On the influence of enhanced angular momentum loss on cataclysmic variables in globular clusters

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INTRODUCTION

Cataclysmic variables (CVs) are interacting binaries composed of a white dwarf (WD) undergoing stable mass transfer from a main sequence (MS) star or a brown dwarf (BD) (e.g. Knigge et al. 2011). They are expected to exist in non-negligible numbers in globular clusters (GCs) that are natural laboratories for testing theories of stellar dynamics and evolution.

Recently, Schreiber et al. (2016) proposed a new formalism to the consequential angular momentum loss (CAML), which is caused by mass transfer, in order to reconcile the observed and the predicted WD mass distribution in the Galaxy. This new approach correspond to an enhanced angular momentum loss which makes CVs with low-mass WDs merge. In this work we investigate how this new approach for CAML affect GC CVs.

In order to account for differences in common-envelope phase (CEP) parameters, we simulated models with two distinct combinations of CEP parameters.

METHODS AND ASSUMPTIONS

We simulate 12 GC models with the Monte Carlo MOCCA code (Hypki & Giersz 2013). The models differ, mainly, with respect to:

→ **model initial concentration (3):**
sparse ($\rho \sim 10^3$ M⊙ pc^{-3}), dense ($\rho \sim 10^5$ M⊙ pc^{-3}), and very dense ($\rho > 10^5$ M⊙ pc^{-3})

→ **initial binary population (2):**
Standard (commonly used) and Kroupa (1995,2013)

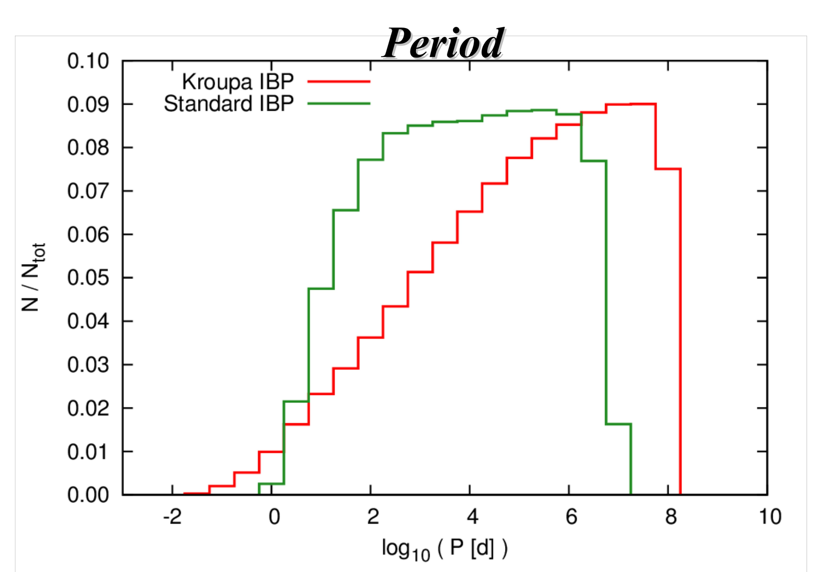
→ **criterion for dynamical mass transfer (3):**
BSE code, cCAML and eCAML

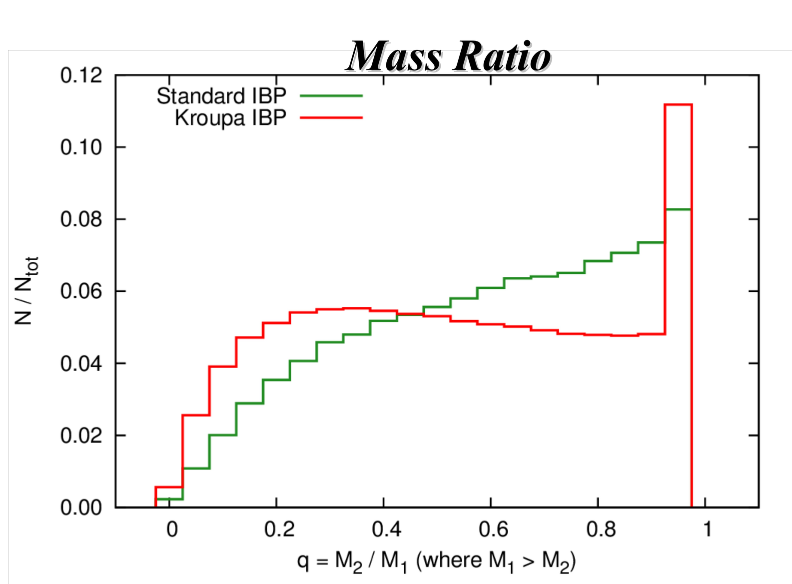
→ **CEP parameters (2):**
($\alpha = 3$, $\alpha_{rec} = 0.5$) and ($\alpha = 1$, $\alpha_{rec} = 0.0$)

