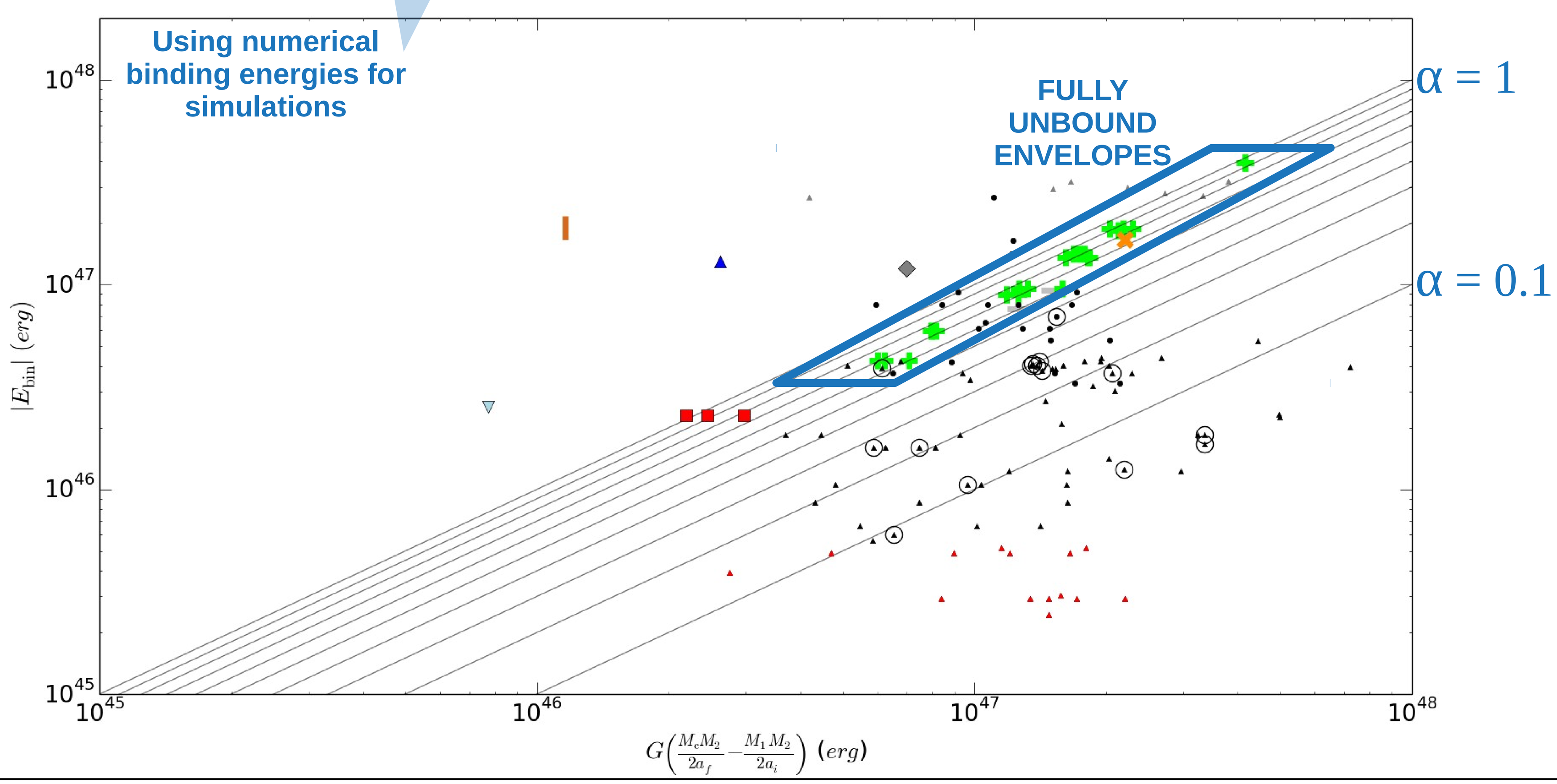


RESULTS 2: COMPARING SIMULATIONS AND OBSERVATIONS IN THE α EQUATION PLANE

-AGB stars have lower α values and, again, simulations offer no comparison

-using the numerical values for the binding energies of simulated stars results in an overlapping of the simulations unbinding the entire envelope with the sample of RGB stars observed (α = 0.6 – 1.0, also deduced in the original papers)





CONCLUSIONS:

1) the binding energies of the simulated systems systematically exceed the observed values, leaving us with a poor parameter space coverage

2) the common envelope simulations that eject the entire envelope show a value of α in line with the values for observed systems that experienced common envelope during their RGB

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