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The kinematics of white dwarfs from the SDSS DR12

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Abstract. We use the Sloan Digital Sky Survey Data Release 12, which is the largest available white dwarf catalogue to date, to study the evolution of the kinematical properties of the population of white dwarfs of the Galactic disk. We derive masses, ages, photometric distances and radial velocities for all white dwarfs with hydrogen-rich atmospheres. For those stars for which proper motions from the USNO-B1 catalogue are available, the three-dimensional components of the velocity are obtained. This subset of the original sample comprises 20,247 stars, making it the largest sample of white dwarfs with measured three-dimensional velocities. The volume probed by our sample is large, allowing us to obtain relevant kinematical information. In particular, our sample extends from a Galactocentric radial distance $R_G = 7.8$ to 9.3 kpc, and vertical distances from the Galactic plane ranging from $Z = +0.5$ to –0.5 kpc.

Keywords. stars: kinematics, stars: white dwarfs, Galaxy: fundamental parameters, Galaxy: kinematics and dynamics

1. Introduction

White dwarfs are the most usual stellar evolutionary end-point, and account for about 97% of all evolved stars (Althaus *et al.* 2010). Once the progenitor main-sequence star has exhausted all its available nuclear energy sources, it evolves to the white dwarf cooling phase, which for the coolest and fainter stars last for ages comparable to the age of the Galactic disc. Hence, the white dwarf population constitutes a fossil record of our Galaxy.

The first study of the kinematic properties of the white dwarf population was that of Sion *et al.* (1988), where a sample of over 1,300 degenerate stars was employed. However, the small sample sizes used in previous studies prevented obtaining conclusive results. Furthermore, in addition to poor statistics, the major drawback of previous studies was the lack of reliable determinations of the true three-dimensional velocities. The reason for this is that the surface gravity of white dwarf stars is so high that gravitational broadening of the hydrogen Balmer lines is important. Thus, disentangling the gravitational redshift from the Doppler shift is, in most of the cases, a difficult task. In spite of this, the need of a statistically significant white dwarf sample, with accurate measurements of true space velocities, distances, masses and ages, is crucial for studying the evolution of our Galaxy. Here we present a large sample of white dwarfs with accurately determined kinematical properties aimed at studying the evolution of our Galaxy.

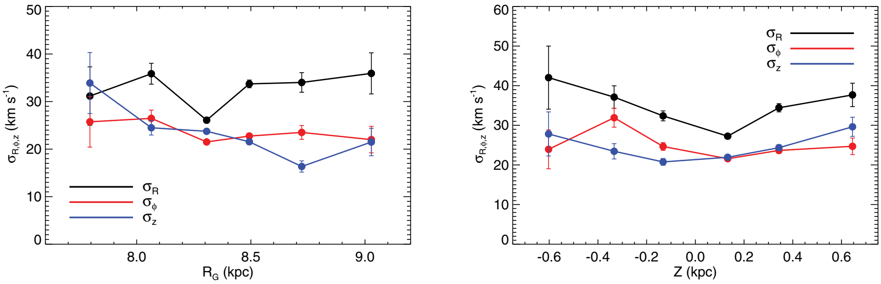

Figure 1. Left panel: variation of the velocity dispersion for the three velocity components with respect to the Galactocentric distance. Right panel: variation of the velocity dispersion with respect to the vertical Galactic distance Z.

2. Methods

Modern large scale surveys have been proficient at identifying white dwarfs. However, it has been the SDSS the survey that has significantly increased the number of known white dwarfs. Actually, the latest release of the SDSS, the DR 12, has produced the largest spectroscopic sample of white dwarfs, with more than 30,000 stars (Kepler *et al.* 2016) with reliable spectra. For these white dwarfs masses and effective temperatures were derived by fitting the hydrogen Balmer series (Anguiano *et al.* 2017). For those white dwarfs for which parallaxes and proper motions were available in the USNO-B catalog we also computed the tangential velocities. Finally, rest-frame radial velocities were derived using the cross-correlation procedure of Tonry & Davis (1979), taking into account the gravitational redshift. Using the derived stellar properties, we interpolated in the cooling tracks of Renedo *et al.* (2010) to obtain the cooling ages, to which we added the main sequence lifetimes of their progenitors. This provided us with accurate ages and velocities for a sample of 20,427 stars.

3. Results and outlook

We computed the velocities in cylindrical coordinates, (V_R, V_ϕ, V_Z). Specifically, we used the Galactocentric distance R_G, ϕ in the direction of Galactic rotation, and the vertical distance Z, positive towards the NGP. Fig. 1 shows the velocity dispersions as a function of R_G and Z. The remaining kinematical properties of the white dwarf population are not shown here for space limitations, and we refer the interested reader to Anguiano *et al.* (2017) for an extensive discussion. Finally, we emphasize that an analysis of the effects of the selection procedures and observational biases using a population synthesis code (García-Berro *et al.* 1999; García-Berro *et al.* 2004) is underway, and will be published elsewhere.

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