Formation, evolution, and survival of massive star clusters
Proceedings IAU Symposium No. 316, 2015
C. Charbonnel & A. Nota, eds.

doi:10.1017/S1743921315009369

The birthrates of SNe Ia in globular clusters

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Abstract. Globular clusters has been proposed as testbeds for type Ia supernovae (SNe Ia). In this work, using a detailed binary population synthesis approach, we studied the birthrates of SNe Ia from various progenitor models in globular clusters, including the single-degenerate model, the double-degenerate model and the Sub-Chandrasekhar model. Here, a single starburst with a total mass of $10^6 M_\odot$ is assumed.

Keywords. binaries: close – supernovae: general – white dwarfs

1. Introduction

Type Ia supernovae (SNe Ia) have high values in astrophysics, especially in Cosmology and the chemical evolution of galaxies (e.g., Howell 2011). They are thought to be thermonuclear explosions of accreting carbon–oxygen white dwarfs (CO WDs) in close binaries, however, the nature of the mass donor is still uncertain (see Nomoto *et al.* 1997).

Several progenitor models have been proposed to produce SNe Ia, that is, the single-degenerate (SD), double-degenerate (DD) and Sub-Chandrasekhar (Sub-Ch) mass models (e.g., Wang & Han 2012; Maoz *et al.* 2014). In the SD model, a CO WD can accrete H- or He-rich matter from a non-degenerate star to increase its mass to approach the Chandrasekhar mass, and then form an SN Ia, in which the donor star could be a main-sequence star (WD+MS channel), a red giant (WD+RG channel), or a He star (WD+He star channel). In the DD model, SNe Ia arise from the merging of two CO WDs. The closeness of two WDs is due to common envelope evolution, which then enables gravitational wave radiation to drive orbital inspiral to merger. In the Sub-Ch model, the explosion of a CO WD is triggered by the detonation of a substantial surface layer of accreted He.

The delay times of SNe Ia are defined as the time interval between the star formation and SN explosion. The various progenitor models of SNe Ia can be examined by comparing the delay time distributions expected from a progenitor model with that of observations. Globular clusters has been proposed as testbeds for SNe Ia (e.g., Pfahl *et al.* 2009). In this work, we will give the delay time distributions of SNe Ia for various progenitor models in globular clusters using a binary population synthesis method.

2. Model and Results

In order to give the delay times of SNe Ia from various models, we first employed the Eggelton stellar evolution code (Eggleton 1973) and adopted the prescription of Hachisu *et al.* (1999) for the accretion efficiency of a CO WD, and carried out detailed binary evolution calculations for close CO WD binaries, and mapped out the initial parameters in the orbital period-secondary mass plane for various WD masses which lead to an SN

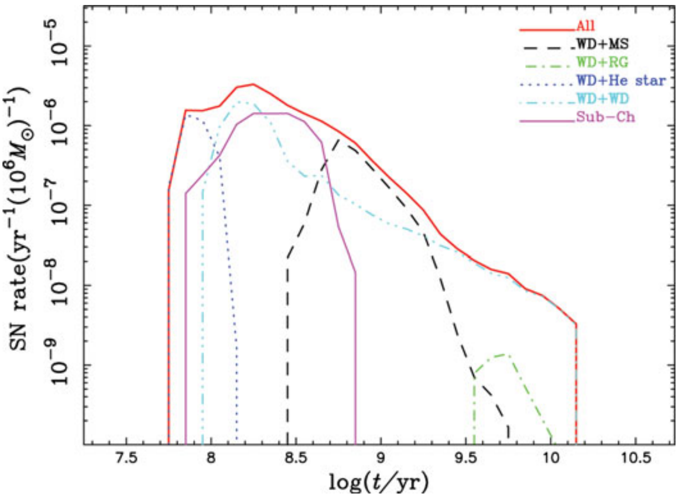

Figure 1. Delay time distributions of SNe Ia for different progenitor models of SNe Ia in the globular clusters, including the WD+MS, WD+RG, WD+He star, WD+WD and Sub-Ch models, in which a single starburst with a total mass of $10^6 M_\odot$ is assumed.

Ia. We then implemented these results into a binary population synthesis study, which is to follow the evolution of millions of primordial binaries, to obtain the birthrates of SNe Ia. We performed a series of Monte Carlo simulations in the binary population synthesis study. In each simulation, we followed the binary evolution via the rapid binary evolution code developed by Hurley *et al.* (2002).

In Figure 1, we present the delay time distributions of SNe Ia for different progenitor models of SNe Ia in the globular clusters. Here, a single starburst with a total mass of $10^6 M_\odot$ is assumed. From this figure, we can see that the WD+He star and Sub-Ch models produce SNe Ia with short delay times, while the WD+MS model contributes to SNe Ia with intermediate and long delay times. In addition, the WD+RG model contributes to long delay time SNe Ia. Furthermore, the DD model may produce both short time delay SNe Ia and long time delay ones. For details of the calculations, we refer the reader to Wang *et al.* (2010a) for the WD+MS model, to Wang *et al.* (2009a,b) for the WD+He star model, Wang & Han (2010) for the WD+RG model, Wang *et al.* (2010b) for the WD+WD model, Wang *et al.* (2013) for the Sub-Ch model.

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https://doi.org/10.1017/S1743921315009369 Published online by Cambridge University Press