→ **CV evolution model (2):**
Knigge et al. (2011) and BSE code

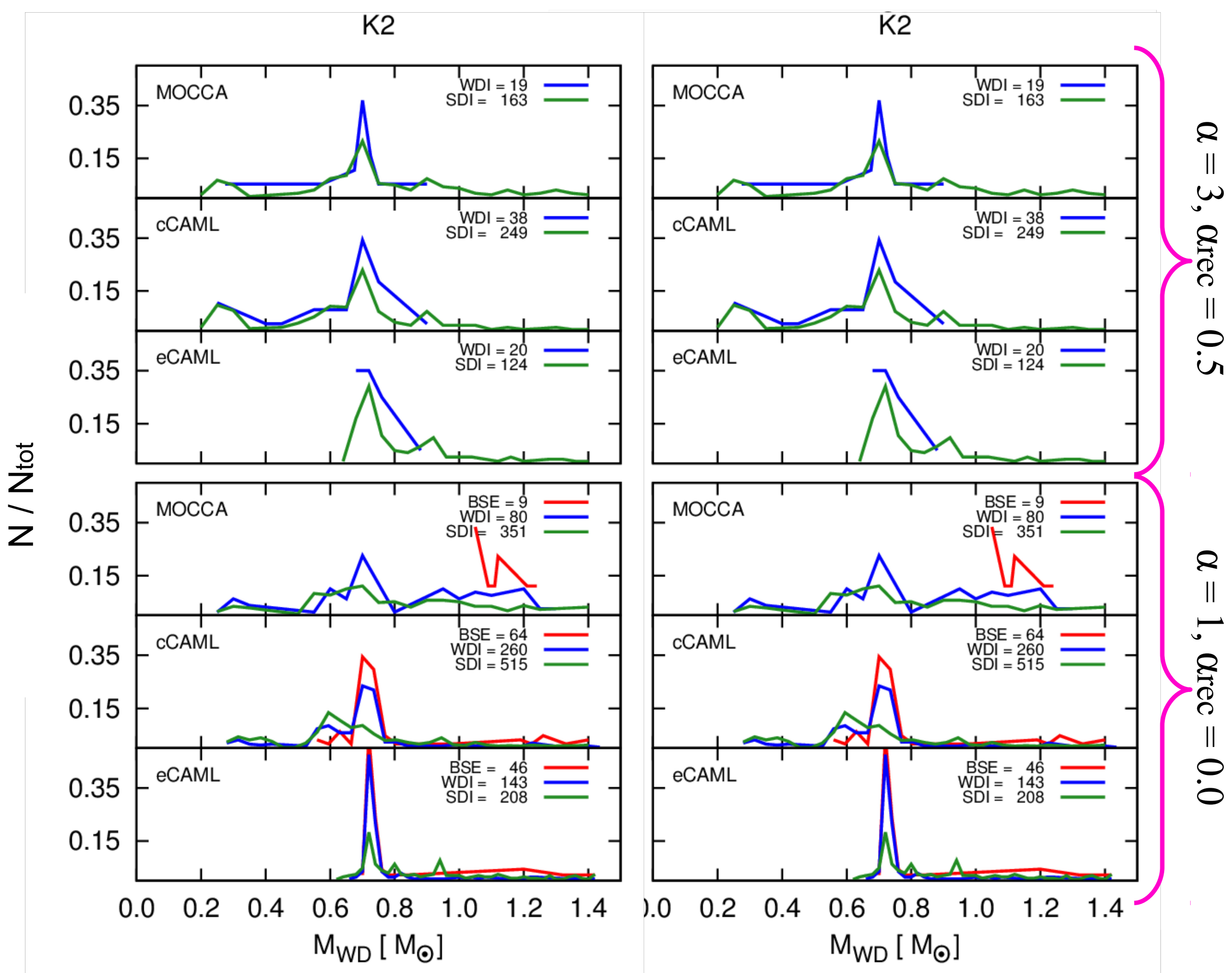
In addition to the BSE evolution (in MOCCA), all close WD-MS were also evolved with the up-to-date code described in Zorotovic et al. (2016). For simplicity, we show results related to only two models, namely S2 (that follows the Standard IBP) and K2 (that follows the Kroupa IBP). All numerical machinery used to analyse the CV populations is described in Belloni et al. (2016).

