Population synthesis study of the *Gaia* single and binary white dwarf population within 100 pc

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Abstract

Single and binary white dwarfs can provide a wealth of information about the origin and evolution of the Galaxy and its constituents. Thanks to *Gaia*, we now have astrometric and photometric data for nearly 300,000 white dwarfs, and the number of binary systems has also increased exponentially. Moreover, the completeness of such systems to a distance of 100 pc is higher than 95%. To understand their physics, we are simulating the different Galactic populations of single and binary systems that contain at least one white dwarf. To that end we use a Monte Carlo code together with stellar evolutionary sequences conveniently adapted to cover a wide range of stars for all ages, masses and metallicities. Different physical processes such as mass transfer, common envelope evolution, collisions or tidal interactions are considered, which can give us a hint about the formation history and evolution of the observed stars. The ultimate end is to compare the outcome of the simulations with the nearly complete observed *Gaia* samples in the Solar neighborhood to constrain current evolutionary models.

The Code

Monte Carlo simulator code (MRBIN) for single and binary population [1]

- Initial Mass Function (IMF)
- Star Formation Rate (SFR)
- Spatial density distribution:
  Thin disk (85%), thick disk (10%), halo (5%)
- Kinematic model
- Initial-to-final-mass relation (IFMR)
- Cooling sequences: DA/DB, metallicity, CO-core, He-core, ONe-core,...

Binary Star Evolution(BSE) [2, 3, 4, 5] code to evolve binary systems

- Eccentricity distribution: $f(e)=2e$
- Semi-mayor axis distribution: $f(a)=a^{-1}$
- Common envelope treatment: α_{CE}
- Mass ratio distribution: $n(q)=q^{nq}$
- Fraction of binary systems: $f_b=0.32$ [6]

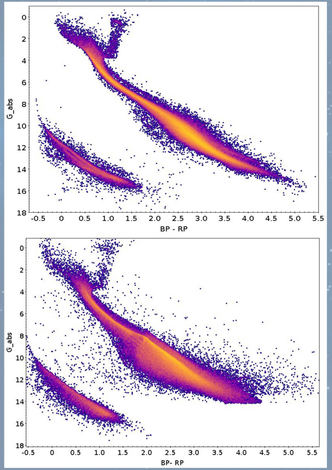
Gaia photometry and selection criteria

- PARSEC Isochrones for main sequence stars
- La Plata tracks [7] + atmospheric models [8] for DA and DB white dwarfs
- Distinction between resolved and unresolved systems (2'')
- Flux with <10% error
- Color excess:
  |C*|<3*sigmas(C*) [9]
  C*=(IBP+IRP)/IG+f(BP-RP)

Validation

Gaia VS Simulations

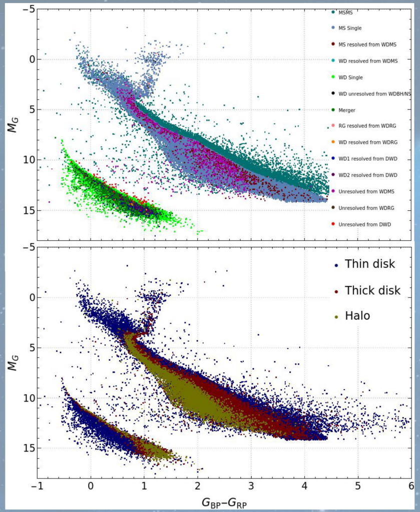
Comparison between *Gaia* observed objects at 100 pc and the simulated objects using our code (Single stars and binary systems)



Results

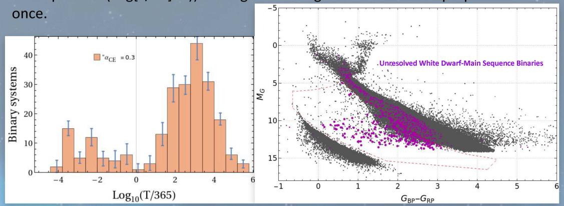
White dwarf binary populations

The code is able to simulate 14 different class of objects in any of the three galactic components (thin disk, thick disk and halo)

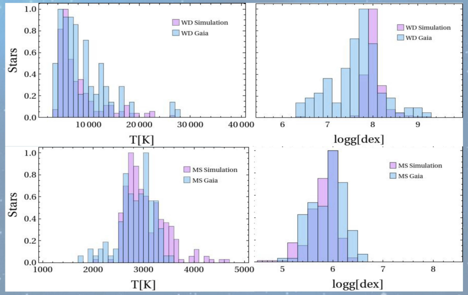


Unresolved White dwarf-Main sequence binaries

Unresolved systems appear in the area between MS and WD. Binaries that have short periods (Log[T/35]<0)) have gone through common envelope phase at least once.



Comparing our simulations with observed WDMS systems [10], Teff and logg distributions generally agree except for some cases. Observed parameters for low mass white dwarf might present some problems and be the cause of the disagreement with simulations.



Conclusions & future work

- Preliminary results are able to reproduce the observations, although we require further tuning of the models and the parameters involved as well as a careful treatment of the observational data. Comparing these simulations with *Gaia* observations can give us a lot of important information about the different type of populations observed by the mission.
- Different subpopulations, including mergers, can be studied using this method. Other type of white dwarf stars such as extremely low mass white dwarfs (ELM) will be soon added. The code currently simulates the solar neighbourhood up to a distance of 100pc around the Sun, where the completeness is almost total, but can be extended to higher distances.

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