Analyzing white dwarf + white dwarf binaries with Gaia trigonometric parallaxes

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Introduction

White dwarfs (WDs) have been used as chronometers to age date the solar neighborhood, open clusters, globular clusters, and even the Galactic halo field population. The availability of highly accurate and precise Gaia trigonometric parallaxes along with nearly all-sky, homogenous photometric surveys (SDSS, Pan-STARRS) now allows us to improve the precision in WD ages. We report on the consistency of ages among seven WD+WD binaries, run through **BASE-9** individually and in pairs.

Methods

BASE-9 is a Bayesian software suite that uses photometry, stellar models, and priors on distance and metallicity to fit stellar parameters such as age and mass. Seven WD+WD binary systems were analyzed individually and as pairs with **BASE-9** using the PARSEC (Bressan et al. 2012) stellar evolution models, the Bischoff-Kim & Montgomery (2018) WD cooling models, and the Williams, Bolte, & Koester (2009) initial-final mass relation.

Results

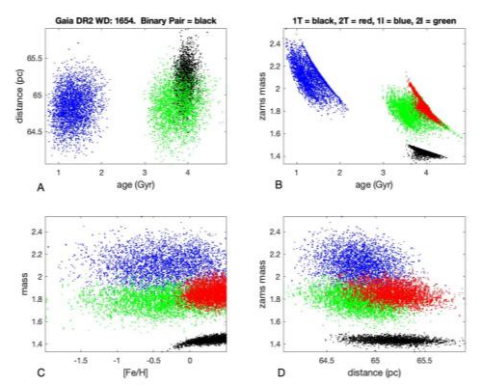

Figure 1: An example WD+WD binary run through **BASE-9** as individual stars (1654.1 = blue, 1654.2 = green) and as a pair (1654.1 = black, 1654.2 = red). Fig 1a requires that both stars must have identical ages and distances. Figs 1b & 1d show that **BASE-9** used these constraints on age and distance to determine that 1654.1 may have started on the main sequence with a lower mass than when run alone. With this new constraint on ZAMS mass, Fig 1c uses the knowledge that both stars should have similar [Fe/H] to derive lower masses for 1654.1.

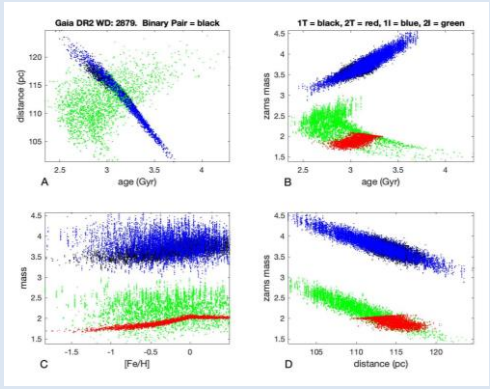

Figure 2: Another example binary run through **BASE-9** as individual stars (2879.1 = blue, 2879.2 = green) and together as a pair (2879.1 = black, 2879.1 = red). In Fig 2a, the distribution of constrained age-distance possibilities lies within the overlap of the unconstrained possibilities. Figs 2b & 2c use the constrained information to provide an upper bound on the ZAMS mass of 2879.2. While Fig 2c indicates poor knowledge of metallicity for this system, the constraints allowed **BASE-9** to narrow down the ranges of possible mass significantly.

Conclusions and Future Work

As shown in Figures 1 and 2, **BASE-9** is able to successfully and usefully constrain stellar ages and other parameters for WD+WD binaries. In some cases the preferred fits are within the overlap region of the distributions of stars analyzed individually, and in some cases the preferred fits are inconsistent with the results of at least one star analyzed individually. Future work will include assessing binaries of unknown spectral types, as well as testing multiple variations of the initial-final mass relation.

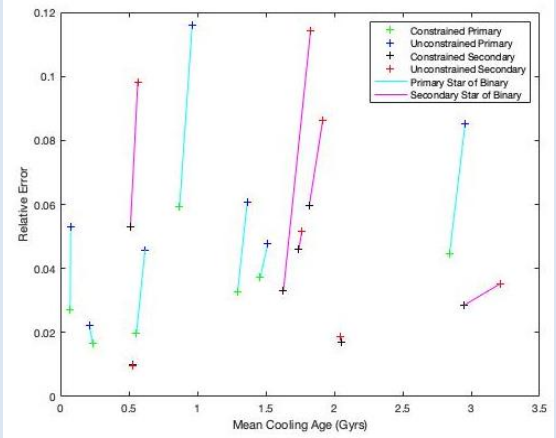

Figure 3: The mean cooling age and relative error of each white dwarf analyzed as a single star and as a member of its pair. The relative age errors for both the constrained and unconstrained cases are low, rarely above 10% and commonly below 5%. Generally, the constrained cases have lower relative errors. These results range from cooling ages of ~100 Myr to ~3 Gyr.

References

Bischoff-Kim, A., & Montgomery, M., 2018, AJ, 155, 187
Bressan, A., Marigo, P., Girardi, L., et al. 2012, MNRAS, 427, 1
Williams, K.A., Bolte, M., & Koester, D. 2009, ApJ, 693, 355