MAIN DIFFERENCE BETWEEN TWO IBPs

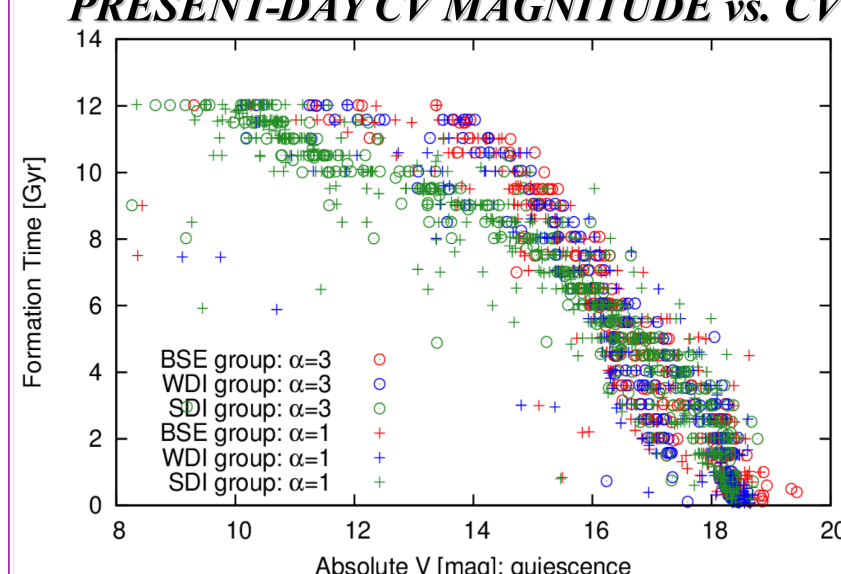




WD MASS DISTRIBUTION



PRESENT-DAY CV MAGNITUDE vs. CV FORMATION AGE

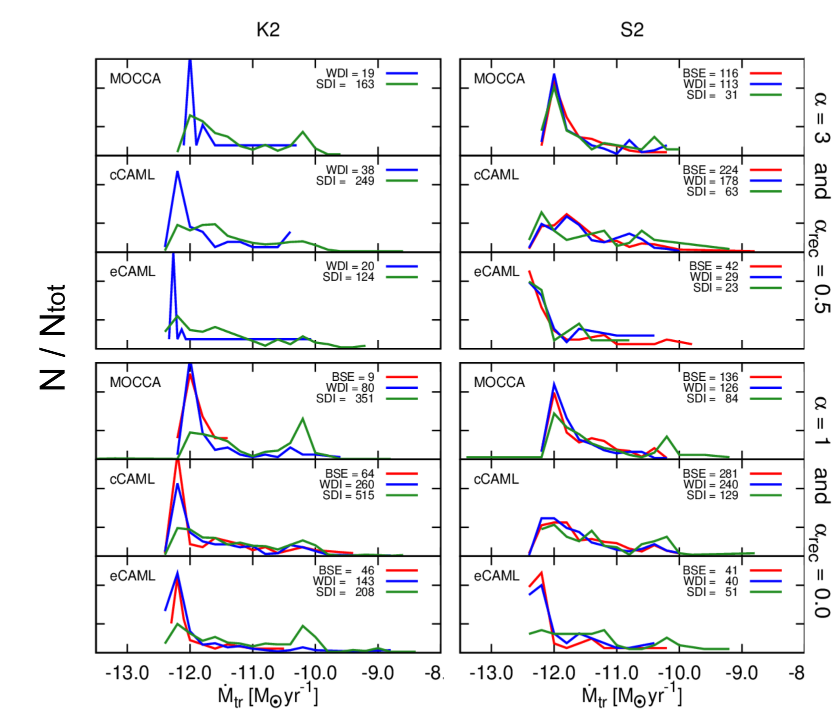


BSE group → CVs formed due to pure binary stellar evolution

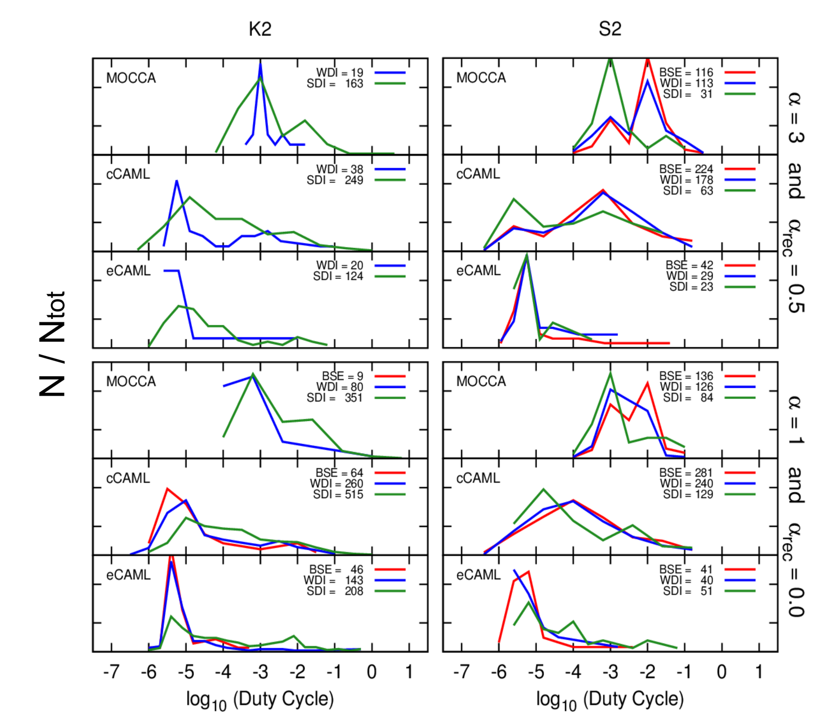
WDI group → CV formed under weak influence of dynamics (mainly fly-bys)

SDI group → CVs formed under strong influence of dynamics (mainly exchanges)

