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The age-metallicity relation from a sample of white dwarf-main sequence binaries

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Abstract. The age-metallicity relation (AMR) is a fundamental observational constraint for understanding how the Galactic disc formed and evolved chemically in time. However, there is not yet an agreement on the observational properties of the AMR, primarily due to the difficulty in obtaining accurate ages for individual field stars. We have started an observational campaign for providing new observational input by using wide white dwarf-main sequence (WDMS) binaries. WDs are natural clocks and can be used to derive accurate ages. Metallicities can be obtained from the MS companions. Since the progenitors of WDs and the MS stars were born at the same time, WDMS provide a unique opportunity to constrain in a robust way the properties of the AMR. We present the AMR derived from analysing a pilot sample of 23 WDMS and provide clear evidence for the lack of correlation between age and metallicity at young and intermediate ages.

Keywords. Galaxy: fundamental parameters, (Galaxy:) solar neighborhood, (stars:) white dwarfs, stars: late-type

1. Introduction

The age-metallicity relation (AMR) is the fossil record of the chemical evolution and enrichment history of the Galactic disc. While early observational studies found a correlation between stellar ages and metallicity (see e.g. Soubiran *et al.* 2008), more recent studies show a substantial scatter in the relation, suggesting that a clear correlation between the age and the metallicity does not exist (see e.g. Bergemann *et al.* 2014). The differences in the observed AMRs are likely to arise because measuring precise stellar ages is a difficult task, prone to substantial uncertainties (Soderblom 2010). The discrepancies in stellar ages, and hence in the derived AMRs, motivate to explore other dating methods.

White dwarf-main sequence (WDMS) binary systems are detached pairs composed of a white dwarf (WD) and a main sequence (MS) star. Using WDMS for analysing the AMR has significant advantages over other methods because WDs are objects with well-studied properties that can be used to derive accurate ages. Moreover, metallicities can be directly determined for the MS companions in the same way as for individual field stars. Since the two stars in the binary are coeval, employing accurate WD ages also allows to determine the age of their MS companions.

Our sample is the largest (>3200 systems) and most homogeneous catalogue of WDMS binaries currently known (Rebassa-Mansergas *et al.* 2010, 2016a), obtained from the Sloan

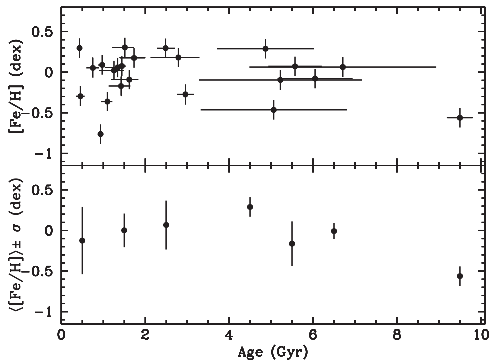

Figure 1. Upper panel: the age-[Fe/H] relation derived from the 23 SDSS WDMS binaries studied in this work. Bottom panel: average [Fe/H] values for 1 Gyr bins, together with their standard deviations.

Digital Sky Survey (SDSS). We selected 118 systems that are bright enough to allow deriving accurate WD ages and MS star metallicities. In this work we present the AMR measured from 23 WDMS binaries in our selected sample. Spectra of these 23 objects were obtained using the Very Large Telescope in Chile and the X-Shooter instrument (Rebassa-Mansergas *et al.* 2016b).

2. WD ages and MS star metallicities

We used the routine outlined by Rebassa-Mansergas *et al.* (2007) to subtract the MS star contribution from the optical X-Shooter spectra. We then fitted the normalized Balmer lines of the residual WD spectra and derived WD effective temperatures and surface gravities. We interpolated these values on the WD cooling tracks of Renedo *et al.* (2010) to obtain the WD masses and cooling ages. We then used the initial-to-final mass relation (IFMR) of Catalán *et al.* (2008) to derive the WD progenitor masses. Finally, the WD progenitor lifetimes were obtained interpolating the WD progenitor masses in the BASTI isochrones, for which we adopted the metallicities as derived from the MS companions. The WD cooling ages added to the MS lifetimes of their progenitors gave the total ages of the binaries.

We obtained the [Fe/H] abundances from the K-band, near-infrared X-Shooter spectra of the MS stars following the procedure described in Newton *et al.* (2014). This method provides [Fe/H] following a semi-empirical multivariate linear regression based solely on the Na I absorption doublet (2205/2209 nm) equivalent width.

3. The age-metallicity relation

In the top panel of Figure 1 we display the resulting AMR. In the bottom panel of the same figure we display the average ⟨[Fe/H]⟩ in 1 Gyr bins along with their standard deviations. The AMR derived in this way shows an intrinsic scatter >0.2 dex for most ages. This significant scatter suggests a lack of correlation between the values of [Fe/H] and ages derived from our pilot data-set of 23 WDMS systems.

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