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A population synthesis study of the local white dwarf population

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Abstract. White dwarfs are natural cosmochronometers, and this allows us to use them to study relevant properties of the Galaxy, such as its age or its star formation rate history. Here we present a population synthesis study of the white dwarf population within 40 pc from the Sun, and compare the results of this study with the properties of the observed sample. We use a state-of-the-art population synthesis code based on Monte Carlo techniques that incorporates the most recent and reliable white dwarf cooling sequences, an accurate description of the Galactic neighborhood, and a realistic treatment of all the known observational biases.

Keywords. Galaxy: disk, (Galaxy:) solar neighborhood, (stars:) white dwarfs

1. Introduction

White dwarfs are the most common stellar evolutionary endpoint. Actually, all stars with masses smaller than $\approx 10\,M_\odot$ will end their lives as white dwarfs. Consequently, the white dwarf luminosity function is a key tool to study the physical process of the evolution of white dwarfs. Furthermore, the luminosity function of white dwarfs endows a wealth of information about the evolution of our Galaxy (García-Berro & Oswalt 2016).

2. The observed and simulated samples

A detailed description of the main ingredients employed in our Monte Carlo population synthesis code can be found in García-Berro *et al.* (1999), Torres *et al.* (2001), Torres *et al.* (2002) and García-Berro *et al.* (2004). We briefly describe here the most important inputs of our simulator. For the Galactic disk we adopted an age of 9.2 Gyr, and a constant star formation rate. We chose a Salpeter initial mass function, with slope $\alpha = 2.35$. Stars were distributed according to a double exponential profile with a scale height $H = 250\,\mathrm{pc}$ and a scale length $L = 3.5\,\mathrm{kpc}$. Velocities were obtained taking into account the differential rotation of the Galaxy and the peculiar velocity of the Sun. The cooling sequences adopted depend on the mass of the white dwarf. For white dwarfs with masses $M_{\rm WD} \leqslant 1.1\,M_\odot$ we used the tracks for CO white dwarfs with hydrogen-rich atmospheres of Renedo *et al.* (2010). For masses larger than $1.1\,M_\odot$ we used the cooling tracks for white dwarfs with ONe cores of Althaus *et al.* (2007). For hydrogen-deficient white dwarfs we used the cooling sequences of Camisassa *et al.* (2017). These sequences incorporate the most recent advances in the field. We derived the ensemble properties

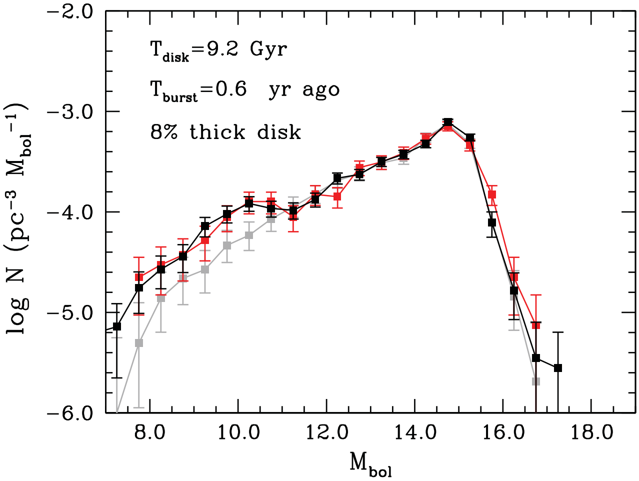

Figure 1. Theoretical white dwarf luminosity functions for the local 40 pc sample compared to observations (red line). The gray line corresponds to a model without a recent burst of star formation, whereas the black line shows a model in which a burst of star formation and a 8% of thick disk contamination is considered.

of a sample of ∼500 white dwarfs within 40 pc of the Sun, and compared them with those of the SUPERBLINK survey (Limoges *et al.* 2015). The estimated completeness of this sample is ∼ 70%, thus allowing a meaningful statistical analysis. Our simulations follow strictly the observational selection criteria. Thus, we only considered stars in the northern hemisphere ($\delta > 0°$) and with proper motions larger than $\mu > 40\,\mathrm{mas\,yr^{-1}}$. Additionally, white dwarfs with reduced proper motions $H_{\rm g} > 3.56(g-z)+15.2$ and magnitudes fainter than $V = 19$ were discarded.

3. Discussion

We used the observed population of white dwarfs within 40 pc of the Sun to study the age and star formation history of our Galaxy. Our simulations match very well the observed white dwarf luminosity function. In particular, they reproduce a previously unexplained feature of the bright branch of the luminosity function, which we propose is due to a recent episode of star formation. We also derive the age of the local Galactic disk employing a combined strategy that considers the position of the observed cut-off and the overall shape of the white dwarf luminosity function, obtaining $9.2^{+0.8}_{-0.2}$ Gyr. Finally, a 8% contamination of thick disk stars is probably present in the observed sample.

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