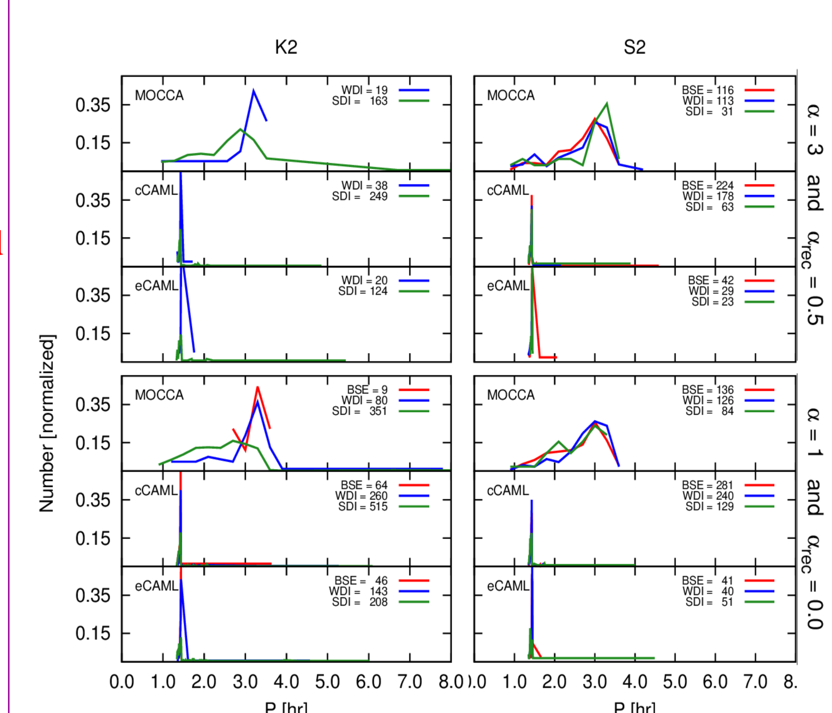
MASS TRANSFER RATE



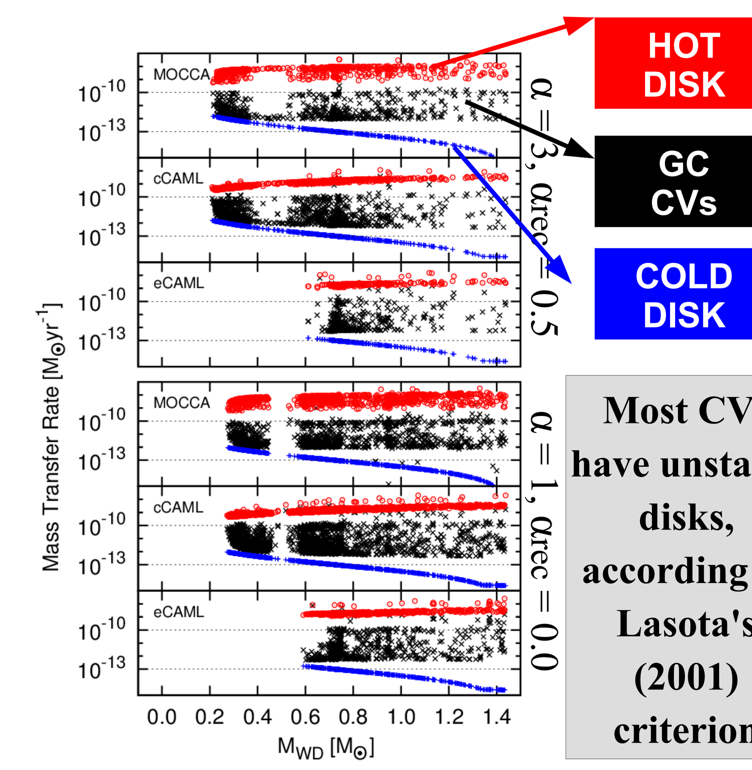
DUTY CYCLE



PERIOD



ARE THEY DWARF NOVAE ?



Most CVs have unstable disks, according to Lasota's (2001) criterion.

Main Discrepancies (see Knigge et al. 2011)

