The Galactic white dwarf population as seen by Gaia-DR2 and the Virtual Observatory

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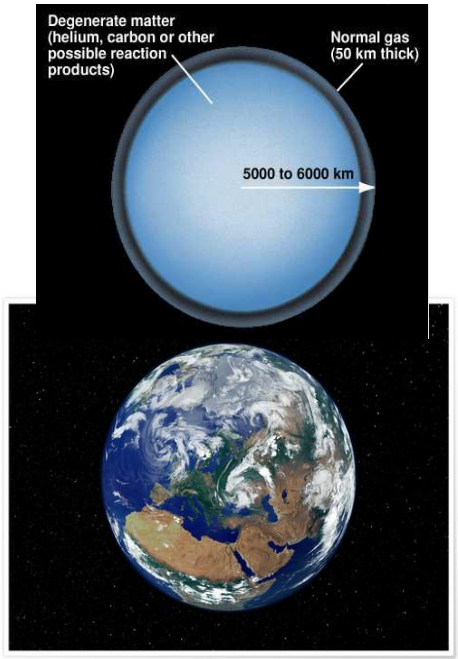
Gaia-DR2 was published on April 2018. The Gaia superb astrometry has allowed the study of the stellar content of our Galaxy as never before. Our group is using the Gaia-DR2 data and the Virtual Observatory to study the population of white dwarfs in the solar neighborhood. Here, we will summarize the main results achieved so far.

White dwarfs

- Very common: the result of stellar evolution $M_{MS} < 10\ M_{\odot}$
- Structure
  - Degenerated core: He ($<0.45\ M_{\odot}$); CO ($<1.04\ M_{\odot}$); ONe ($>1.04\ M_{\odot}$)
  - Thin layer of He
  - Even thinner layer of H
- Classification
  - ~80% DA (H lines)
  - ~20% non-DA, including DB (only He lines)
- Why WDs?
  - Retain the past history of the Galaxy
  - Study of stellar clusters
  - Test no-standard physics



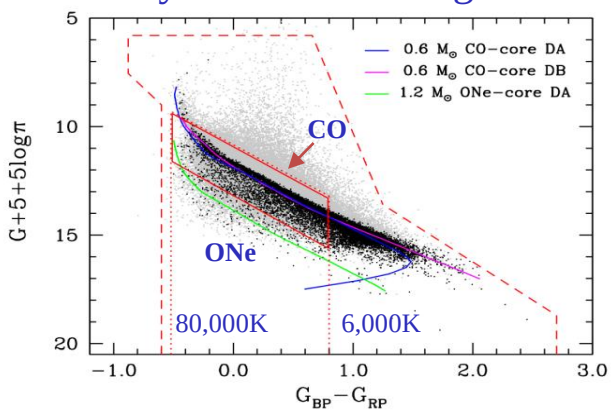
Gaia & VO

- Gaia theoretically provides us with an unprecedented number of WDs
  - 400,000 up to 400 pc
- We also need to estimate their stellar parameters
- VO provided us with the ideal framework
  - easy and fast access to multi-λ deep photometry → SED
  - VO tools permit the study of thousands of objects at once

Methodology

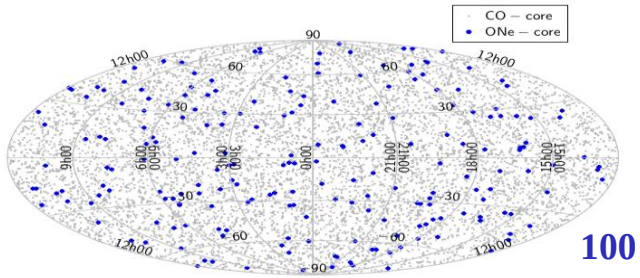
Search criteria:
Defined in the H-R diagram with the aim of a Population Synthesis Code

Synthetic H-R Diagram



The Gaia WD catalogue

- 73,221 WDs
- **8,554 within 100 pc: The most complete volume-limited sample to date**
- Very low (< 1%) contamination (sdBs & CVs)

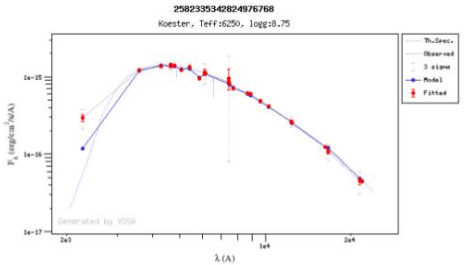


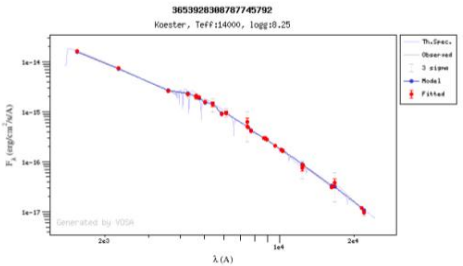
100 pc

Equatorial coordinates

Physical characterization of the sample

- Used VOSA to:
  - built the SEDs from VO (UV-NIR)
  - Fit to DA white dwarf model spectra (Koester 2010)
  - T_{eff} and L for ~91% of sources
- $L = 4\pi R^2 \sigma T^4 \rightarrow R$
- Log$g$ & M from evolutionary sequences (Renedo et al. 2010)





