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On the Dynamical Capture of a MSP by an IMBH in a Globular Cluster

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Abstract.
Globular clusters (GCs) are rich of millisecond pulsars (MSPs) and might also host single or binary intermediate–mass black holes (IMBHs). We simulate 3- and 4-body encounters in order to test the possibility that an IMBH captures a MSP. The newly formed system could be revealed from the timing signal of the MSP, providing an unambiguous measure of the BH mass. In current surveys, the number of expected [IMBH,MSP] binaries in the Milky Way is ~ 0.1. If next-generation radio telescopes (e.g. SKA) will detect ~ 10 times more MSPs in GCs, we expect to observe at least one [IMBH,MSP] binary.

Keywords. pulsars: general, globular clusters: general

1. Introduction

Recent observations suggest that intermediate-mass black holes (IMBHs hereon) might be hosted in some globular cluster (GCs) (Gebhardt *et al.* 2005). There is strong evidence that GCs also host a high number of millisecond pulsars (MSP, Ransom *et al.* 2005). We study the possibility for an IMBH to capture a MSP by dynamical interactions.

2. Simulations

In order to determine the properties of [IMBH,MSP] binaries in Galactic GCs, we run 3- and 4-body simulations between a single or binary MSP interacting with a single or binary IMBH. The companion of the MSP, when present, is assumed to be a white dwarf (WD). The initial distributions adopted for the orbital parameters of the [MSP,WD] binaries are those typical of the Galactic population of binary MSPs (Camilo & Rasio 2005). We divide the entire population of MSP binaries into three families:

- class I (short period binaries): systems whose orbital period P is less than 1 day;
- class II (long period binaries): systems with 1 <P (days)<10;
- outliers: systems whit P> 10 days.

The companion of the IMBH is either a stellar mass BH or a star (for the initial distribution of the eccentricities and semi-major axes of the IMBH binaries see Devecchi *et al.* 2007).

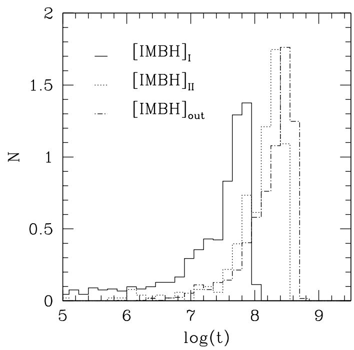

Figure 1. Lifetimes for [IMBH,MSP] binaries formed after the interaction of the single IMBH with [MSP,co] binaries belonging to class I ([IMBH]$_{\rm I}$), class II ([IMBH]$_{\rm II}$) and outliers ([IMBH]$_{\rm out}$).

3. Results

From our simulations we determine the cross-sections Σ_X for the formation of [IMBH,MSP] binaries. We find that the presence of a secondary BH inhibits the formation of an [IMBH,MSP] binary. The highest value of Σ_X is found for a single IMBH interacting with outliers.

The formation rate for [IMBH,MSP] binaries for a particular channel X is related to the cross-section by:

$$\Gamma_X \sim n_{MSP} \omega_X \langle v_\infty \rangle \Sigma_X \tag{3.1}$$

where n_{MSP} is the number density of MSPs in the Galactic GCs' cores,$\langle v_\infty \rangle$ is the mean relative velocity and ω_X corresponds to the probability of channel X. Even in the most favourable case (i.e. the single IMBH interacting with a binary MSP) the formation time-scales are of the order of the Hubble time.

Once these systems are formed, the probability of detecting an [IMBH,MSP] binary is also related to its lifetime, and thus depends on its orbital parameters. We infer the distributions of the semi-major axis and eccentricity of the [IMBH,MSP] from our simulations. Typical orbital separations are a few AU, in agreement with analytical models both for the single IMBH (Pfhal 2005) and for the [IMBH,star] cases (Devecchi *et al.* 2007). The eccentricities are very high, particularly for the single IMBH. The lifetimes of the newly formed binaries are calculated accounting for hardening by stellar encounters and by gravitational waves. Because of their high eccentricities, the binaries have typical lifetimes of $\sim 10^8$ yrs. This relatively short lifetime, combined with the low formation rate, makes [IMBH,MSP] binaries extremely rare: their expected number is ~ 0.1 for the Galactic population of GCs. If next-generation radio telescopes (e.g. SKA) will detect ~ 10 times more MSPs in GCs, we expect to observe at least one [IMBH,MSP].

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