PROBLEMS WITH BSE CODE

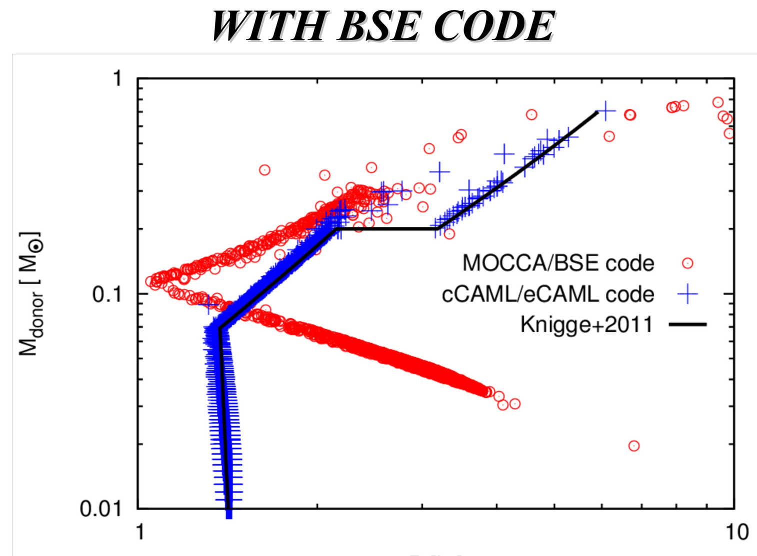
(i) donor mass-radius ;

(ii) normalization factors adopted in BSE for the AML above and below the gap;

(iii) Roche-lobe radius geometry;

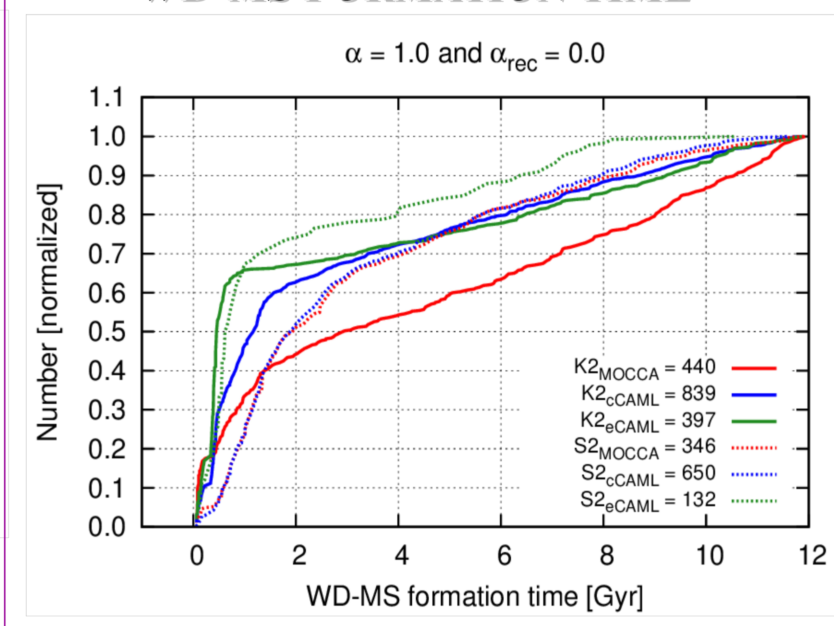
(iv) in BSE there is no prescription for CAML;