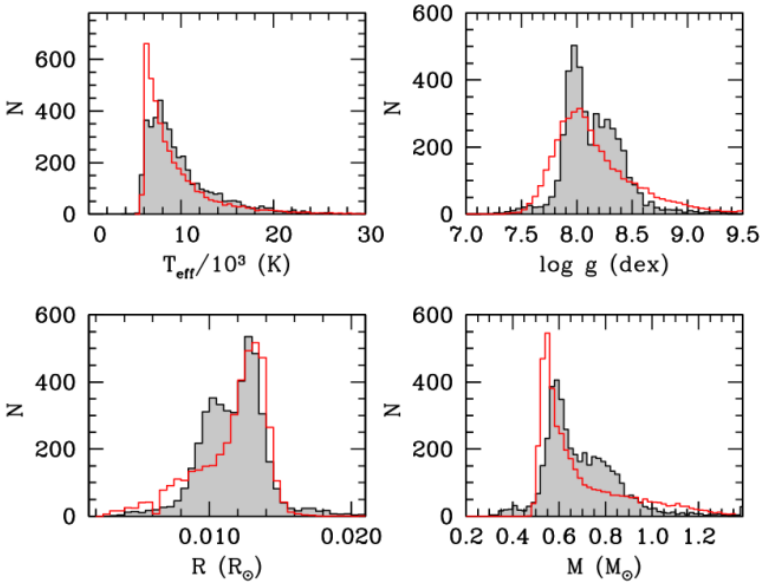
High reliable estimate of physical parameter for ~59%

Figure 8. Examples of observational SEDs and their fit to the synthetic spectra done by VOSA for two of our whi observational photometric points are shown in red joint by gray lines, blue dots joint by blue lines are the synthetic photo cyan line corresponds to the theoretical model.

Results

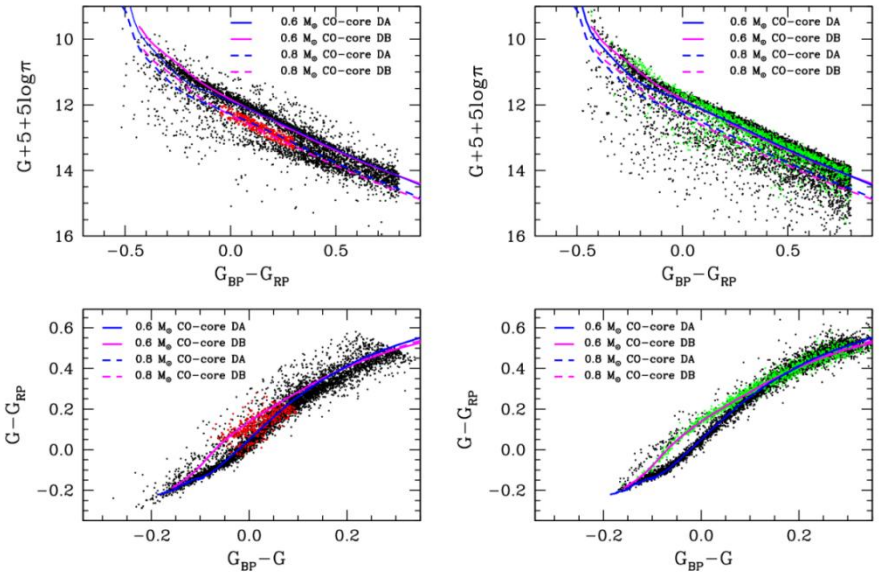
Physical parameters (100 pc)

- Concentration at T_{eff} ~ 8,000 K (Lack T_{eff} < 8,000 K)
- **No predicted Bimodal-like** distribution for *R*, log*g*, *M*
- **Unexpected high-mass population:** ~0.8 $M_{\odot}$ - 0.01 $R_{\odot}$ - 8.3 dex
- Small fraction of He-core: ~0.45 $M_{\odot}$ - 0.017 $R_{\odot}$ - 7.6 dex



The bifurcation in the H-R diagram (100 pc)

Observational Theoretical



- Good agreement with our model of the Galaxy
- **Bifurcation is not fully explained by DA/DB type**
  - Only 30 − 40 % of DB

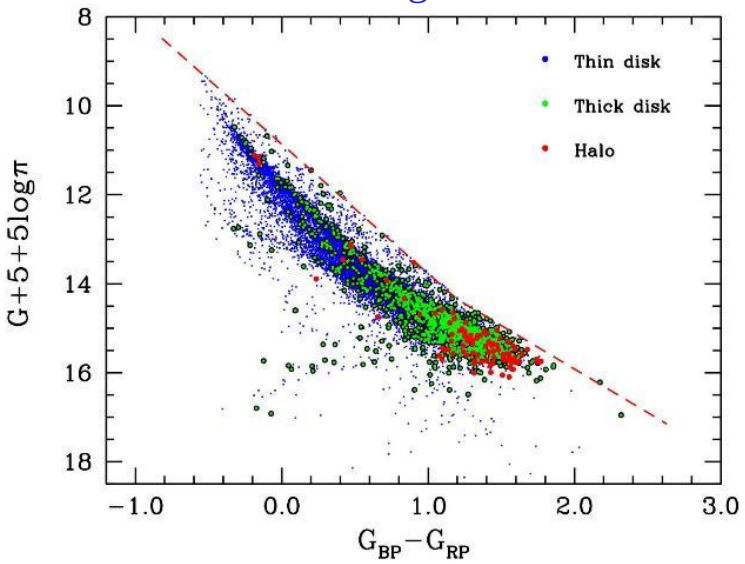
Results

Identification of the Galactic components

- We used and Artificial Intelligent algorithm based on **Random Forest** method
- We analyzed an **8-dimensional** space: **(α, δ, π, G, G_{BP}, G_{RP} , μ_α, μ_δ.)**

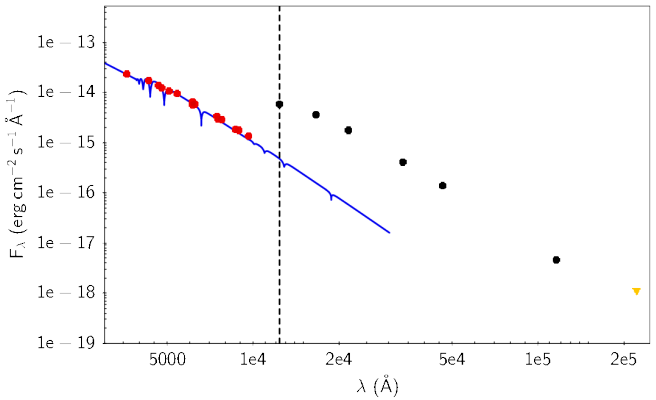
	N_WDs	%
Thin	12227	89
Thick	1410	10
Halo	95	~1

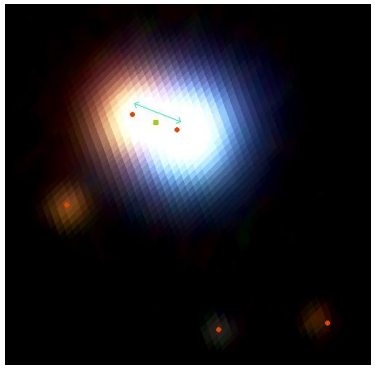
H-R Diagram



WDs with IR excess

- We use VOSA to find WDs associated to SEDs with IR excess either due to a circumstellar debris disk or the presence of a brown dwarf companion.
- We analysis 3733 WDs within 100pc:
  - 77 selected candidates, 52 of which are new.
- Our sample is volume-limited





Left: Composite SED. Back dots are photometry affected by IR Excess.
Right: SDSS image of the partially resolved system

Impact

The first an most complete volume-limited (100 pc) sample WDs up to date

- 8,343 CO-core and 212 ONe-core analyzed by VOSA
- Contamination < 1% (sdBs & WD)
- Reliable physical parameters for ~59%

We identified **bimodal-like distributions of *R*, log*g* and *M***

Bifurcation $0.0 < G_{BP} - G_{RP} < 0.3$

- more massive objects → ~0.8 $M_{\odot}$ peak
- discrepancies between **DA** and **DB cannot fully explain** it

Thin:Thick:Halo WD population:

- Posteriori 89:10:1 → Priori 74:25:1

The fraction of IR excess WDs:

- 1.6+-0.2 % for debris disks
- 0.1-0.2% for brown dwarf companions

Prospects for the future

Use the catalogue to study:

- Other **features of the HR-diagram** that remain unclear, e.g. the Q-branch,
- **Study the binary white dwarf population** by identify common p.m. pairs of **WD+WD, WD+MS, WD+RG**
  - provides important information about the formation and evolution of binary systems
- **Follow-up observation** of the WDs with IR excess