(v) predicted donor radius is not increased in BSE;

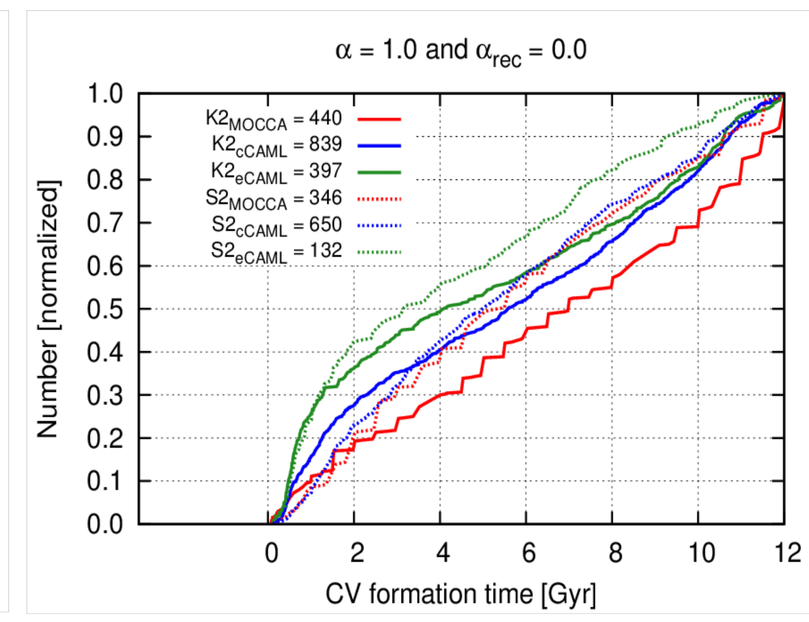


(vi) critical mass ratio such that dynamical mass transfer from a low-mass MS star is not accurate in BSE (see Schreiber et al. 2016, for more details).

CUMULATIVE DISTRIBUTION OF WD-MS FORMATION TIME



CUMULATIVE DISTRIBUTION OF CV FORMATION TIME



CONCLUSIONS

→ Models that follow the Kroupa IBP show better agreement with respect to the WD mass distribution in Galactic CVs than those that assume the Standard IBP;

→ Contrary to what we concluded in Belloni et al. (2017), the CV formation rate seems to depend on our assumptions, especially during the first 1-2 Gyr;

→ CVs formed through weak interactions (WDI group) seem to have similar properties to the ones formed without any interaction (BSE) rather than to those formed by strong interactions (SDI);

→ Assuming more realistic (lower) values for the common-envelope efficiencies we found that more CVs (and less PCEBs) are produced, especially in the models that follow the Kroupa IBP;

→ Also, including the empirical approach for CAML from Schreiber et al. (2016), CVs with low-mass (helium-core) WDs are not produced, which is consistent with the observations;

→ Despite all the uncertainties involved in simulating CVs in GCs, we can infer that bright CVs in GCs are young and mainly formed due to exchanges. These tend to be concentrated towards the center of the cluster, but outside the core;

→ The apparent lack of outbursts in GC CVs could just be a selection effect, in the sense that our knowledge is limited to a small population of very close CVs that are frequently observed in outburst, since these are the easiest systems to detect (e.g. Servillat et al. 2011;Knigge 2012; Belloni et al. 2016).

→ Finally, as has already pointed out by Knigge (2012), the natural path toward improving our understanding of GC CVs is a deep survey for DNe in GCs that would guarantee the detection of at least a few WZ Sge systems. This would allow for a much more thorough comparison between the predictions of theory and observations, a crucial step toward disentangling the true nature of GC CVs.

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FUTURE PERSPECTIVES

→ First, we will perform population synthesis starting with the Kroupa IBP in order to constrain even more binary stellar evolution parameters (CEP parameters and stability criterion for dynamical mass transfer) using observed properties of WD–MS PCEBs and CVs in the Galaxy;

→ Second, once we obtain the best values for binary stellar evolution parameters related to Galactic field CVs, we will simulate hundreds of globular cluster models with the MOCCA Monte Carlo code, for different globular cluster initial conditions;

→Finally, we will extend our scripts to analyse the populations of other accreting white dwarf binary system such as AM CVns, symbiotic stars and SN Ia progenitors in these models.

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